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TELECOMMUNICATIONS

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VOLUME II

TELECOMMUNICATIONS

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CHAPTER 1

REVIEW OF R.A.F. COMMUNICATIONS BETWEEN THE WARS

Soon after the end of the First World War, the Army Council suggested a conference to discuss the measures needed to fulfil the R.A.F. requirements for telephone, telegraph and W/T communications in the field. Questions as to the relationship between the Army Signals Service and the R.A.F. were made the subject of an informal discussion between the Deputy Director of Communications Air Ministry and S.D.6 War Office on 11 December 1918. The relationship of the R.A.F. to the Army wireless communications was considered under four headings:—

(a) W/T between one formation and another. This was regarded as a domestic concern of the R.A.F.

(b) W/T between long range bombing or reconnaissance machines and the Army with which they were co-operating. It was thought that these, too, should be provided by the R.A.F.

(c) W/T between aircraft and artillery. This was thought to need further discussion.

(d) W/T between aircraft and infantry for contact patrol work. This was also marked down for further discussion.[1]

Further conferences were later held on this subject, the outcome being that, while the G.P.O. and Army retained responsibility for R.A.F. landline and telephone services, the R.A.F. was responsible for providing its own wireless communications.

The only Air Ministry wireless station in existence after the First World War was that situated at Kingsway. At this centre, a large number of messages on all kinds of matters concerning the Royal Air Force and civil aviation were handled. In addition, the station was the centre of a scheme of communications organised for the broadcast, transmission and reception of weather reports and general meteorological information. There were two continuous-wave transmitters in use. The first was of a standard R.A.F. ground station pattern, using wavelengths between 1,000 and 2,500 metres, with a useful range of up to 400 miles. This transmitter was used for the transmission of messages within the British Isles. The second transmitter, of a non-standard pattern and specially designed by a serving officer, was of a much higher power with a useful range of up to 1,500 miles, using wavelengths from 1,200 to 4,200 metres. This transmitter was used for communication with stations in Paris, Brussels, Norway, Holland, etc., for meteorological reports and for the transmission of information on the civil aviation services, such as arrival and departure messages. There were also

[1] A.M. File 383830/22.

two receivers in operation, one used for the reception of all continuous wave (C.W.) messages, and the other, a special radio telephone receiver, for the interception of messages passed between the civil aviation stations at Hounslow and Lympne.

By November 1919, as a result of conferences between the Controller General Civil Aviation and the Controller of Communications R.A.F., the basis of a post-war system of communications at R.A.F. and Civil Aviation stations was laid. In the original scheme there were 16 R.A.F. and 9 Civil Aviation stations, some of which already had W/T in existence; later, for reasons of economy, a number of stations in the scheme were relinquished.

The main control station for the United Kingdom on all wavelengths remained at the Air Ministry, but to assist in the control of W/T traffic, various groups of stations were placed under the immediate control of sub-control stations. The hours of watchkeeping varied, but they did not extend beyond 0700 to 2100 except in isolated cases. By 1921 the R.A.F. organisation consisted of some 30 stations organised in two main sections, one of 1,300 metres and the other of 1,210. The Air Ministry station acted as section guard on 1,300 metres, and Uxbridge on 1,210. The normal wavelength for aircraft in flight was 1,300 metres, but aircraft were at liberty to change temporarily to 1,210 metres or to civil aviation stations.

Meteorological messages were collected in strict routine, stations transmitting in correct order and at pre-arranged times. A station not having its message to hand when called gave operating signals to that effect, and sent its message at the end of the routine. At the times of meteor collection, as it was called, other traffic on the same wave ceased, except in the case of priority messages or signals to and from aircraft. A Confidential Communication Order (C.C.O.) embodying this organisation was issued in 1921.

In the same year, details of the W/T organisation in force in the Middle East were requested by the Air Ministry, so that a similar C.C.O. dealing with overseas stations could be compiled. In the Middle East area, which included Egypt, Palestine, Transjordan, Iraq and Persia, there was a total of approximately 20 W/T stations in existence. The main control station for Egypt and Palestine was situated at Headquarters R.A.F. Middle East, and that for Mesopotamia at Headquarters R.A.F. Mesopotamia Group, Bagdad. These stations were organised in three distinct groups, the Egypt group on 1900 metres, the Palestine group on 1800 metres and the Mesopotamia group on 2700 metres. Each of these three groups was controlled by a sub-control station. A system of collection and broadcast of meteorological reports and forecasts was in operation. The general standard of communications was, however, far from satisfactory. Continual delays were occurring in signals traffic and the whole service was much too slow. Even special cyphered messages could not always be relied upon to reach their destination in time to be of use. The main causes of delay were the lack of proper organisation of watches or wavelengths to be used, slack procedure, and untrained or insufficiently skilled personnel. The introduction of a standard W/T organisation did much to remove the first two causes of delay. A signals office was formed at Headquarters R.A.F. Middle East at which the best routine method of despatch was decided. This resulted in far greater efficiency. New personnel were drafted in and the opportunity was taken to increase the hours of watch. A monitoring watch was established at Headquarters R.A.F. Middle East to check procedure, and a signals officer was placed in charge of traffic matters generally. The combined effect of these measures was a great speeding up of the whole system.

With the improvement of the ground W/T point-to-point system, attention was given to landline telephone systems. Expenditure on these two items in the Middle East was extremely high, due to the uncertainty of the W/T system and to insufficient use of State and Army landlines. The introduction of the Signals Office and Traffic Office brought increased control of these items as well, and resulted in remarkable economies.

In 1923, fresh inter-Service wireless instructions were issued to supersede those previously in force, and a controlling body known as the W/T Board (Egypt and Palestine) was formed with the following responsibilities:—

(a) co-ordinating the wireless resources of the three Services in the area;

(b) maintaining up-to-date information regarding wireless stations in action and surplus sets;

(c) furnishing information of surplus wireless personnel;

(d) arranging inter-Service wireless practices for the three Services.

The equipment in use at ground stations in the Middle East at this time was the transmitter Type T.19, T.56B or T.57; and the receiver Type C or Tf. Wireless traffic between the three Services was passed by means of liaison wireless stations. By June 1923, there were four Middle East wireless sections—1650 metres for point-to-point in Palestine Command and between Headquarters Palestine and Headquarters Middle East; 1800 metres for aircraft guard, meteorological messages, and all operational or administrative traffic dealing with the Egypt-Iraq air route (all stations in Egypt, Palestine and Transjordan whose duty was primarily concerned with the trans-Desert route operated on this section); 1975 metres for point-to-point in the Egypt group of stations; and 2300 metres as an inter-Command frequency between Headquarters Middle East and Headquarters Iraq.[1]

The volume of R.A.F. traffic in India was small, but nevertheless a W/T organisation was prepared and issued in 1921, showing Headquarters R.A.F. India as the Main Control Station, with Peshawar as sub-control. There were five other stations in existence, and the wavelengths allotted were between 1400 and 1700 metres. There was no meteor routine but a 24-hour meteor broadcast was transmitted daily by Headquarters.

[1] A.M. File S.16932.

By 1924, R.A.F. W/T stations at home were split up into different groupings which varied according to circumstances and according to the wavelength used. These groupings were known as Organisations 1-4, only one organisation being in use at any one time. An organisation was brought into use on orders from the Air Ministry. There was a total of 22 R.A.F. W/T stations taking part in the combined organisation. The stations at Air Ministry and Uxbridge continued to act as control.

Confidential Communication Orders continued to be published yearly laying down the W/T organisation to be employed at home and abroad, and in 1924 the R.A.F. Signals Manual was produced for the first time. This Manual laid down the functions of R.A.F. Signals, the chain of responsibility, and the general organisation of wireless communications.[1] The Signals Branch formed part of the Directorate of Organisation and Special Duties in the Department of the Chief of Air Staff. The Head of the Signals Branch was responsible to the Director of Organisation and Special Duties for the organisation and efficient working of all R.A.F. Signals communications. Commands, groups, wings and squadrons each had an appointed signals officer whose duty it was to organise their unit or formation signals as laid down in the manual. The Head of Signals was also responsible, under the Director of Organisation and Special Duties, for the general policy with regard to the design and production of all signals equipment.

The principal wireless equipment in use in 1926 on the ground was the T.19 and the T.28 long range transmitters, used for point-to-point and ground to air communications, and the receiver R.27.[2] In the following year it was decided that the Service should have a guide to wireless apparatus in use, and a C.C.O. entitled 'Wireless Apparatus in the Royal Air Force' was published in February 1927. The main transmitters for ground use remained the T.19B and the T.28; also in use was the T.30 high power transmitter. The receivers listed were the R.27, for point-to-point and aircraft communication at fixed and mobile stations; and the R.45, a W/T battery receiver. Several new types of equipment were under investigation.[3] Meanwhile, short-wave communication was developing rapidly: a detailed account of this development is given in Chapter 5.

C.C.O. No. 1 for 1931 listed detailed W/T organisations for commands and areas both at home and overseas. Stations in Air Defence Command were organised into five point-to-point sections, each controlled by Uxbridge, with a sub-control station for each section. Ten stations were listed in the Coastal Area organisation. The main W/T organisation for Inland Area was split into two separate frequencies, each comprising some five permanent and a number of temporary stations, both controlled from the Inland Area Headquarters at Stanmore. The transmitter in use in the home organisation was the T.19B. There were two separate organisations in the Middle East,

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1 A.M. File 493038/24.
2 A.M. File S.23564.
3 A.M. File S.25783.

one for normal use in peacetime and the other for use in emergency periods when local disturbances might be expected to interrupt landline and other methods of communication. The W/T point-to-point organisation in Iraq Command was split into two sections, north and south. At Malta, transmitters were centralised at Kalafrana and remote control lines connected them to the R.A.F. Headquarters at Valetta or to the airfield at Halfar, as appropriate. The T.19B was in use for W/T and the T.35 for R/T. The organisation for R.A.F. W/T stations in India was split into two sections, summer and winter. The organisation comprised ten stations. Other stations operating overseas, mostly with the T.19, were Hong Kong, Singapore, and Aden.

New ground equipment came into use in 1933, including the T.70 medium power W/T and R/T transmitter on intermediate frequencies, and the R.64 general purpose ground receiver. In 1934 a new long-range transmitter, the T.77, was produced as a replacement for the T.19. By 1939, both the T.70 and T.77 were in general use, and also a new transmitter/receiver combination for general purpose medium-range work, the T.1087/R.1084, had been developed and was being brought into general use.

A conference was held at the Air Ministry on 7 October 1936 to discuss W/T reorganisation for ultimate inclusion in CCO.1/1937. The conference was attended by signals officers from the Air Ministry, Bomber, Fighter, Coastal and Training Commands, and the R.A.E. The main topic discussed at the conference was the question of the allocation of frequencies. It had been apparent for some years that the use of the medium frequency range for R.A.F. purposes would eventually become impracticable owing to the higher power and the increasing number of broadcasting stations, and also to the expansion of civil aviation. More recently, the great increase in the number of aircraft frequencies required under the expansion schemes had made a change over to working on the higher frequencies a matter of urgency. This need had stimulated the development of new air and ground wireless equipment suitable for high frequency working, such as the T.1087/R.1084 ground equipment and the T.1083/R.1082 for aircraft. Issue of this new apparatus to squadrons and stations was being effected in accordance with a planned programme, and all units were completed to scale by 1937. As far as possible, point-to-point communication was kept out of the aircraft bands. Provisional allocations of frequencies were made for the various commands. The scale in Bomber Command was one frequency to each heavy and medium bomber station. Thirty frequencies were required for operational purposes in Fighter Command and sixteen in Coastal Command.

By this time, point-to-point communication by wireless had been relegated to a standby role, landline communications being substituted between stations in the United Kingdom. Nevertheless, the expansion of the various commands resulted in frequency congestions, and most of the bands allocated had to be extended. This congestion, coupled with the inadequate performance of H.F. R/T, eventually drove much R/T traffic into the very high frequency bands; development of suitable equipment was in progress, but its introduction was some way ahead, and in any case the congestion in the H.F. band remained.

The question of international frequency distribution presented an extremely complex problem. The major difficulty was that broadcasting had developed before air forces and civil aviation and had obtained a position from which it was now practically impossible to dislodge it. The need for international control was realised, and an international conference had been held at Madrid in 1932 at which a list of General Radio Communications Regulations was issued. The next international conference was due to take place in Cairo in 1938, and this conference was looked forward to with some apprehension. The right of exclusiveness for the aircraft bands had been recognized at Madrid, and the intention was to maintain and considerably extend them. This exclusiveness was of particular importance since radio aeronautical services were essential safety services, indispensable to all forms of aviation and air navigation. It was not considered that they could be compared with parallel services for ships, which could remain afloat although temporarily deprived of radio communication. The principle of exclusiveness was therefore stressed; without it, it would be impossible to arrive at agreements so that the same wavelengths could be reserved in different regions for aircraft purposes.

As a result of the Cairo Conference, certain small additional frequency bands were made available for Service purposes, and a conference was held at the Air Ministry on 28 July 1938 to decide the best means of re-allocating the frequencies available to provide some 400 channels at 10 to 20 Kc/s. separation, the requirement under the latest expansion scheme. The magnitude of the problem of fitting all these channels into the available frequency bands, and of finding additional frequencies for further expansion, called for constant supervision and for liaison between all the commands.[1]

In Bomber Command, stations were divided into six sections, each section having a control station which operated a regional area guard D/F and R/T frequency, and each station having two squadron frequencies and a station D/F frequency. These frequencies ranged between 3,000 and 4,500 Kc/s. In Coastal Command, each station had one or more squadron operational waves, depending upon the number of squadrons accommodated, and each station ultimately had H.F. D/F. In addition, there were group reconnaissance waves, training waves, and waves for marine craft and for inter-communication between Services. Fighter Command had four R/T channels per sector with a 20 Kc/s. separation.

Signals policy continued to undergo changes to meet the increasing demands for aircraft and ground communication. The shortage of useful frequencies and the greatly increased number and performance of aircraft were the main problems. The rapidly increasing demands for W/T channels

[1] A.M. File S.42947.

made it essential to adopt spot frequency working wherever possible, and to this end crystal control was applied as a modification to the fighter R/T set, the T.R.9. In ground station technique, the frequency flexibility offered by general purpose aerials had to be abandoned in favour of the high performance and stability given on selected frequencies by specially designed aerial systems. The policy for new ground point-to-point stations became:—

(a) Array type aerials for operational frequencies.

(b) The siting of transmitting stations remote from airfields to avoid obstruction to flying by W/T masts and interference from electrical apparatus at stations.

(c) The remote siting of receiving aerials and their connection by H.F. cables to the receiving station on the airfields.

Landline provision was well advanced by mid-1938. All bomber stations were connected to their groups by at least two lines capable of carrying both teleprinter and speech. Groups had at least one line direct to command and two lines to Central. In Fighter Command at least three lines were provided between sectors and groups and three between groups and command and also to Central. Coastal Command landlines were on a similar scale to Bomber Command. Thus all the operational commands already had a workable landline system a year before the outbreak of war.

Overseas, teleprinters had been delivered to Malta, Egypt and Singapore. In Singapore, where the cable system was underground, satisfactory working was effected. In Egypt, satisfactory working was established where circuits were underground, as was the case between Cairo and Alexandra; on overhead routes humidity and certain electrical problems caused serious difficulties. In Malta, an inter-Service cable scheme was under construction. The provision of underground W/T stations and operations rooms was proceeding at Malta, and a layout for underground combined battle headquarters at both Singapore and Hong Kong had been agreed by the three Services and the building work set in motion by the end of 1938.

On the personnel side, there was an acute shortage of mechanics due to the variety of equipment in use and the long period of training required. It was decided in 1938 to reintroduce the trade of electrician. Two permanent cypher officers were established at all command headquarters at home as a nucleus for a quick expansion when required; this had already been done at the main command headquarters overseas. Apparatus had already been installed at all headquarters of commands, both at home and overseas, for mechanical cyphering. A smaller cypher machine was developed for use in aircraft; preliminary trials were satisfactory and the machine was in use early in 1939.

Civil Aviation policy was largely influenced by the necessity of reaching a common European agreement on uniformity of equipment, organisation and procedure. To some extent, this limited the co-ordination of civil and R.A.F.

signals; but, in the main, civil aviation communication systems were so organised as to be readily adaptable to R.A.F. needs in case of emergency. The most up-to-date ground equipment covered both the civil and R.A.F. frequency bands, and, similarly, landline communications between civil airfields (which except in rare cases had replaced point-to-point W/T) was routed in such a way as to facilitate connection with the R.A.F. system should the need arise.

CHAPTER 2

PRE-WAR LANDLINE COMMUNICATIONS

Up to 1936, wireless telegraphy was the main system of communication between R.A.F. headquarters and units. Landlines were used in addition, and all R.A.F. stations had their own private branch exchange, joined to the local G.P.O. exchange; but for reasons of economy, flexibility, and practice for operators, wireless telegraphy carried the bulk of the traffic.

Soon after the end of the first world war, the measures needed to fulfil the R.A.F. requirements for telephone and telegraph communications were discussed informally between the Deputy Director of Communications at the Air Ministry and the corresponding department at the War Office (S.D.6).[1] It was agreed that it was most undesirable to have a multiplicity of authorities responsible for the provision of lines and exchanges, and that in the United Kingdom the G.P.O. should normally provide the circuits that the R.A.F. required, in the same way as they supplied the War Office requirements. At this time it was intended that responsibility should be assumed in war by the Army. With an expeditionary force, the responsibility for the provision of lines, manning of signals offices and the operation of telephone exchanges was to rest wholly with the Army Signal Service: the scale of provision would be discussed in detail by representatives of the two Services, and the Army Signal Service would then make the necessary arrangements to meet the requirement. Arrangements for wireless communication were also made at this meeting and these are fully discussed elsewhere. The proposals made were later confirmed and the agreement of the Chief of the Air Staff given.

Landline communications for the air and ground units comprising the Home Defence Force were an integral part of the Home Defence Scheme approved by the Government in 1923, and in 1924 a joint War Office and Air Ministry sub-committee of the Air Defence committee, known as the 'Romer' committee, made a number of recommendations on the general organisation of the Air Defence of Great Britain (A.D.G.B.). Amongst other aspects of the problem dealt with by this committee was the question of communications. The sub-committee recommended that the following would be required :—[2]

(a) A line telephone system connecting the A.O.C.-in-C. A.D.G.B. to all government departments and to Fighting Area Headquarters and also to Bombing formations.

(b) A line telephone system connecting A.O.C. Fighting Area to all headquarters and formations under his control during operations, and to defended areas on the coast.

[1] A.M. File 383830/22.
[2] A.M. File S.25122/I.

(c) Line telephonic communication between aircraft sectors, units, gun groups, searchlights, etc., and their respective headquarters.

(d) A line telephone system connecting observation posts to observation centres laterally, to Fighting Area headquarters and certain aircraft sectors, and also connecting certain coastguard stations to observation centres.

(e) A line telephone system for the W/T interception and D/F organisation.

(f) A W/T and R/T system to communicate to aircraft and to supplement (a), (b), (c), (d) and (e) was necessary.

Each Service was to be responsible for the provision and maintenance of those circuits required for its own use, the Army being at that time responsible in addition for the communications required by the Observer Corps organisation. This responsibility was transferred to the R.A.F. in 1928.

Formation of Air Defence Landline Telephones Committee

The task of working out a detailed scheme of landline communications in accordance with the general terms laid down by the 'Romer' committee was entrusted to the A.O.C.-in-C. A.D.G.B., who formed an Air Defence Landline Telephones Committee for this purpose, composed of representatives of his own staff, the staff of the G.O.C. Air Defence Formations of the Territorial Army, and the G.P.O. The original terms of reference of this committee were: to draw up a complete scheme of landline communications which would eventually be required for the air defence of Great Britain and to submit the scheme in due course for the consideration of the War Office and Air Ministry. The scheme thus submitted, having been agreed, was to be lodged with the G.P.O. Under an extension of the terms of reference dated 1926 the committee was to continue in being until such time as the full landline scheme was completed, meanwhile dealing year by year with the landline requirements for the ensuing training season.

The new committee presented its report to the Home Defence Committee, the report being known as Home Defence Committee Paper No. 90 (H.D.C. 90).[1] The report contained a full schedule of the communications which it was thought at that time would be required when the Home Defence force was fully formed.[2] The report was considered and approved by the Home Defence Committee, and the schedule remained the basis of all operational landline requirements for air defence. Nearly a third of the cost of the scheme was covered by normal telephone development. However, bearing in mind that Cabinet policy was based on the assumption that war would not occur for ten years, and by delaying outward development so that the expanding London telephone system would provide a number of the circuits

[1] A.M. File S.25122/II and S.41023.
[2] A.M. File S.41023.

required, further economies were expected. This had been the Air Ministry's object in pressing for the circulation of the report to the G.P.O. at the earliest possible moment.

By the end of 1928 it became apparent that the work of the committee was being carried out on too narrow a basis, and it was extended to an inter-departmental committee with War Office and Air Ministry representation, A.D.G.B. still providing the chairman and secretary. In January 1930 the terms of reference became, first, to review and keep up-to-date the scheme of landline communications required for the Air Defence of Great Britain (C.I.D. Paper H.D.C. 90); secondly, to examine any proposals, including those for alterations or additions to the air defence intelligence scheme, which might be referred to or originate in the committee, in order to report as to the effect of such proposals on the air defence landline scheme; and thirdly, to draw up and submit annually (if necessary), until such time as the air defence landline scheme was completed, proposals for the landline telephone communications required for the air defence training exercises for the following season, with an estimate of the cost involved.

Operational Landlines

There were no major changes or reviews of landline policy until 1935.[1] Arrangements were made each year for operations landlines to cover the annual exercises, but by 1934 it had become apparent that the lack of permanent landline communication facilities was seriously hampering progress in Fighting Area.[2] There were no permanent landlines between Fighting Area Headquarters at Uxbridge and the sector stations, and temporary arrangements had to be made each year. H.D.C. 90 had laid down that at least three circuits from Fighting Area Headquarters to each sector station were necessary for war purposes, but it was considered that two such circuits, one operations and one intelligence, would suffice in peacetime; application was therefore made for these circuits and Treasury sanction was given in February 1935. Two circuits each were completed between Uxbridge and Duxford, North Weald, Hornchurch, Biggin Hill, Kenley and Tangmere in time for the 1935 exercises.

Meanwhile, a series of trials was being carried out at Uxbridge with the object of determining what the total wartime telephone requirements of a Fighter Group operations room would be, and by May 1936 sufficient experience had been gained for a schedule of the lines required to be prepared by Headquarters A.D.G.B. The eighth meeting of the Air Defence Landline Telephones Committee was called, on 7 January 1937, at the instigation of the Air Defence Communications Committee, (the committee which dealt with policy matters, formed in 1936) primarily to deal with these requirements. Under the terms of reference of the committee, the requirements had

[1] A.M. File S.25122/II.
[2] A.M. File S.33020.

to be agreed by the Air Ministry and the War Office before being included in H.D.C. 90 and lodged with the G.P.O. The recommendations of the committee for No. 11 Group were :—[1]

(a) *Sector Operational Circuits.* The existing wartime scale of one circuit per sector was confirmed.

(b) *Sector Intelligence Circuits.* The committee raised the scale from one for each sector station to two. The Intelligence circuit had been used for both speech and teleprinter working, and experiments were being conducted to enable both methods to be used simultaneously on the one circuit; however, the G.P.O. were not in favour of introducing such a system as yet, and the committee therefore recommended that each sector station be allocated two Intelligence circuits, one for teleprinter working and one for spares. Extended trials of the use of both methods on one circuit simultaneously were however recommended.

(c) *Sector Plotter Circuits.* The existing wartime scale of one circuit per sector was confirmed.

(d) *Observer Centres.* There were Observer Centres at Maidstone, Horsham, Winchester, Watford, Bedford, Oxford, Cambridge, Colchester, and Norwich. One wartime circuit to each centre was agreed.

(e) *Defended Ports.* One circuit to each of the four defended ports in the Group—Portland, Dover, Harwich, and Portsmouth—was agreed.

(f) *Inner Artillery Zone and Gun groups.* Two circuits to War Headquarters, one circuit to the Headquarters A.A. Group at Chatham.

(g) *Fighter Command.* One operations, one intelligence and one plotter circuit, and three tellers' circuits.

(h) *Laterals to other Groups.* One operations and one intelligence circuit to No. 12 Group.

(k) *Electric Clock.* One time impulse circuit from the G.P.O. Exchange.

(l) *Trunk Tests.* One circuit to the Inspector, Trunk Tests, G.P.O.

(m) *R.D.F. Circuits.* The committee allotted a total of 60 circuits to R.D.F. stations, on the basis of three to each of 20 such stations, as directed by the Air Defence Communications Committee.

(n) *Uxbridge Station P.B.X.* Four circuits to the Uxbridge Station P.B.X. as an outlet from the group operations room to the headquarters' offices and the G.P.O.

(o) *Development.* The provision for development comprised a total of ten circuits for Balloon Barrage units, on the basis of one per squadron, 30 circuits for Inland R.D.F., and two circuits for alternative Observer Centres.

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[1] A.M. File S.25122/III.

(p) *Reserve Circuits.* One for each sector station, one for each observer centre, and one to each of H.Q. Fighter Command, Inner Artillery Zone, and H.Q. No. 20 A.A. Group, Chatham. The Reserve Circuits to H.Q. Fighter Command and the sector stations to be set up so that they could be used for either speech or teleprinter working.

Several other points were considered by this committee, among them the question of outlets from group operations rooms. The Air Defence Communications Committee had recommended that there should be at least two outlets, each cable to be connected to a different G.P.O. exchange for security reasons. In the case of No. 11 Group, however, three such outlets had been recommended, one to Uxbridge exchange, one to Ruislip, and a third possibly to Southall. The difficulty was that other exchanges in the vicinity had limited trunk facilities and the full requirements of the Headquarters could not be met. The G.P.O. were asked to investigate the details of routeing circuits out to the G.P.O. network, bearing in mind the principle that three separate routes should be used. Spare circuits, searchlight circuits, and sector requirements were discussed in brief. The Army was made responsible for searchlight circuits between visual plotter stations and the local G.P.O. exchange, and the R.A.F. for arrangements between the exchange and the sector operations room. The rewriting of H.D.C. 90 was recommended.[1]

Meeting the Requirements of No. 11 Group

To meet the stated requirement, and to allow for a margin of spares, bringing the total up to about 250 circuits, as well as to ensure the desired additional measure of security by dividing the circuits between Uxbridge and two other exchanges, two new measures were carried out by the G.P.O. A new 54-pair cable was provided between Headquarters No. 11 Group and Ruislip Exchange (the maximum that could be provided by this route), and an existing London-Uxbridge trunk cable was diverted and looped into Headquarters No. 11 Group, being brought in and out by different routes so that in the event of damage to one leg the other would remain. Although the cost of the diversion was paid by the Air Ministry, no additional rental was charged for the diverted cable as wires in the cable were not actually set aside for air defence circuits; the diversion simply allowed public circuits to be made readily available as and when required. With the 100 pairs existing to the Uxbridge Exchange, the 54 pairs to Ruislip Exchange, and the further 100 pairs either to London or Uxbridge in the diverted cable, a total of 254 pairs was available. The Ruislip cable was connected in July 1938.[2]

[1] A.M. File S.25122/III.
[2] A.M. File S.25122/III.

Other Fighter Command Requirements

With the reorganisation of the Royal Air Force in 1936 and the establishment of Fighter Command Headquarters at Stanmore, consideration was given to the requirement for operations and administrative circuits. It was agreed that a 50-pair cable to the Bushey Heath exchange for existing and future administrative requirements and operations needs was enough for the time being. Further additions to the number of operations circuits were provided by means of a cable to Stanmore exchange, thus providing a dual outlet. By February 1937 installation had reached a stage at which it was possible to carry out dummy runs on an experimental scale, and as a result of early practices, additional equipment was installed. In May 1938, with the inception of the Filter Centre and other new commitments, it became clear that the existing number of cables was too small and that their concentration on one road rendered them too vulnerable, and a 54-pair cable providing an outlet by an alternative route was laid to Stanmore Exchange. Also, in consequence of a decision that all R.D.F. stations should be connected direct to Stanmore and the information distributed to groups from there, the provision of a new 100-pair cable was necessary.

With the expansion of Fighter Command and the formation of No. 12 Group, authority was sought in July 1937 to extend the system of lines existing in No. 11 Group—two lines from each fighter sector station to the group headquarters, to enable operations and intelligence messages to be sent simultaneously to the new group, which was located at Hucknall. The first four stations in the new group were located at Wittering, Digby, Church Fenton, and Catterick. The outlets from Hucknall to the G.P.O. system were limited, and in order to provide for permanent and emergency circuits a 54-pair cable was installed between the Headquarters of No. 12 Group and the G.P.O. exchange at Hucknall; it was also necessary to loop in an existing Hucknall-Mansfield cable. A similar teleprinter scheme was wanted as that already approved for Headquarters No. 11 Group. And in addition to the requirements at No. 12 Group, similar provision was wanted at a third fighter group about to be formed—No. 13.

Operational Lines in Bomber and Coastal Commands

In the case of Bomber Command, the operations requirement was met by the provision of one permanent line with both telephone and teleprinter facilities between Bomber groups and their respective stations, with the proviso that in war it would be necessary to have a second and possibly a third line, for which purpose arrangements were made to earmark lines used in peace for the public service. The requirement of only one line between Bomber groups and stations in peacetime as compared with two lines between Fighter groups and stations was due to the difference in operational function: the whole technique of the control of fighter forces in home defence demanded the provision of two lines, and one of the most important requirements was that fighter squadrons should be ready for war at short notice.

Pending the final layout of Bomber Command and its groups and stations it was not possible to give precise details of the eventual requirement, but a schedule compiled in August 1937 listed six Bomber groups and nearly fifty stations. In Coastal Command, the final location of groups and units was even more unsettled,[1] and the requirement was somewhat nebulous, but the same schedule listed three groups and twelve stations with one operations line to each station.

The layout and scale of operations and administrative lines for Bomber Command groups was further discussed in mid-1937.[2] The Headquarters of No. 3 Group at Mildenhall was taken as the standard, and a detailed plan prepared. The system of communications suggested was thought to be the minimum essential for the conduct of bombing operations and the necessary liaison with Fighter Command, and a similar layout was proposed for all groups in the Command. The system included, in war, two telephone lines, two teleprinter lines, and one telephone D/F line from groups to stations; some of these lines were provided in peace under the permanent landline scheme. Groups were connected to their nearest long-range D/F control station, and stations to their associated short-range D/F control station. Operations and administrative lines were provided between Command and groups, both permanent and wartime, and groups were connected one to another. Direct channels were available from Command to the Air Ministry and to Fighter Command, also to each long-range D/F station.

No. 4 (Bomber) Group was accommodated at Linton-on-Ouse and No. 5 (Bomber) Group at Grantham, and arrangements for landlines were made accordingly, to the requirements already laid down at No. 3 Group.[3] A special cable was needed from York to Linton for No. 4 Group in order to provide the necessary outlet; the estimated maximum number of circuits required, including exchange lines and teleprinter and operational circuits, was 49. In addition a cable was provided between the Group headquarters and the station headquarters on the airfield. A similar number of circuits was required for No. 5 Group, plus a cable between the Group headquarters and the R.A.F. station at Grantham.

Administrative Landlines

For many years wireless telegraphy had been the main system of general communications between R.A.F. headquarters and units; but by 1936 it had become apparent that a system based on point-to-point wireless was ill-suited to the needs of expansion and lacked the elements of security essential in time of war.[4] Nevertheless the W/T operator training it provided was a great asset which proved invaluable in the expansion later on.

[1] A.M. File S.37801/I.
[2] A.M. File S.41032/I.
[3] A.M. File S.41032/I.
[4] A.M. File S.37801/I.

Increasing difficulty was experienced in providing frequencies for both ground and aircraft communications, and since all ground-air and air-ground communications had of necessity to be via wireless telegraphy or radio telephony, the only type of communications susceptible to a fundamental change were the point-to-point. And on the security side, the Italo-Abyssinian dispute had proved that it was possible in a very short time to piece together a comprehensive picture of any air organisation (in this case the Italian) which relied for its communications on wireless; whereas with the German air force, which relied on a system of landline teleprinter communications throughout, it had been impossible to achieve this success. On the other hand, for all practical purposes private wire teleprinter circuits were immune from unauthorised interception. Teleprinter circuits were routed almost exclusively in underground cable, and liability of contact with other circuits was small. Such contact if it did occur was likely to be quickly evident through faulty teleprinter reception.

A proposal to provide an alternative to wireless as a means of communication within the United Kingdom and Northern Ireland for general R.A.F. Administrative, Civil Aviation, and Meteorological purposes, other than communications to aircraft in flight, was therefore prepared. In deciding to use landlines, the R.A.F. was falling into line with established policy in the Navy and Army, and it was significant that, in spite of the distances involved, Russia and Germany favoured the use of landlines for military purposes. The advantages of landlines over wireless were:—

(a) *Relief from Congestion.* Wireless congestion had made it impossible to continue to find sufficient channels, and with the expansion planned for the future the situation would become progressively worse.

(b) *Security.* Landline communications offered almost complete security, whereas there was a serious lack of secrecy in W/T communication unless a high grade of cypher was used, which in turn caused delay. Considerations of security applied equally to the meteorological service, since the dissemination of information by wireless would furnish a hostile power with a complete weather map of the British Isles and with detailed forecasts.

(c) *Speed.* Greater speed was required. With the existing point-to-point system there was liable to be considerable delay in times of pressure.

(d) *Expansion in Emergency.* The point-to-point system had to be capable of rapid expansion in emergency. This was not practicable with wireless, but under a landline system arrangements could be made for spare channels to be reserved for use when required, although additional teleprinters and operators would still be required.

(e) *Economy in Personnel.* The use of teleprinters would help to overcome deficiencies in skilled wireless personnel. It took much less time to train a teleprinter operator. The new scheme involved the establishment of a Central exchange (which was eventually located at Leighton Buzzard).

Two or more administrative circuits were provided from Central to each command and group headquarters and a number of circuits to the Air Ministry. For each group headquarters, one or more administrative circuit was provided via Central to each station under its control. Each main meteorological station was connected by direct teleprinter circuit to Central and thence to meteorological headquarters at the Air Ministry and elsewhere. The meteorological system had to function quite separately from the other landline systems since incoming and outgoing messages occupied the channels permanently. The new system of administrative lines was entirely independent of the existing intelligence and operations circuits provided in peace or earmarked for war by the G.P.O. for air defence purposes. Separate landline systems were provided for R.D.F., D/F and other services.

Progress with the Administrative Landline Scheme

Obviously such a comprehensive scheme could only be introduced piecemeal, and it was decided to put a portion of the system to the test as soon as possible. Pending the establishment of the new Central exchange at Leighton Buzzard, the existing Air Ministry exchange acted as Central for the initial stage. The Chief of the Air Staff agreed on 1 July 1936 to a try-out of the initial stage. The G.P.O. fully recognised the importance of the scheme, and it was arranged that lines and teleprinters should be provided and maintained by the G.P.O. and that operating should be performed by the R.A.F. except for the switchboard at Central and possibly the teleprinters there. The teleprinters were operated in the first instance by wireless operators drawn from the stations included in the experimental scheme, and arrangements were made for training these men in teleprinter operation. Full instructions for the scheme were issued to Commands in January 1937. Ordinary private 4-wire or 2-wire lines, known as Tariff 'D' lines, were used, repeatered where necessary, with transmission equivalents such as to make telephone conversation practicable between stations in one group and stations in another group via Central and the two group headquarters. Voice-frequency signalling was used on most circuits.

Report on the Initial Phase

The new scheme was prepared in two phases, and late in January 1937 the initial phase, Phase 1, embracing the whole of No. 11 Group, the Air Ministry, Abingdon, Market Drayton, Grantham, Mildenhall, Andover, and certain other satellite stations, was put into operation, and a system introduced by which thirty men at a time were trained at the Central Telegraph Office by the G.P.O. over periods of six weeks. Owing to the necessity for speed in putting the system into operation, and lack of the latest apparatus, the G.P.O. were compelled to fit an out-of-date type of switchboard for the temporarily located Central exchange, and this, combined with a number of unexpected troubles, mostly due to line reflections, caused considerable difficulties in the early stages of the scheme. After the first six weeks, however, these troubles were mostly eradicated, mainly because of the great interest taken in the progress of the scheme by the G.P.O. Throughout the ensuing two months other minor troubles appeared, but these were mostly teething troubles and were quickly cured. One thing soon became apparent: if signals traffic was to be rapidly handled it was essential to segregate certain lines solely for teleprinter working; and arrangements were made to terminate these lines on small switchboards in the signals offices rather than on the main private branch exchanges.

On 11 March 1937 a conference was held at the Air Ministry which was attended by the Chief Signals Officers (C.S.O.s) of all commands at home, representatives of the R.A.E., and of the G.P.O. departments concerned. This conference discussed in detail the lessons learnt and the working of the system up to that time and was unanimous in concluding that the initial trial period showed that, with small modifications, the major scheme was workable and was in fact the best available to meet R.A.F. requirements. The segregation of certain lines for teleprinter working was agreed, and a new schedule of lines for the major scheme was prepared. The importance of retaining a wireless organisation as a stand-by and the need for retaining wireless operators at all points in sufficient numbers was confirmed. In order to keep operators in practice, similar procedure to that employed for wireless telegraphy was used for teleprinter working.

The new schedule showed a substantial increase on the estimates made in the previous year. The reorganisation within the R.A.F. under which commands dealt direct with stations on many matters of administration involved a considerable increase in telephonic communications. To provide lines direct from commands to stations was clearly uneconomic, but the increase in traffic necessitated the reinforcement of lines between commands and groups (from where the lines radiated to the stations). Again, since the original schedules and estimates on which the initial scheme had been based, a considerable increase in the number of stations to be fed had occurred as a result of expansion schemes. A new decision was that, while teleprinter lines were to be connected via the Central exchange, telephone lines were to be connected direct from groups to commands. The whole scheme for administrative and meteorological landlines involved a total of over 300 lines and teleprinters, and this was exclusive of other R.A.F. landline requirements—operations and intelligence lines for Fighter, Bomber and Coastal Commands (for which Treasury sanction had already been given), lines to W/T direction-finding stations, lines to R.D.F. stations, and remote control lines.

While the details of the new scheme were being decided and the results of the early experimental period awaited, it was found impossible in some cases to deal with the great increases in telephone traffic resulting from current expansion; the private wires approved for the experimental period were insufficient. Sanction was therefore obtained for the installation on a temporary basis of a limited number of additional lines, provided they were required both immediately to relieve congestion and ultimately as part of the full scheme if and when approved.[1] Treasury approval for the scheme to proceed was given on 24 November 1937. Approval was also given for the construction of a Central exchange outside London. Installation of lines proceeded on a priorities basis. It was apparent that for some time the R.A.F. would still have to be content to use the ordinary trunk telephone system, with the difference that in many cases the G.P.O. connected principal R.A.F. centres to the nearest G.P.O. trunk centre, thus giving as near an 'on demand' service as possible. Regarding direct lines for teleprinter signalling, the G.P.O. were unable to give the full service at once, but they had gone some way towards it by the end of 1937, and were well advanced a year later. In war, the G.P.O. could arrange at once for trunk and local lines in public service to be fitted with the necessary switching apparatus to enable them to be handed over.

The programme for installing and providing the lines for the R.A.F., Meteorological and Civil Aviation system was, first, up to 1 April 1938, to provide the genesis of the Meteor scheme to link up the main Meteor centres and as many stations as line provision allowed, and to link the R.A.F. groups and centres not in the initial scheme and all stations for which lines could be made available: second, to complete about two-thirds of the scheme by the end of the financial year 1938-1939: and third, to complete the rest of the scheme as soon as possible thereafter.

The other principal landline requirements of the R.A.F. at home, the operations and intelligence lines, lines for the R.D.F. system, lines for the direction-finding system, and lines for the remote control of transmitters, were kept separate for administrative reasons, but together they comprised one single landline system for air defence, and they were so arranged and routed that, if one or more parts failed through enemy action or other cause, the remaining lines could be used for the more important services pending repair of the damaged lines.

Meteorological Service

It was realised at an early stage that it would be of great value if the meteor system and the R.A.F. landline system operated over the same routes (though not actually over the same wires), as this would allow the two systems, although operating independently, to form a stand-by to each other; and any further stand-by, such as a spare landline or wireless telegraphy system, would be a stand-by for both systems. The layout for the meteorological system was therefore prepared on these lines.

[1] A.M. File 617539/37.

R.A.F. and Civil airfields in each area were connected to a central meteorological station in the area. These central stations were located at Air Ministry, Turnhouse, Linton-on-Ouse, Grantham, Wyton, Mildenhall, Abingdon, South Farnborough, Hullavington, Lee-on-Solent, Market Drayton, and Eastchurch.[1] (Widely scattered stations, such as Mount Batten, Pembroke Dock, and Aldergrove, reported by separate line direct to the Air Ministry, as did Civil airfields in the London Area. It was also necessary to establish a number of reporting points in areas not covered by the existing system.) From each of these centres a line ran direct to the Meteorological Office in London. Each station or group headquarters at each centre and the termination of the line in London was equipped with a teleprinter. At the point of junction of the lines at each centre apparatus was fitted which omnibused all lines connected to it, so that any message sent on any teleprinter in the area or at the centre, or at the termination of the line in London, was automatically reproduced at all points simultaneously. Thus information sent from any station in any area was recorded in London, where a separate teleprinter was allotted at the termination of the line from each area. Each of these teleprinters was equipped with a reperforating apparatus which, in addition to producing a plain language record, produced a perforated tape enabling the reports received to be re-broadcast at high speed at will.[2]

Air Ministry Landline Committee

The Air Defence Landline and Telephones Committee remained in being until 1937, when it was reconstituted on an Air Ministry basis, with strong Fighter and Bomber Command representation, under the title of the Air Ministry Landline Committee.[3] A new composition and new terms of reference were agreed upon, and the scope of the new committee was extended to include the whole network of landline schemes. The old committee had been under the chairmanship of the Senior Air Staff Officer (S.A.S.O.) A.D.G.B., and, when this formation ceased to exist, the S.A.S.O. Fighter Command. The chairmanship now passed to the Director of Signals, Air Ministry, and the other R.A.F. members were the representative of the Deputy Chief of the Air Staff (F.O.1), the Senior Air Staff Officers of the three operational commands (Fighter, Bomber, Coastal) or their representatives; a representative of the Finance Division; and a representative of Signals 1(a), the branch of Air Ministry Signals that dealt with landlines. Also serving on the new committee were representatives of the Admiralty, the War Office, the A.A. Divisions of the Territorial Army, the G.P.O., and the Home Office (A.R.P.). The terms of reference of the committee were :—[4]

(a) To draw up a complete scheme for the landline communications which would eventually be required for all purposes connected with

[1] A.M. File S.37801/I.
[2] A.M. File S.37801/I.
[3] A.M. File S.41023.
[4] H.D.C. Minute No. 34 dated 5 August 1937.

the air defence of Great Britain, and to determine the extent to which such landline communications should be provided both in peace and war.

(b) To lodge, periodically, with the G.P.O., the schedule of lines as agreed.

(c) To continue in being until such time as the scheme was completed and thereafter to deal year by year with the landline requirements for the ensuing training season and other questions affecting the provision of landlines.

(d) To appoint such sub-committees as were necessary to deal with specific problems.

The principal and most urgent task of the new committee was thus the formulation and consolidation of new and comprehensive schemes of landline communications in replacement of the obsolete scheme contained in H.D.C. 90. To implement the decision of this committee, a small section was formed in the Directorate of Signals to centralise and co-ordinate the entire provision of landlines, and in this new section an officer was appointed to visit commands and discuss their requirements. It remained the responsibility of commands to estimate and notify their requirements.

Defence Teleprinter Network (D.T.N.)

The scheme of defence communications for the R.A.F., finally approved in November 1937, had provided for a network of telephone circuits linking various headquarters, commands, groups and stations, and included provision for alternative teleprinter working in the majority of cases. The original scheme as modified was expected to take about three years to complete. By early 1938, certain preliminary phases, giving direct communication between headquarters of commands, groups and stations, with lateral lines to other defence establishments, had already been completed. But it soon became apparent that the use of a line for purely teleprinter traffic was uneconomic; and with the mass of requirements accruing from all departments of state, it was becoming clear that in spite of all the G.P.O. could do there would never be enough lines to go round.[1] In the past, when the Services had been smaller and their demands on the G.P.O. light, it had always been possible to meet emergency requirements at short notice, and the danger of this was that departments were apt to be lulled into a false sense of security. However, the seriousness of the situation was realised at the Air Ministry, who, as the largest users of landlines amongst all the Services, felt a sense of responsibility for leadership in landline matters. In view of the very large number of circuits required for teleprinter communication in peace and war, and the grave shortage of lines, what was needed was a system of channelling lines which was capable of greatly increasing signals facilities without undue increase in lines. A scheme of multi-channel line equipment had in fact already been evolved by the Directorate of

[1] A.M. File S.37801/II.

Signals and was in use on the intelligence and meteorological lines already supplied, having then been thoroughly tested by the G.P.O. The scheme was examined and approved by the Air Ministry Landline Committee, and it was generally felt that the adoption of a multi-channel system, besides effecting a considerable economy and saving in line plant, would also greatly assist in solving many of the problems of line telecommunications. A meeting of the Defence Services Line Telecommunications Board was therefore called to consider the matter.[1] The Admiralty, who were at this time considering the construction of a new Naval exchange, were anxious that this construction should be carried out in association with the Air Ministry scheme, which also had the support of other departments of state, including the War Office, Home Office and Foreign Office, who all wished to rent circuits. It would allow for the building up of a network such that no link would be vital, alternative routeing being possible in case of failure to any particular circuit. The Board met on 11 May 1938 and referred the question of the proposed multi-channel voice-frequency teleprinter scheme (to be known as the Defence Teleprinter Network) to a sub-committee for consideration in detail and the formulation of definite proposals for submission to the Treasury.

The teleprinter voice-frequency system consisted of a teleprinter which produced double current on the five-unit signalling system. This was then passed into a valve converter which sent signals to a line at a frequency of approximately 1,600 cycles per second. The system did not interfere with speech circuits in the same cable. The complete installation consisted of a table about 2 ft. 6 in. square, on the underside of which were mounted switch gear and rectifiers for supplying line current when the supply was A.C., or smoothers and dropping resistances when the supply was D.C. On top of the table was mounted the teleprinter itself, with its various plug connections. By the end of May 1938 the scheme had been fully agreed, a plan was drawn up by the sub-committee, and apparatus was installed as quickly as possible.

Originally there were three main centres under Phase I of the D.T.N. programme—Uxbridge, Stanmore, and Lee-on-Solent.[2] However, when it was decided to move Headquarters Coastal Command from Lee-on-Solent to the London area, it was arranged for Headquarters Coastal Command to work off Stanmore and Uxbridge until the new headquarters location was chosen. The equipment and fitting out of a central exchange was to be the first task in Phase II, but until this exchange was ready, a means of marrying up the existing landline system and Phase I of the D.T.N. was found by taking a number of V.F. circuits into the Air Ministry wireless station at Adastral House to make a change-over point for signals traffic.

[1] A.M. File S.37801/II.

[2] *See* G.P.O. Diagram of Phase I of the D.T.N. at Appendix No. 1. A number of alterations and adjustments were made to this plan but this in substance was the work completed in the first year.

To a minor degree Uxbridge and Stanmore acted in the same capacity. The existing meteorological landline system was absorbed into Phase I wherever possible.[1]

The schedule for Phase II was produced by the Air Ministry in December 1938. It contained a large number of new installations, at Central, Stanmore, Uxbridge, Hucknall, Newcastle, and six other new stations of the group headquarters type plus seven new stations of the sector headquarters type plus nearly fifty other new stations plus a number of extensions to existing installations.[2] Phase II was taken to include all equipment which was planned for installation by March 1940. As installations progressed the scheme had to be modified in many ways.

It was now even more essential, in order to provide the links for the other Services, together with administrative and maintenance facilities, that the building of the new central exchange be proceeded with at once, and an urgent request to this end was sent to the Director of Works. The laying of the G.P.O. cables to the site at Leighton Buzzard was well advanced, and the apparatus to go into the exchange was ready early in 1939. The original D.T.N. scheme was to take roughly the same time to complete—three years—as the original Air Ministry administrative landline scheme as modified, but it gave very considerable economies in line plant. Separate telephone communication was necessary in most cases in addition, but altogether the new scheme, in addition to providing all the facilities originally required by the Air Ministry for permanent landlines, also effected economies in the wartime requirements for telephone and teleprinter communications of all the departments concerned.

Lessons of the Munich Crisis

The load placed on R.A.F. communications during the emergency of September 1938 proved to be more than they could carry and led to serious delays: it was therefore considered imperative that arrangements be made so that an effective 24-hour service could be maintained from the outset of any emergency.[3] Peace establishments of signals personnel, however, did not permit the operation of such a service, and all possible remedial measures were closely examined, the Director of Signals being asked to submit full proposals for the effective maintenance of a 24-hour service from the outset of an emergency. The existing situation was that units were organised on a one-and-a-half watch system, a full 8-hour watch being followed by a 4-hour watch, by which time all signals traffic for the day was generally cleared. Most communications were now carried by landline, but it was still regarded as absolutely essential for operational units to have a wireless organisation as a stand-by in case of landline failure. This

[1] A.M. File CS.1468/I and II.
[2] A.M. File CS.1456/I.
[3] A.M. File 861448/38.

stand-by organisation could not carry anything like the volume of traffic for which the line system was designed, but it guarded against complete isolation.

The personnel to keep the stand-by organisation in existence, to exercise it occasionally and to man it in the case of cable breakdowns, had of course to be wireless tradesmen; and since the number required for this organisation coincided with the number necessary to man the 1½-watch teleprinter system (which operated on the basis of one man to two teleprinters), the trades were combined and most wireless operators were also capable of teleprinter operating as well.

To extend the existing system to one capable of expansion to a 24-hour watch for exercises and crisis periods it was necessary to augment the wireless/teleprinter trained personnel, but the additional staff did not have to be wireless-trained. The Director of Signals therefore proposed that personnel for the operation of teleprinters be provided on the basis of two operators to three teleprinters instead of one to two; and that the overall requirement for three watches to be manned should be met by the recruiting of some 900 personnel in a new trade of teleprinter operator.[1] Of these 900 it was intended that 650 should be servicemen in a new R.A.F. Group IV trade and the balance civilians; the new trade to be regarded as a training trade for wireless operators. The particular value of this proposal was that it limited the requirement of fully-trained wireless operators to those necessary to act as a stand-by in the event of landline failure. The balance of personnel for purely teleprinter duties were recruited from personnel of the clerk type and their training was very much shorter; indeed they were mostly trained 'on the job'.

In the course of 1939 the manning situation improved but there was still a huge deficiency of teleprinter operators in August 1939, and the Director of Signals was apprehensive that in an emergency the whole operational efficiency of the Service might be impaired through lack of proper communications.[2]

A second important factor to be faced was that the G.P.O. had stated that they could not provide in 24 hours all the additional circuits that the Services and other Government departments required to be set up at the outbreak of an emergency.[3] During the 1938 crisis they had coped fairly well, but this had been largely due to the fact that departments had asked for their listed emergency circuits at intervals one after the other. Such a contingency was not likely to be repeated, and the situation had to be faced that under a sudden threat or actuality of war, the G.P.O. would be expected to set up all the emergency circuits required by the many different authorities simultaneously. With the very high proportion of emergency to per-

[1] A.M. File 861448/38.
[2] A.M. File 861448/38.
[3] A.M. File S.37801/II.

manent circuits, this was manifestly impossible. The G.P.O. therefore requested that the R.A.F. should have a higher proportion of their war circuits set up in peace for everyday use, the remaining switched and emergency circuits to be set up in war to be separated into three categories: first, those to be set up in the first two hours; secondly, those to be set up in 24 hours; and thirdly, those to be set up in 72 hours. For technical reasons the two-hour circuits had to be limited to comparatively short lines such as Observer Corps, gun and sector lines. The 24-hour circuits would be a proportion of the longer lines required by Coastal and Bomber Commands, and the 72-hour circuits would constitute the remaining lines.

The G.P.O.'s proposals were considered and agreed at the fourth meeting of the Air Ministry Landline Committee on 9 November 1938. In choosing the allocation of lines, the three operational commands had to be considered first. Fighter Command must be able to function immediately to full war scale in case of an attempt by the enemy at a knock-out blow. Coastal Command, with its immediate responsibilities for the safety of shipping and for reconnaissance of the movements of enemy ships of war, could not be denied its war communications in any period of strained relations preceding the proclamation of a precautionary period, when long sea/air patrols might be of vital importance. And Bomber Command must have full signals facilities to enable its striking power to be applied at great distances and over a wide area.

In deciding which line communications were to be increased in peacetime, two main factors were taken into account: first, which lines were the most difficult to provide quickly in emergency, and secondly, which were the most economical lines to have in peace. As it happened, the answer to both questions was the same—the lines connecting commands and groups. They were mostly long cross-country lines involving much setting-up and liable to upset due to the G.P.O. reconstruction programme, and the demand for calls on these lines had greatly increased with the expansion schemes and the increase in the number of stations and in the strength of units. Again, the periods for which such lines had to be hired for exercises was becoming so great that it was more economical to hire them permanently; and once hired permanently they could be used to carry administrative traffic now carried by trunks, and thus save the cost of these calls. In short, the provision of increased direct command to group lines was both an operational requirement and a financial economy.

A full statement of the additional landlines required, besides those already agreed and either provided or in the process of being provided, was made by the Air Ministry Landline (A.M.L.L.) Committee. The new requirements fell into five distinct categories. First, the requirements for operational lines in Coastal Command, which had been under consideration for some time, were listed; the layout of Coastal Command was now reasonably stable and the lines had actually been installed during exercises and the Munich crisis. Details were then set out of the new circuits required between the headquarters of commands and groups. The scale asked for in Bomber and Coastal Commands was on a peacetime basis of two to each group headquarters, but in Fighter Command the full war scale was provided, exercises in this command being more frequent and intensive and the need in emergency more instant. Additional lines were also required between the Air Ministry and the various command headquarters, especially the operational commands, the Munich crisis having proved the inadequacy of existing lines. (Some of these lines were ultimately transferred to the Central Exchange at Leighton Buzzard.) A further requirement arose under Expansion Scheme 'L', lines to the already agreed requirements being necessary to newly-formed groups and their stations, and to new stations in existing groups.[1] Schedules of switched emergency and permanent circuits were revised and re-issued with each phase of the R.A.F. mobilisation scheme.[2]

Maintenance Command

The requirements for the newly-formed Maintenance Command were now known, and the basis was that, for large main supply units, direct communication was provided with both command and group headquarters and the Air Ministry. Miscellaneous units were linked to the nearest R.A.F. telephone and telegraph centre. A large proportion of the Maintenance Command requirement was met by the new multi-channel teleprinter network.

Local End requirements had increased arising from expansion measures, and these too were detailed, including those for Coastal and Maintenance Commands. Observer Corps lines were also included. The provision of landlines for Observer Corps posts had been dealt with previously by the Treasury Inter-Service Committee. Hitherto the policy had been that the local termination at Observer Corps posts would be a line to the nearest G.P.O. exchange, but in many cases this proved impracticable owing to the very limited outlets from rural exchanges. Serious interference with public facilities had arisen, and it was now decided to make the connection to the nearest G.P.O. exchange capable of giving the facilities required.

Requirements for D/F Stations

Another landline requirement was for communications for the new chain of M.F. and H.F.D/F stations. M.F. stations operated in sections, with one station acting as section control, and landline communications between the stations within a group was essential for the passing of bearings to control, unless valuable time was to be taken up through passing such messages by W/T. Other circuits required for the M.F. stations were an extension from the nearest station P.B.X. and a direct telephone line from the receiving station to the associated transmitting station, together with remote control circuits. Lines were placed underground within 350-400 yards of the D/F station. Spares had to be provided in view of the impossibility of laying additional cables into D/F stations once they were completed. (All landline circuits had to be laid concurrently with power cables etc. to facilitate erec-

[1] Further new requirements were listed under Expansion Scheme 'M' in June 1939.
[2] A.M. File CS.1090.

tion and calibration of stations).[1] It had been anticipated that the new chain of H.F.D/F stations in Bomber Command would operate on the same principle, and approval for the two sets of landlines was given in January 1938, but subsequently a change of policy dispensed with the necessity for the interconnection of H.F. stations, landline communication being required to the bases served and to the appropriate group headquarters only. In Fighter Command, three H.F.D/F stations were provided per sector, one located in the vicinity of and the other two 30-40 miles forward of the sector station, to which all three were connected by landline. Further pending landline requirements, details of which were due for decision, were the forward R/T relay stations now decided on for Fighter Command, and lines for the Balloon Barrage stations.

Provisional Teleprinter Establishment

An establishment of teleprinters for peace and war was prepared and generally agreed, to come into effect gradually during the ensuing months. Details were confirmed at the A.M.L.L. Committee meeting of 9 November 1938, following the preparation of a schedule by Signals 3. For Bomber Command in peacetime, the Air Ministry had already catered for three teleprinters at each station, one for administrative traffic, one for operations and intelligence traffic, and one for the meteorological service, with one operations/intelligence teleprinter for each station at group headquarters, plus two for administration and one for the meteorological service. It was now decided to add, in peace and war, one extra administrative channel at group headquarters, and, in war only, an extra teleprinter at each station to make a separate intelligence channel, with a corresponding number of extra channels at group headquarters according to the number of stations in the group (normally between five and seven). The group total in Bomber Command in war therefore became one operations and one intelligence teleprinter channel for each station in the group, a total of three administrative teleprinter channels, and one meteorological channel. At Bomber Command Headquarters it was decided to have in war, one operations and one intelligence teleprinter for each of the six groups, one meteorological channel, eight administrative channels, two channels to the Air Ministry, and three to other commands: a total of 26 teleprinters in all. Only eight of these were fitted, leaving eighteen wanted on the outbreak of war. The number fitted in peacetime was therefore increased to 14, so as to give reasonable training facilities.

This left a balance to be provided in war of twelve teleprinters at Headquarters and 95 for the whole Command, figures which might be expected to vary a little either way as Expansion Scheme 'L' settled down, but which were generally agreed to be a fair estimate of the Command's likely requirements. As to the supply of the extra teleprinters in war, 100 teleprinters had

[1] A.M. File C.11582/42.

been installed at the Electrical and Wireless School at Cranwell for the training of operators,[1] and these were earmarked as a war reserve. The installation of a further 100 teleprinters for training purposes at the new No. 2 Electrical and Wireless School being built at Yatesbury was expected to cover the immediate additional war needs of the other Commands.

In Fighter Command, stations had one administrative teleprinter channel, one operations and one meteorological channel in peace, with an intelligence channel added in war. The three fighter groups had one operations teleprinter line to each station, a total of two administrative lines, and one meteorological line, with one intelligence line to each station and one extra administrative line added in war. At Fighter Command Headquarters there were, in peacetime, four administrative, three operations, three intelligence, one meteorological and two special teleprinter channels: the only change in war was the addition of two additional special channels, both operations channels to the Air Ministry.

Eight Coastal Command stations had one administrative, one operations, one intelligence, and one meteorological teleprinter channel in peace and war. Four other stations of varying peacetime scale were brought up to this scale in war. The three Coastal groups had, in peace, one operations and one intelligence channel to each station, two administrative channels and one meteorological. In war, one extra intelligence and one extra administrative channel were added. Coastal Command Headquarters had, in peace, four administrative, three operations, three intelligence, and one meteorological channels, and four special channels to the Air Ministry and other commands or headquarters. This was increased in war by one additional intelligence and one additional operations channel, and four additional special channels.

Question of Placing Landlines Underground

The reasons for placing landlines underground on and in the vicinity of R.A.F. stations were to avoid obstruction to flying of overhead lines, to give additional security from attack, and to avoid possible interference with wireless. The stations particularly affected by the security question were Fighter Command sector stations and all those operational stations situated to the east of the line Southampton - Birmingham - Edinburgh - Perth. The general principle was that external circuits were placed underground a quarter of a mile from the airfield boundary. Internal operational lines at sector stations were also placed underground, and by 1937 Air Ministry had ruled that all landlines within R.A.F. stations should be put underground as far as possible.[2] The distance from the airfield boundary for which lines were to be put underground was later increased to half a mile. However, during

[1] Teleprinter training was given to all operators during their course, but on a small scale only due to pressure of the course. Nevertheless, largely due to the keenness of trainees in practising in their own time, they were capable of doing 30 words a minute by touch typing on leaving the course, and were thus in a position to increase their speed rapidly later. (A.M. File S.34961.)

[2] A.M. File S.38680.

the war the plant and labour shortage dictated a relaxation of this ruling, and by 1943 overhead routeing on R.A.F. stations was allowed where no flying obstruction was involved.

Underground Operations Rooms in Fighter Command

A sub-committee meeting of the Air Ministry Landline Committee was held at Uxbridge on 27 October 1938 to discuss the provision of cables and the layout of landline signals arrangements necessary for the establishment underground of the Headquarters No. 11 Group Operations Room, an Air Ministry decision to put the operations rooms at all Fighter Command groups and at Fighter Command Headquarters underground having been taken. The plan authorised by this sub-committee was that the Group P.B.X. and signals arrangements should be permanently established in the underground operations block and function there in peace and war. All cables were to be brought in for the last 100 yards of approach to the operations room in steel duct at a minimum depth of six feet.[1]

Details of necessary apparatus and dates of supply were discussed between the G.P.O. and the C.S.O. Fighter Command, and it was decided that at Stanmore some 400 pairs in all would be needed. There were in existence approximately 80 pairs to Stanmore Exchange and 50 to Bushey, leaving a total of 270 to be provided. It was decided in December 1938 to lay a 208-pair cable to Hatch End; but after survey it was found that it was not possible to terminate the cable at Hatch End without extensive building alterations, and it was later decided to extend the cable to Pinner, where there was sufficient room. This entailed additional surveying and led to further delay. By July 1939, however, arrangements were in hand to complete the provision of the cable route from Pinner to a tentative pillbox site at Stanmore as a matter of urgency.

The question of providing a protected lead-in to the underground building at Stanmore was raised in April 1939. The original scheme had envisaged the entry of cables at depths of up to 20 feet below surface level, but experience with the new underground operations room at Headquarters No. 11 Group showed that such a scheme was unworkable, as it involved the laying of pipes in made-up ground with a very heavy weight of earth above the pipes; it was found that even with supports placed under the pipes, they shifted, with consequent danger of damage to the cables.[2] It was therefore necessary to devise a new scheme in which the cables were taken down the normal entrances to the buildings. The disadvantages of this was that the cables were thus crowded together at the entrances only a few feet below the surface, so that a single bomb might put at least half the entire communications system out of action. It was therefore proposed that, at Fighter Command Headquarters, the cables should terminate in concrete pill-boxes

[1] A.M. File S.25122/III.
[2] A.M. File S.47499.

just inside the camp grounds, a separate pill-box being provided to terminate the circuit to each outlet. From each pill-box, two cables would be laid to the underground block, one entering the building at the west entrance and the other, a reserve cable, entering at the east entrance. Thus in the event of the destruction of the west end of the building and the pipes around it, the communications could be restored in a very short time by the reversal of links in the pill-box and in the underground building. A meeting was held on 23 May 1939 at which it was decided to adopt this system, and the same system was later put in force at all Fighter Command groups.[1] There was some delay in obtaining the sites required for the erection of the pill-boxes, but most of the difficulties had been overcome by August 1939.

Other Immediate Landline Requirements in 1939

By April 1939 a period had been reached in the development of major landline schemes where many months of effort were beginning to show results.[2] The first phase of the Defence Teleprinter Network had already begun to come into action, and it was completed by the end of May. The new central telephone exchange at Leighton Buzzard was ready for testing at the end of April and the first lines were put through early in May. Gradually all Central lines to Adastral House were diverted to Leighton Buzzard.[3] On 22 May control of the inter-command W/T system was taken over, and shortly afterwards the Central teleprinters were transferred to Leighton Buzzard from Adastral House, the Air Ministry teleprinters being transferred to a new London centre of Air Ministry communications in Whitehall. The first ten 12-channel teleprinter equipments were installed at Leighton Buzzard by the end of July. A teleplotter scheme was introduced for the Observer Corps, which effected a saving in lines and equipment as well as giving a better record in fighter operations rooms. The G.P.O. provided special staff to deal with the lines for the new forward R/T stations in Fighter Command, and most of these were ready by the end of June.[4] A schedule of circuits required for the new Fighter Command group headquarters at Newcastle-on-Tyne—No. 13 Group—was prepared in March, and the large switch-over of lines involved took some weeks to organise. New sector stations were sited and local end cables laid.[5]

The new Bomber Command Headquarters was connected to the main Post Office cable running between High Wycombe and Princes Risborough, thus giving two outlets. Two spurs were provided to this main cable to guard against damage—one for circuits routed via High Wycombe and one for circuits routed via Princes Risborough. By April 1940 the transfer of lines to the new headquarters had been completed, as had also the transfer of Headquarters Fighter Command and Headquarters No. 13 Group to

[1] A.M. File S.47499.
[2] A.M. File S.41023.
[3] A.M. File S.41023.
[4] A.M. File S.48851.
[5] A.M. File S.48851.

underground accommodation. These transfers were carried out with great efficiency and speed by the G.P.O., and at Stanmore about 140 operational circuits were transferred so that complete communication was available in the underground building within a minute of the signal being given for the transfer to take place.[1]

The provincial communications required for Balloon Command were discussed at a sub-committee meeting of the Defence Services Line Telecommunications Board on 1 September 1939. It was agreed that, in view of the considerable difficulty which was anticipated in meeting the comprehensive requirements of Balloon Command in the provinces, these communications would be met as far as possible by utilising existing private circuits.[2]

Abuse of Landline Facilities

The increasing use of the telephone led easily to abuses of landline facilities. Long distance telephone calls were often made on matters of minor importance and urgency, and an effort was made on the outbreak of war to eliminate calls of this type and to restrict the use of the telephone, whether by private wire or the public exchange system, to matters of real urgency which could not be dealt with by letter, postagram or signal. Instructions were issued designed to make fuller use of the postagram service. Another difficulty was that, in spite of the heavy landlines programme already in existence, demands for increased facilities to serve existing units and formations continued to be made. In spite of the scale of engineering work in progress to meet existing and anticipated needs, the position had been reached where the public telephone services, including trunk services for industry and local government use, were being seriously curtailed in order to provide communications for defence purposes. Demands were therefore carefully scrutinised in order to ensure that they were reduced to the absolute minimum consistent with the essential needs of the Services. All commands were warned of the position by means of a special Air Ministry letter in November 1939.[3]

Further Work of the Air Ministry Landline Committee

The work of the Air Ministry Landline Committee was being gradually carried out by the compilation, under its terms of reference, of a schedule of line telecommunications required for the air defence of Great Britain. It was intended that this document should eventually be distributed to all departments, formations and establishments concerned, but up to the war it was impossible to produce anything like a complete schedule for lodging with the G.P.O.[4] The rapid expansion of the R.A.F. at home, and the various alterations in the different scales of communications to be provided.

[1] A.M. File S.37801/II.
[2] A.M. File S.48851.
[3] A.M. File S.37801/II.
[4] A.M. File S.49645.

necessitated continual revision of landline requirements. In addition, the formation and expansion of the A.A. Command of the Army brought new and urgent requirements which the committee had no opportunity of examining; these lines were provided under direct War Office authority. No information was received on landlines for air defence purposes required by the Home Office. The progessive installation of the Defence Teleprinter Network caused considerable alteration in the inter-communication systems of all the defence Services. Nevertheless, progress was made with the R.A.F. part of the schedule, although the difficulties of making and distributing amendments at frequent intervals remained.

All landline requirements of the R.A.F. were still scrutinised by the Air Ministry Landline Committee before submission to the G.P.O., but this was not so in the case of the other defence Services, so that the various requirements of the different Services were no longer being co-ordinated by the committee. When these requirements were in conflict they were dealt with by the Defence Services Line Telecommunications Board, of which the G.P.O. held the chairmanship.[1]

[1] A.M. File S.49645.

CHAPTER 3

LANDLINES FOR R.D.F STATIONS

A meeting was held at the Air Ministry on 5 February 1936 to decide what telephone or other landline facilities would be required for the proposed R.D.F. system. Initial requirements at Bawdsey had been met by the provision of an exchange circuit, one private telephone circuit to Orfordness, and an internal extension to the laboratory. It was thought then that the requirement consisted simply of lateral lines to connect individual transmitting and receiving stations, and long-distance circuits to connect the system to the Fighting Area organisation at Uxbridge.

Lateral communications consisted of single telephone circuits linking the stations (as Bawdsey—Great Bromley, Bawdsey—Orfordness, Canewdon—Great Bromley, Canewdon—Dunkirk, Dover—Dunkirk). Trunk circuits required for the purpose of trials during September 1936 were three telephone channels between Uxbridge and each of the receiver stations, Bawdsey, Canewdon and Dover. All R.D.F. communications in 1936 were provided on a temporary basis, in the same manner as operational circuits normally provided for exercises.

A memorandum on landlines for the R.D.F. system was produced at the Air Ministry in April 1937.[1] The requirements were based on the immediate coming into operation of the stations at Bawdsey and Dover, the early operation of four stations at Great Bromley, Canewdon, Dunkirk and North Foreland, and the ultimate operation of nine other stations whose siting was approximately known. Lines were to be provided on the following basis :—

(a) Two lines for signalling between stations and the appropriate fighter group headquarters filter room (to be taken where possible through different routes).

(b) One line for telephonic communication for operational control between stations and appropriate fighter group headquarters.

(c) Two lines for signalling between neighbouring stations.

(d) One line for telephonic operational control between stations.

(e) The three stations covering the line of divisions between Nos. 11 and 12 Groups to be connected to both groups.

All signalling lines were to be G.P.O. 'D' tariff, upgraded to teleprinter standard and having upper and lower cut-offs not less than 300 to 2,500 c/s, and were subsequently to be placed underground.

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[1] A.M. File S.37237/I.

The Superintendent at Bawdsey Research Station made further proposals for landline circuits in August 1937, as a result of which a meeting was held in mid-August at Bawdsey which was attended by the Superintendent and members of his staff, two representatives of the Post Office Engineering and Telecommunications Staff, and representatives of the Air Ministry. At this meeting it was decided that the requirements could be met by using a multi-channel system working one high-grade four-wire circuit between the various points. These circuits were known by the G.P.O. as Tariff 'E' circuits, in which continuity of service was guaranteed, and which contained electrical values which could not be provided by Tariff 'D' circuits. The lines needed at this time were Bawdsey to Dover, Dunkirk, Canewdon and Great Bromley, and Bawdsey to the Air Ministry, with an extension to the new Fighter Command headquarters at Stanmore. This type of circuit, however, was of an experimental nature only, and whether such communications would prove satisfactory in future was to be decided after test transmissions on these lines had been operated for some months at least. The circuits were provided in October 1937.

Liaison with the G.P.O.

Apart from the purely financial aspect, it was important, if time was to be saved in providing facilities to new stations when erected, that the G.P.O. should have the earliest possible information of their location and the probable maximum number of lines which would be required to them. As for fixing their final locations, it was very desirable that the G.P.O. be consulted, because although it was obviously not possible to vary the siting of the stations considerably, even the difference of a mile or two might save a great deal of time and money in cable provision. The intention was, therefore, that the Senior Post Office Engineer should be advised as soon as a provisional site was selected in each case.

The necessity for a forecast to be made as soon as possible of what circuits would be required for the final scheme was stressed at an early stage by the G.P.O. Unless at least nine months notice were given to the Post Office prior to the completion of the R.D.F. stations themselves, it was doubtful whether the high grade of line required could be produced in time. Advice of the probable location of ten stations was given to the G.P.O. on 27 August 1937.

By the end of 1937, fifteen R.D.F. stations had been approved, of which five were already in action and a further ten were to be completed within twelve to eighteen months.[1] But of equal importance to the completion of the stations was the provision of a system of landlines for passing information to the appropriate centres. The Air Ministry were therefore most anxious that a system should be put forward to the G.P.O. at once, one which would cater for any system of control and use of these stations which

[1] A.M. File S.37237/I.

could reasonably be envisaged. The system now put forward provided for an 'E' tariff line from each R.D.F. station to pass either into or near the sector station lying in its immediate rear, to which the line could either be run in or a parallel tail led in. From this point the line would run to the group headquarters of the sector concerned, and thence to Headquarters Fighter Command Stanmore. This system had the advantage that, apart from the particular sections of the line between the R.D.F. stations and the sectors, the lines would run between points already connected for operational and administrative purposes by other lines, and therefore the lines would provide spares to each other in case of failure, and any spares laid for one set of lines would automatically be available as spares for the other. There was no suggestion at this stage that R.D.F. information would actually be sifted at sector level, but if this should ever be necessary or become the policy, the system allowed for it.

A preliminary statement of the lines requirements was made by the Air Ministry to the Telecommunications Department, G.P.O., on 10 March 1938, and a conference was suggested, to include representatives of Headquarters Fighter Command and Bawdsey Research Station. However, at this stage, and before a conference could be held, intimation was received at the Air Ministry from Headquarters Fighter Command that pending further trials the Commander-in-Chief wished all work in the direction of the planning and laying of lines for R.D.F. stations to be indefinitely postponed. The conference, arranged for 30 March, was therefore cancelled. The situation remained, however, that unless a start was made right away with these lines, the R.D.F. stations would be completed but no facilities would be available for communicating the intelligence they obtained.

In the end a working compromise was reached between the desire of the Air Ministry signals planning staff to give the G.P.O. reasonable warning and to ensure that the lines were ready in time, and the desire of the C.-in-C. Fighter Command to build the R.D.F. system gradually in the light of experience gained in the first few months of operation with the stations already in existence. The C.-in-C. wanted the existing line connecting Bawdsey with Headquarters Fighter Command to be extended to Uxbridge so that both Headquarters Fighter Command and Headquarters No. 11 Group could receive R.D.F. plots from Bawdsey simultaneously, and he also wanted the system to be made capable of being extended so that the A.O.C. No. 11 Group could switch any of his sector stations at North Weald, Hornchurch, Biggin Hill and Kenley into the system. On the other hand he agreed that the provision of 'local ends' (landlines joining R.D.F. stations to the nearest G.P.O. centre where outlets could be provided) could be proceeded with, as this would be an essential part of any system whatever its final form. This went a long way towards meeting the Air Ministry point of view.

Local Ends

A meeting to determine the local ends required was held at the Air Ministry on 8 April 1938, at which the following requirements were defined :—[1]

(a) Where practicable, two routes to be provided from suitable neighbouring G.P.O. centres to each R.D.F. station, to allow for the possibility of interruption to one route. Where two routes were laid, the circuits required to be divided to some extent between them.

(b) Where two routes were laid, each to consist of eight pairs, so as to allow the necessary circuits to be four-wire. Where one route only was available, 15-pair cable to be provided.

(c) At those stations situated so that they would be responsible for reports to more than one group, 15 pairs in each alternative route to be provided, to allow for the additional circuits.

The chief circuits to be provided were one main and one spare reporting circuit, one lateral circuit in each direction, and one exchange line in each direction. There was also a possible requirement for two D/F circuits. These requirements were varied slightly to conform to individual needs. The cables were terminated at a Main Distributing Frame in the receiver hut. In the main reporting circuit, five channels were to be provided by means of the special apparatus being designed by the G.P.O. and Bawdsey Research Station. These were one speech channel, two technical control channels, one signalling circuit, and one spare channel. Internal wiring and arrangements on R.D.F. sites were to be in accordance with the Bawdsey layout. The cable layout was individual to each site, and in general cables were run, suitably protected, in the same trenches as the power cables.

On 28 April 1938 the G.P.O. were requested to begin the laying of the local cables as soon as possible. The principle was confirmed that in general each R.D.F. station should, where reasonably possible, have outlets to two places at which connection to long underground circuits would be possible. The small inter-communication requirement within the R.D.F. stations was also stated. High-grade four-wire circuits between Stanmore and Uxbridge, and Uxbridge and the four sector stations, were requested in May.

Reporting Lines

The Air Ministry continued to exert pressure on Headquarters Fighter Command to make provision for the longer lines, and emphasised that a decision must be made at once if these lines were to be ready in time for the opening of the R.D.F. stations, bearing in mind that the special high-grade lines required would take a long time to provide. On 12 May 1938, at a conference between the C.-in-C. Fighter Command, A.C.A.S., and Air

[1] A.M. File S.37237/I.

Ministry Signals, the layout of R.D.F. lines for reporting purposes was discussed. It was decided that the central descrambling or filter room should be located at Headquarters Fighter Command. Direct lines were to be provided from all R.D.F. stations to this filter room, to which all initial plots would be reported, and from which the controller would direct the work of the R.D.F. stations. The reports would be plotted in the filter room, and from three teller's positions in this room lines would run direct to the three Fighter Group operations rooms and the Fighter Command operations room. The outgoing plots from the filter centre to the groups would be repeated over special direct lines to the sector stations under those groups. High-quality speech lines would be needed, especially in view of the fact that from groups the information would have to be distributed simultaneously to a number of sectors. The possibility of using a form of teleprinter signalling was borne in mind as a possible development. As regards switching at groups, it was agreed that at first the incoming plots from the filter centre should be automatically relayed to all sectors under the group, switching to be embodied if possible as the technique progressed. It was decided that inverted speech was not necessary.

Air Ministry Instructions to the G.P.O.

Instructions on the organisation of R.D.F. lines were sent to the G.P.O. on 24 June 1938.[1] As a matter of general principle, the main outlet from all R.D.F. stations was to be underground. The alternative route could be overhead, though if it could be provided underground easily, this was to be done. The alternative route was to be such that circuits towards London could be provided on a trunk route entirely distinct from that involved with the main outlet. (In most cases, primary and secondary routeings had already been provisionally agreed with the G.P.O.)

At all stations where two underground outlets were available, two 15-pair cables from the site were now required. (The meeting of 8 April had stipulated 8-pair cables, but 15-pair cables were now wanted so as to provide for the possibility of intercommunication with D/F locating stations.) Where only one underground route was available, one 15-pair cable was to be provided, and the alternative route brought underground with a 15-pair cable a quarter of a mile from the site. Detailed instructions were given designed ultimately to bring the five R.D.F. stations already operating up to this scale, and to put the work in hand for seven other stations, starting with the main outlets. On the subject of main lines, each station required one Tariff 'E' circuit (or the best available at the moment, to be improved up to full Tariff 'E' standard when possible), equalized to 2,700 c/s, direct to Headquarters Fighter Command, and a reserve circuit on another route (and via the alternative route from the station concerned). This reserve circuit was to be treated as a switched line available at two hours' notice in peace and taken permanently in war. The Air Ministry asked

[1] A.M. File S.37237/I.

the G.P.O. to route the speech reporting circuits from R.D.F. stations north of the Wash to Stanmore via G.P.O. telecommunications centres near Hucknall or Newcastle as appropriate, so that in the event of filter rooms being set up at these places, the lines could easily be diverted into them. The idea paid dividends later, when filter rooms were in fact established at these two group headquarters.[1]

From Headquarters Fighter Command, one high-quality line was required to Uxbridge and one to Hucknall. Later, in order to handle the volume of traffic and to pass sufficient information to meet the needs of a group and its sectors, three were wanted to each group. These lines were terminated at the group headquarters on a conference amplifier, and were used to broadcast information from Uxbridge to the local operations room and to the sectors, and from Hucknall similarly. After the opening of No. 13 Group a similar system was required there, but at first, sectors planned to come under the new group were added to the conference amplifier at Hucknall. High-quality speech lines were required from group headquarters to sectors to enable the information to be broadcast. It was expected that speech would be passed in one direction only, i.e. from group to sectors. but in the first place a standard G.P.O. conference amplifier was suggested. Reserves were required for all lines on this system,. to be available at two hours' notice in peace and permanently in war.

Communications at R.D.F. Stations

The division of responsibility at R.D.F. stations was as follows. The G.P.O. dealt entirely with the main incoming trunk telephone lines to the receiving block, including digging the trenches and providing and laying the ducts. (These incoming main lines were laid in a separate trench from the incoming power cable.) The P.B.X. and terminal equipment were bought by the Air Ministry, who became responsible for subsequent maintenance. Within the R.D.F. site, the Air Ministry provided the trenching, advising the G.P.O. well before the work at a particular site was due to start. The site was then surveyed by a local Post Office engineer, who made an estimate of the number of ducts etc. required. Ducts were then supplied by the G.P.O. and laid by the Air Ministry contractors, supervised by the G.P.O.

Three co-axial cables were provided between each receiving and transmitting station, approximately half a mile on two alternative routes (six co-axial cables in all), and in addition one 15-pair cable was required on each route. At sites where corrosion was likely to occur, protective covering for the cables was provided. The manufacturers laid the co-axial cable and the G.P.O. supplied, laid and tested the 15-pair cable. A single four-inch duct was sufficient to accommodate the three co-axial and the 15-pair cables.

[1] Correspondence with Group Captain W. S. Allen (retired).

The planned completion date of the whole scheme, main and internal lines, was December 1939, work being begun about August 1938.

Lines from Bawdsey to R.D.F. Stations

For the early experimental work, Bawdsey Research Station was connected by landline direct to the other R.D.F. stations. On 7 July 1938, the Air Ministry raised the question whether, now that the policy was to connect R.D.F. stations to Headquarters Fighter Command direct, the lines connecting Bawdsey to the other R.D.F. stations could be given up. It was thought that it would be quite possible, with the high grade of line being provided for R.D.F., to switch lines through at Headquarters Fighter Command when stations were required for experimental work with Bawdsey. The Director of Communications Development agreed provided not less than three Bawdsey-Stanmore channels were permanently available, not less than three additional channels available on a rental basis, and provided that the existing lines connecting Bawdsey to the original group of stations at Dover, Canewdon, Dunkirk and Great Bromley were retained for the time being. The G.P.O. were warned that, since it might be necessary for any station in the R.D.F. scheme to be worked from Bawdsey through Stanmore for experimental purposes, four-wire lines having a transmission equivalent of three decibels would be required to make this possible: and further, the requirement might oblige the Air Ministry to request, as the R.D.F. scheme grew, a further two Stanmore-Bawdsey lines.

General R.D.F. Lines Policy

The question of high-quality lines between Stanmore and Groups was studied at the Air Ministry in September 1938. Important factors were that the provision of these lines was extremely expensive, they were difficult to provide, and replacement in case of damage due to enemy action or other failure was regarded as almost impossible over some routes. Yet according to the existing plan three such lines were required to each group. The possibility of using the standard G.P.O. apparatus that would eventually be provided by the Defence Teleprinter Network therefore demanded close scrutiny. A comprehensive scheme of voice-frequency multi-channel working, using standard G.P.O. apparatus, was in the course of being installed for a combined Services network, and the work was well advanced. The system gave a considerable number of channels between commands and groups, and between groups and sectors and stations, and it was most desirable that any line of research involving the transmission of signals other than speech should aim at employing this type of channel if at all possible so as to fit in with the general scheme. The new network was already being used for the remote control of transmitters, and plotting by teleprinter from observer centre to group was also being done. It was obviously desirable that any system of R.D.F. reporting planned for the future should be made to fit in with this system if at all possible.

The practicability of this was therefore studied at Bawdsey. It meant that the R.D.F. system would depend only upon a special carrier system such as the proposed 1 telephone plus 4 telegraph channels, but that it would be designed to line up with the general R.A.F. network depending on the 18, 12 or 4-channel voice-frequency telegraph system now standard in the G.P.O. This meant that the whole R.D.F. reporting system would rely entirely on automatic means of communicating intelligence.

A re-examination of the requirements for communication between R.D.F. stations and the Fighter Command filter room confirmed that these were:—[1]

(a) A good-quality speech channel. This would always have to be provided. Even if routine plots were passed automatically, the controller at the filter room would still require to talk to the R.D.F. operator.

(b) Telegraph channels for various purposes, including synchronisation, numbering of raids, automatic plotting, and wave-change control.

It was agreed at a conference at Bawdsey on 13 September 1938 that these requirements could best be met by the proposed system of a wide-band line on which could be worked one speech channel and a small number of telegraph channels. The dangers with this system—that it might not be possible at first to provide a high-quality reserve line to every R.D.F. station, and that in the event of a large number of cables going faulty under war conditions a serious difficulty in maintaining wide-band lines might be encountered by the G.P.O.—were well known. The conclusion of the conference was that, in the event of failure of the main and reserve wide-band lines, it would be possible to work an R.D.F. station at reduced efficiency over an ordinary telephone line, and that the risk that the G.P.O. might not be able to maintain a wide-band line under emergency conditions must be accepted.

The possibility of using teleprinters for telling from the filter room to groups and sectors, however, was regarded as deserving serious study The Air Ministry view was that the teleprinter network would connect every group and sector with Stanmore and that two telegraph channels at least could be allocated for R.D.F. purposes. If teleprinter channels could be used for telling instead of speech circuits there would be a great saving in lines, particularly as several lines were now required between Stanmore, groups and sectors instead of the one originally planned. Moreover, an omnibus system was required and this could be given far better on a telegraph basis. The Air Ministry felt that the amount of time that would be wasted by using teleprinters instead of speech was negligible. The view at Bawdsey remained that telephony was the most suitable method, but they were keen to get experimental data on the use of teleprinters for R.D.F. purposes.

[1] A.M. File S.37237/I.

Hastening of the R.D.F. Chain

At a D.C.A.S. meeting to consider all possible measures of increasing war readiness, held in October 1938, following the Munich crisis of September, it was agreed that the date for completion of the R.D.F. Chain should be brought forward to 1 April 1939. The Director of Communications Development promised to have 19 R.D.F. stations working by this date, subject to certain limitations and to the endorsement of planned emergency action, which included the acceleration of line provision for the main chain. The scope of G.P.O. emergency liaison officers was widened to include the R.D.F. network and instructions on the circuits required for a number of new stations were given to the G.P.O. To facilitate the working-out of the main and alternative routes, two G.P.O. representatives visited the sites at an early stage, accompanied by representatives of Bawdsey and the local area G.P.O. engineers. The dates for the readiness of eleven new R.D.F. stations were given on 17 December 1938, ranging between mid-January and the end of March 1939. The G.P.O. were advised so that laying of the main outlet to Stanmore and the ducts for local cabling could begin. With regard to the main lines, in most cases the long local ends from the last repeater or amplifier station necessitated additional amplifiers, and it was decided that it would be preferable to install these in the R.D.F. stations rather than at some local exchange *en route,* especially as two distinct routes from the stations were required. The amplifiers were owned and maintained by the Air Ministry and became part of the communications equipment of the R.D.F. station. At Stanmore, however, amplifiers, where they were necessary, were supplied and maintained by the G.P.O. The question of intercommunication cabling on the sites was determined by Bawdsey representatives and the local area G.P.O. engineers.

Change of Lines Policy by G.P.O.

A meeting was held at the Air Ministry on 15 December 1938 to discuss the technical provision of lines for R.D.F.[1] The object of the meeting was to arrive at the technical methods to be adopted to implement the R.D.F. communications policy already laid down, and to provide for administration and possible future methods of plotting. The line requirement was re-stated as:—

(a) A speech channel of good quality for the passing of plots and communication between operator and plotter.

(b) A channel that would carry a synchronising signal.

(c) A channel over which administrative messages could be sent.

(d) Two channels over which automatic plotting might ultimately be done.

If possible, lines must be used which could be reasonably easily replaced by others if interrupted by enemy action, or easily re-routed in the event of

[1] A.M. File S.37237/I.

damage to the plotting centre. For this reason, lines having a cut-off higher than about 2,500 c/s were undesirable. Even under the pressure of emergency conditions it had taken several days, and in some cases weeks, for lines of the grade originally demanded by Bawdsey to be set up.

The G.P.O. representatives told the meeting that the 1+4 (one speech plus four signalling channels on one four-wire circuit), which had been planned, was now unacceptable to them: its practicability had, in any case, always been in some doubt. The suggestion put forward was that a circuit should be produced giving good speech, with a control signal for synchronisation injected into it at a suitable point in the speech spectrum, the whole giving a sufficiently good intelligibility to enable the necessary plots to be passed without repetitions. It was decided that the Post Office Research Station at Dollis Hill should combine with the Bawdsey Research Station in investigating the provision of such a circuit, the development of which was expected to take until December 1939. The grade of circuit needed was a four-wire circuit, equalised to an order of 2,500 c/s, with a loss of not more than six decibels without terminal amplifiers. The Post Office and Bawdsey were to report as soon as possible on whether the provision of such a 'one-in-one' circuit, as it was known, was practicable. In the meantime, the existing speech circuits were used for speech plotting and the second circuit, an emergency one to be taken up on the outbreak of war, was to be used in war for synchronisation. This second circuit was also capable of being provided for short periods of training and for exercises.

Progress in 1939

By the end of January 1939, the work of providing the main underground outlet at the first 15 R.D.F. stations had been put in hand. The permanent underground outlet already existed at Bawdsey; temporary underground outlets were in existence at Canewdon, Dover and Dunkirk, and forecast dates for completion at the remaining eleven stations varied between February and June. Planning of the alternative outlets at these stations was not yet completed. The G.P.O. did their best to keep abreast of the requirements, and the importance of consultation with them before a site was chosen was always realised, but the locality in which a station was situated was determined fairly closely by tactical and technical considerations and could not possibly be adjusted to suit the G.P.O.'s lines problems. Nevertheless, where alternative sites were available and practicable, the communications aspect was kept in view, and wherever possible sites were viewed by the G.P.O. before they were purchased. In March 1939, when four more R.D.F. stations were authorised as an extension to the R.D.F. chain, alternative sites were referred to the G.P.O. for recommendations from the landline point of view.

In March 1939 Headquarters Fighter Command carried out a review of the R.D.F. telling system and stated their requirements for the building up of this system as new sectors came into being.[1] They now asked for two omnibus systems at No. 11 Group, one covering the telling from, geographically, Kenley to Filton inclusive, and another from Kenley to Debden inclusive. Two R.D.F. telling circuits were therefore necessary between Kenley and Uxbridge. The type of omnibus circuit now requested was the multiphone amplifier. This type had already been installed at Hucknall and had given much better results than the conference amplifier at Uxbridge, replacement of which had been requested in the previous month.

The outcome of this review was that on 5 May 1939 the Air Ministry informed the G.P.O. that as a result of experience in working the existing R.D.F. system it had become evident that the network at Uxbridge for telling out to sectors must be split into two parts as the amount of information could not be dealt with over one channel. Further, it now appeared essential that sector stations on the borders of two groups should receive information from both. In order to effect the improvement desired by Headquarters Fighter Command, the following was required:—

(a) A second multiphone amplifier at Headquarters No. 11 Group.

(b) A further circuit between Headquarters No. 11 Group and Headquarters Fighter Command, to be used to speak from Stanmore into the second multiphone amplifier at Uxbridge, and to be four-wire throughout. The grouping of lines on the two multiphone amplifiers was: No. 1 Amplifier—Kenley, Biggin Hill, Hornchurch, North Weald, Debden. No. 2 Amplifier—Kenley, Tangmere, Filton, and one further sector to be included when established (Northolt).

(c) An additional circuit Headquarters No. 11 Group—Kenley.

(d) A circuit between Headquarters No. 12 Group and Debden.

Emergency and Alternative Circuits

In March 1939 the A.O.C.-in-C. Fighter Command proposed that, in war, a scheme of landline communications should be set up between sector and R.D.F. stations, so that if the Fighter Command filter room or important landline cables to it were put out of action, the sectors would be able to obtain some information direct from their nearest R.D.F. station if the normal system were interrupted.[2] The G.P.O. were warned of this requirement at the same time as the additional circuits listed above were requested. Emergency circuits from fifteen R.D.F. stations to their nearest sector stations were involved. It was envisaged that, at a later date, these lines would form the basis of a teleprinter R.D.F. reporting system working over the D.T.N.

Correspondence on emergency circuits had passed between the Air Ministry and the G.P.O. on 28 March 1939. The full schedule was not

[1] A.M. File S.37237/II. *See* diagram at Appendix No. 7.
[2] A.M. File S.37237/I and II.

available, but in view of the political situation and the importance of the circuits it was felt that the requirements should be put immediately. The circuits listed were the reserves to the telling circuits already provided between Stanmore—Uxbridge and Stanmore—Hucknall, and between Uxbridge and Hucknall and their sectors. With regard to the reserve reporting circuits from R.D.F. stations to Headquarters Fighter Command, these were to be provided eventually to an alternative Fighter Command headquarters which was being constructed at Leighton Buzzard, but as this was not yet ready, and in view of continuing European tension, the Air Ministry had to ask for these lines to be laid for the time being to Stanmore.

The alternative Fighter Command headquarters at Leighton Buzzard was established to guard against damage or destruction of the headquarters at Stanmore. An alternative filter room was built, and in order to allow this to function if the filter room at Stanmore was destroyed, and to allow the extension to Stanmore of the alternative R.D.F. reporting circuits if the main circuit was cut, six linking circuits to Stanmore were provided. The programme of synchronisation was effected by the plans for an alternative Fighter headquarters, and a second synchronisation plant was provided there.

The Air Ministry also suggested the establishment of reserve sector plotting rooms for the same reason, the idea being that these should be situated at G.P.O. centres near the sector stations and thus be readily available in case of damage to the main plotting rooms. The lines passed through such centres anyway, and it was a simple matter to arrange for them to be switched to an emergency plotting room. The G.P.O. backed the scheme, but Fighter Command rejected it on the ground that the plotting room must remain at the sector station, and their view prevailed. In the event, when sector operations rooms were knocked out or damaged during the Battle of Britain—as occurred at Biggin Hill and elsewhere—alternative plotting rooms had to be quickly established at the first place readily available, diverting labour and effort from expansion and repair work just when it was most needed.

By the end of June 1939, G.P.O. enquiries regarding the provision of alternative outlets at R.D.F. stations had been completed and the Post Office Engineering Department's proposals for each station were notified to the Air Ministry.

In order to comply with the policy that emergency circuits from R.D.F. stations should be routed to Leighton Buzzard, and having regard to the agreed principles that permanent circuits should be wholly underground and that emergency circuits should be set up in completely alternative routes, it became necessary to re-route certain permanent circuits to give alternative routeings, with the result that in some cases the new outlet became the permanent one. It was expected that all stations would have their full provision of lines, including alternative outlets in most cases, by December 1939, and in all but one instance the alternative outlet was to be by an underground route. But late in the year no steps had been taken to provide the permanent alternative outlets from the majority of R.D.F. stations, although alternative lines to Stanmore were already working on temporary outlets. Hastening action was taken by the Air Ministry.

In addition to the importance of duplicating lines between R.D.F. stations and Fighter Command, there existed a similar need for alternative lines between Command, groups and sectors. The information passed over these lines was just as vital, and arrangements had to be made to replace a line if it failed for any reason. To save laying a separate special line, ordinary private wires were upgraded. They were still used normally but were provided with quick switching-over facilities.

Voice Frequency Telegraph Channels

The R.D.F. lines meeting at the Air Ministry of 15 December 1938 had laid down the policy that eventually R.D.F. stations should be linked in to the nearest Fighter Command Voice-Frequency Centre (it was known that generally these would be sector stations) by voice-frequency four-channel equipment. This was followed up by a proposal from Bawdsey Research Station on 3 April 1939 that, in view of the likely development of automatic plotting equipment, each R.D.F. station of the Final Chain should be equipped with a voice-frequency telegraph terminal connected to the D.T.N. at the nearest sector station. Such apparatus would not only provide communications channels for the automatic plotting method when developed but would also provide immediate teleprinter circuits for administrative purposes.

At the next meeting on R.D.F. lines at the Air Ministry on 4 May 1939, it was agreed that three voice-frequency channels plus one spare be provided from R.D.F. stations to their nearest sector station, of which two would be extended to group and command. The Air Ministry promised to provide one four-channel voice-frequency telegraph equipment for each station, with duplicate, when available. Teleprinter installation for R.D.F. stations, however, could not be contemplated until the Observer Corps teleplotter system was complete, but the voice-frequency four-channel lines were put in, the planned date of completion under the D.T.N. programme being June 1940.

Teleprinter plotting from R.D.F. stations to filter rooms was later developed and was used for a time to a considerable extent. Under this system, apparatus was designed and installed at R.D.F. stations which received the plot from a set of push-buttons at the R.D.F. plotter's position, converted it into five-unit form and transmitted it by a voice-frequency channel to the filter room. Here it was received on a small teleprinter receiver, the printed tape being delivered direct to the filter room plotter through a slot in the table. The method was good, but the teleprinter receivers used gave a great deal of trouble and this led to the scheme being discontinued.[1]

Position in Summer of 1939

In May 1939 the position on the Intermediate Chain was that nineteen stations had been provided with lines, and underground outlets had been provided in all but four cases. Service conditions on these lines, however, showed an extremely high fault liability, and measures taken to improve serviceability included daily checks and weekly transmission measures. These nineteen stations were working on a 24-hour basis. Four more stations were in immediate anticipation, all sited, making a total of 23, and two more were envisaged which might not be sited for some time. With the formation of Headquarters No. 13 Group at Newcastle it had been possible to resolve the last queries about the teller circuit routeings, and to regularise the general situation with regard to financial sanction. There remained, however, one major outstanding commitment—the provision of the line terminal equipment which, following the R.D.F. lines meeting of December 1938, Bawdsey Research Station had been working on in conjunction with the Post Office Research Station at Dollis Hill.

Line Terminal Equipment

Owing to the investigation of the proposed one-in-one telephone system by which it was hoped that speech reporting and a synchronising signal could be passed over the same telephone circuit, it had been impossible to take any steps towards the provision of the telephone terminal equipment. Research was still in progress in May 1939, and although Bawdsey suggested at this time that the Dollis Hill Research Station be given authority straight away to provide the necessary equipment for the Final Chain, the Air Ministry after consultation with the G.P.O. decided that nothing could be done until the final scheme was settled. However, on 27 June Bawdsey stated that the scheme was now finalised, and gave details of the equipment the one-in-one system comprised.[2] A full specification was later provided by Bawdsey, and on 24 August the Air Ministry requested the G.P.O. to arrange for production to proceed as soon as possible. Some difficulty was found in obtaining certain stores, but it was expected that the whole installation would be completed by January 1940. In fact, contract action had not been completed by this date, but the equipment was in production. Contract action was completed in early February and delivery effected shortly afterwards. The allocation of equipment was:—

Single Station Terminal Equipment

R.D.F. stations to Fighter Command	23
Alternative Fighter Command	1
Spare for B.R.S.	1

[1] From correspondence with Group Captain W. S. Allen (retired).
[2] A.M. File S.37237/II.

Central Station Terminal Equipment

Fighter Command and Alternative Fighter Command—Equipment for working to 25 outstations at both.

Voice-operated Relays

Voice-operated relays were used to provide ringing on all circuits between R.D.F. stations and Fighter Command. The use of this type of equipment had been discussed several times, and on 9 June 1939 the Air Ministry requested that approximately 75 such relays be allocated for use on R.D.F. circuits, installation to start in August. The voice-operated relay presented the best answer to the problem of signalling on these circuits, an outstanding advantage being that these relays were expected to reduce fault liability of signalling and afford greater flexibility of circuit routeing in the event of breakdowns. Arrangements for provision were put in hand by the G.P.O.

C.H.L. Advance, Intermediate and Mobile Stations

The lines commitment for the new Chain Home Low stations was discussed in October 1939. Twenty-four C.H.L. installations were to be provided—23 at C.H. sites and one at Ravenscar. Base Maintenance Headquarters were asked to produce details of all extra telephone facilities required for C.H.L. operation, and arrangements were made for the necessary ducts for piping telephone and power lines to C.H.L. buildings to be obtained by the Works contractors from the G.P.O. and laid under G.P.O. supervision. However, later in the same month the whole C.H.L. programme was completely amended to counteract the enemy's use of minelaying aircraft. The original intention of erecting one C.H.L. set on each C.H. station had to be abandoned, new sites being selected so as to combat the enemy tactics. Owing to delay in the production of the C.H.L. sets, G.M. (modified gun-laying sets) were used in lieu. The stations covered the areas Firth of Forth, Harwich, Humber, Dover, Tyne—Tees, Southwold—Channel, and were sited in proximity to suitable C.H. stations. Each C.H.L. station was linked by telephone lines direct to the filter room. Seven more C.H.L. stations were demanded in January 1940 and all were working a month later. The use of voice-operated relays for the C.H.L. stations, giving simple re-routeing facilities, was particularly important as these stations were not provided with alternative routeing. For the advance and intermediate stations established towards the end of 1939, landlines were provided to connect these stations with adjacent main stations. Mobile stations were also established about a mile from each main station in case both the main and standby station on the main site should be put out of action. The sites were chosen in proximity to either the main or alternative outlet and provision was made to enable the mobile station to be connected to one or other of these routes in emergency.

Evacuation of Bawdsey Research Station

The lines required at Bawdsey for scientific research on operational and other R.D.F. problems were stated in July 1939. However, in the following month the possibility of evacuating the Research Station to Dundee was suggested, the reasons being the deteriorating political situation and the proximity of Bawdsey to the coast and the continent. The move was agreed and the G.P.O. provided switchboards, local telephones and lines. Operational research was discontinued and the lines requested for this purpose were cancelled.

Further Extensions to the R.D.F. Chain

Before the end of 1939, enemy aircraft were making deeper penetrations ranging over the western districts of England and the Irish Sea, resulting in an urgent requirement for R.D.F. cover in these areas. The C.A.S. approved a list of 8 additional C.H. stations and 12 new C.H.L. stations to fill the gaps. In order that the siting and routeing problems arising from the proposed extensions could be resolved, a special survey party was formed, with representatives from the Director of Signals, Fighter Command, the Director of Communications Development, the Director of Works, and the G.P.O.[1] Such liaison between the interested departments at so early a stage had never been achieved before.[2]

The work of providing satisfactory communications for the Home R.D.F. Chain up to 1940 has been fully recounted because this was a new commitment and one in which good communications played an absolutely vital part. From 1940 on, the work was almost entirely one of expansion: the type and scope of communications required had long been agreed and it was mainly a question of provision. The full story of the operation and expansion of the Home Chain is told elsewhere.[3]

[1] A.M. File S.44282.
[2] A.H.B./IIE/64.
[3] *See* R.A.F. Signals History, Volume IV: 'Radar in Raid Reporting'.

CHAPTER 4

LANDLINE COMMUNICATIONS 1939-1945

The Defence Teleprinter Network

The Defence Teleprinter Network (D.T.N.) was an administrative inter-Service teleprinter network in the United Kingdom providing a means of connecting stations to each other through the medium of teleprinter switchboards.[1] It extended over the whole country on a switching basis. Stations were connected to switchboards, and inter-switchboard junction lines (mainly channels in the voice-frequency carrier system) provided the linking media.[2] The system was an integrated one between the three Defence Services, circuits between the principal switchboards being provided on a common-user basis; additional circuits were provided between the individual switchboards of each particular Service.[3] The control of traffic over such a network was a complex subject, contrasting with the comparatively simple organisation of an operational tied teleprinter network confined in a relatively small area to traffic concerning a few stations and their headquarters.[4] While point-to-point communication was accepted as the only means of ensuring the speed required by the operational commands for the disposal of operations traffic, the D.T.N. switching system was considered suitable for administrative traffic.[5] Under this system, the maximum use was made of the main junction circuits, and traffic circulated over defined routes, the provision of such routes being in accord with the strictest economy in line plant and installation.[6]

The switching system had been advocated for the administrative network on the supposition that the number of stations and the volume of traffic would be limited and that messages would, in the main, be for disposal to the next highest formation in the chain of command. This did not prove to be the case, and mainly due to the decentralisation of command, the functional rather than regional chain of command (each operational and non-operational command covered the same areas within the United Kingdom), and the high volume of traffic that resulted from total war, the system failed in its original conception.[7] However, the system was developed and extended to meet the changed circumstances, and in the main provided excellent facilities combined with economy in line plant through the medium of the voice-frequency channel system.[8]

[1] A.H.B./IIE/252.
[2] A.H.B./IIM/B26/1A.
[3] A.H.B./IIE/252.
[4] A.H.B./IIM/B26/1A.
[5] A.H.B./IIE/252.
[6] A.H.B./IIM/B26/1A.
[7] A.H.B./IIE/252.
[8] A.H.B./IIM/B26/1A.

The outbreak of war threw a heavy load of traffic on the D.T.N., and the rapid expansion of all the Defence Services which followed was accompanied by greatly increased demands on the Post Office for channels of communication.[1] The fall of Fance, and intensified measures for the defence of the United Kingdom, rendered even more important the provision of adequate and secure telecommunications facilities in this country. A vast increase in landlines was necessary in order to provide operations, intelligence, meteorological and administrative channels for the rapidly increasing number of stations under the control of Fighter Command, Bomber Command, and to a lesser degree Coastal Command. Similar increases were needed by the other Services, and later, heavy bombing led to demands for communications to serve alternative and emergency accommodation for Service establishments. Many of these urgent requirements had to be met by diverting telephone circuits from the public service to the exclusive use of the Services, and additional plant was provided as rapidly as possible in areas where the demands were the greatest. But as it would have been impossible to meet all the requests for essential defence communications by the provision of speech circuits without virtually closing down the public telephone service, wherever possible use was made of teleprinter communication over voice-frequency channels.

The cumulative effect of these circumstances was that the D.T.N. considerably outgrew the original conception.[2] This growth was carefully guided by the Defence Services Line Telecommunications Board, and new plant was laid out systematically to meet the combined interests of the three Services (the R.A.F. remaining by far the largest user); but the vital necessity for providing communications for a continually expanding service regardless of the capacity of the system gave rise to conditions which seriously reduced the effective availability of lines and equipment, and, in consequence, the traffic handling capacities of the system. The network was strained to the utmost by these conditions.

The network was built up in phases, each covering broadly one financial year, and by the end of 1941 Phases I-III had been completed. Detailed proposals for Phase III, covering a vast number of circuits throughout the country, were produced in December 1939.[3] Phase IV, which was scheduled for completion in March 1942, extended in fact well into the year 1942/43. This phase included the establishment of a new North-West Central Switching Centre near Old Boston.[4] Further new requirements, many of them urgent, were put in hand as Phase V, but limitations of manufacturing and installing capacity compelled deferment of much of the work until 1943/44. Included in Phase V was the establishment of a new South-West Central Switching Centre in the Corsham Caves.[5] Phase VI was planned in

[1] A.M. File S.37801/II.
[2] A.M. File S.37801/II.
[3] A.M. File S.1457.
[4] A.M. File S.6262.
[5] A.M. File CS.12701/I.

October 1942, and Phase VII a year later.[1] As well as additional voice-frequency equipment, which constituted the main item, there was the provision of landlines, teleprinter instruments, and other miscellaneous items. But the circuits utilised, whether long distance or local, were almost entirely in cables which had already been provided, either before or after the outbreak of war, to meet the general needs of defence and public telephones and telegraph services and not specially to serve the D.T.N.[2]

The administrative teleprinter organisation, considered from the traffic angle, came under five general headings. These were Organisation, Traffic Handling, Signals Office Organisation, Staffing and Watchkeeping, and Control and Liaison.

Organisation

All R.A.F. stations at home whose traffic was such that it warranted the installation of teleprinter facilities were provided with one or more teleprinters according to the scope of the particular station. Generally speaking, the volume of administrative traffic varied directly as the extent of the operational functions of the station varied. The problem resolved itself into the fact that there were a vast number of teleprinters throughout the country which might require to establish communication with almost any other, however geographically remote it might be. In actual fact, such exclusive communication was not generally demanded, but was confined to a certain number of key stations.[3] However, it was impracticable and uneconomic to set up point-to-point communications for these essential stations, and the network as originally conceived was based on a main switching centre known as 'Central'.[4] The voice-frequency telegraph equipment and associated power plant at this centre were augmented under successive phases up to May 1942. By this time, however, having regard to the immense number of R.A.F. stations in the country, the growth of the network and considerations of reliability necessitated the opening of two more large switching centres, one known as North-West Central, in which the installation of equipment began in the summer of 1942 and which was completed in 1943, and a second known as South-West Central, which was not completed until 1944.[5]

By the end of 1940 it became apparent that, with the ever-increasing need for communications in the north-west of England, for the R.A.F. and also to a lesser extent for the Army and Navy, it was necessary to establish a central teleprinter and telephone exchange, on the lines of Leighton Buzzard, in the area between Manchester and Liverpool. The new centre gave communications for R.A.F. operational, maintenance and training units in the north-west and in Northern Ireland, supplied part of the communications

[1] A.M. Files CS.16555 and S.20602/1.
[2] A.M. File S.37801/II.
[3] A.H.B./IIM/B26/1A.
[4] A.H.B./IIB/252.
[5] A.M. File S.37801/II.

for No. 9 (Fighter) Group at Preston and No. 18 (Coastal) Group at Liverpool, and also catered for Admiralty establishments in connection with the Western Approaches, War Office establishments in the north-west, and meteorological services in the area. It gave considerable relief to the pressure on Leighton Buzzard, which was left to concentrate on the eastern half of England, where communications were already congested and could not be extended.[1]

New Central Switching Centres

The site for the new centre was chosen at Blackbrook, near Old Boston, some 17 miles from Liverpool. The need for the centre was agreed in principle by the Defence Services Line Telecommunications Board in 1940 and finally confirmed on 28 February 1941, but there was considerable delay in starting construction of the necessary buildings due to disagreements as to the type of building to be constructed. A site was chosen at the edge of a colliery tip, which gave considerable protection, but it was felt by the Signals Directorate that the building itself should also be strengthened and protected to some extent. After some months of discussion, the plans were agreed in August 1941 and a contract arranged. Further delays followed due to labour difficulties.[2]

By the end of 1941 the lack of this new centre, with its many inter-Service commitments, was causing delays to traffic in the north-western area. Damage to cables in this area had been sustained in air attacks in the spring of 1941, disrupting communications, and the danger to communications from further attacks of this kind was extremely serious. A temporary arrangement was made in the summer of 1941 by installing a limited amount of equipment at the G.P.O. repeater station at Old Boston, in order that a number of circuits, both existing and projected, could be routed clear of Liverpool and Manchester; but space in this station was restricted and no real security was afforded until the new centre opened.[3] The first phase of the transfer of landline circuits to the new centre was completed on 1 September 1942, and the temporary centre at the G.P.O. repeater station was closed. The majority of circuits were completed by early 1943. An additional commitment over and above that for which the centre was originally agreed was the new American stations in the north-west, the Americans having chosen this area for their main maintenance, supply and personnel depots.[4]

Towards the end of 1941, nearly twelve months before the opening of the North-West Signals Centre, there emerged a need for a similar signals establishment in the south-west, an area which the Air Ministry considered was likely to become increasingly important from the Services' aspect as

[1] A.M. File CS.8110/I.
[2] A.M. File CS.8110/I.
[3] A.M. File CS.9420.
[4] A.M. File CS.8110/II.

the war progressed. Details of the requirements for a second new centre were given by the Air Ministry in the schedule for Phase V of the D.T.N., the actual site to be decided after viewing the accessibility of main cable routes. At a meeting of the Defence Services Line Telecommunications Board on 6 February 1942, the site of the new centre was discussed. It was not practicable to extend the existing D.T.N. switching centre at Cheltenham, where all available accommodation and equipment was being rapidly absorbed. The Air Ministry signals centre at Gloucester had been established because of the proximity of the Cheltenham D.T.N. switching centre and the bulk of its work was to be transferred to the new centre. The recommendation of the Board was that the new centre should be established in the Corsham Caves, Wiltshire, alongside the new underground accommodation provided for No. 10 (Fighter) Group, Rudloe Manor. This site, later known as Hawthorn, was chosen because it was desirable from the cabling point of view, excellent protection was afforded by the caves, and good accommodation was available.[1]

Originally it was thought that the telephone switchboard at Headquarters No. 10 Group could be used for the switching centre as well, but by November 1942 it had become apparent that such an arrangement would be altogether unsatisfactory. The south-west was an area in which, although the number of air force establishments had not greatly increased, the number of personnel had increased considerably, and this increase was expected to continue as preparations for the landings in Europe developed. The original target date for the opening of the centre was 1 January 1943, but building difficulties, mainly due to labour shortages, again caused delays, and the centre was eventually opened in August 1943, with an establishment of 400 other ranks, mostly W.A.A.F., and 20 officers and senior N.C.O.s, slightly under that for the North-West Signals Centre.[2] A considerable number of additional teleprinter and telephone positions were later required.[3]

The establishment of these two new centres gave three main switching centres at focal points at which all the teleprinter circuits in the area were collected on a switchboard. These switching centres carried main junction circuits to the other switching centres, the main junction circuits being provided as demanded by the circulation of traffic to and from the area.[4]

The main advantage of the switching system was that it enabled, within certain technical limits, the station of origin to be connected, via intermediate switchboards, to the station of destination, and thus avoided retransmissions.[5] The success of the system was mainly dependent upon the provision of circuits and terminal instruments in sufficient numbers to

[1] A.M. File CS.12701/I.
[2] A.M. File CS.12701/I.
[3] A.M. File CS.12701/II.
[4] A.H.B./IIM/B26/1A.
[5] A.H.B./IIE/252.

avoid 'engaged' conditions, and the adoption of routeings to avoid the technical limitations of the circuits. Immediate confirmation that a message had been received by the station of destination was obtained, thus avoiding the necessity for station-to-station check sheets. Economy of equipment and maintenance was effected by the grouping of line equipment at certain focal points. A common method of operation was employed and interchange of traffic between the Services thereby facilitated.

The institution of switching centres resulted in an economy in line plant, but it presented another problem: a large number of teleprinter stations in any one area were competing for the use of a limited number of junction circuits.[1] The incidence of unavoidable traffic peaks of long duration at numerous stations throughout the country resulted in a surge of traffic of widespread direction throughout the network.[2] Conditions in which a number of stations required connections to the same station at the same time persisted and resulted in saturation of circuits and teleprinters, followed by inevitable delays. The provision of apparatus, personnel and accommodation on a scale sufficient to avoid these conditions was impracticable and uneconomic, even by wartime standards. One of the worst manifestations of this delay was the preponderance of ineffective calls. This persisted throughout the war, and instances in which stations passed as many as twenty ineffective calls to one effective were common. The primary causes of ineffective calls were the impracticability of unlimited provision of personnel and equipment, the impossibility of limiting incoming calls to the capacity of any particular station, and the cumulative effect of other ineffective calls.[3] In addition to occupying the local and intermediate switchboard operator's time, ineffective calls also occupied the terminal station and switchboard teleprinters, not only against outgoing calls, but also against incoming calls. A considerable proportion of calls were ineffective at the final switchboard after having been set up via a number of switchboards over trunk circuits. The time occupied in establishing and then disconnecting each call frequently extended to two or three minutes, during which time the trunk and local circuits were completely ineffective. The loss of line time that resulted from these conditions was so serious in the early stages of the war that through switching was restricted to major stations only. Minor stations dropped all traffic—except that for stations connected to their own switchboard—at an appointed Signals Centre and, in effect, operated on a point-to-point basis.[4] Of the many expedients resorted to in an endeavour to alleviate the strain, signals centre working was by far the most successful.[5] But ineffective calls were by no means eliminated.

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[1] A.H.B./IIM/B26/1A.
[2] A.H.B./IIE/252.
[3] A.H.B./IIE/252.
[4] A.H.B./IIE/252.
[5] A.M. File S.37801/II.

The Signals Centre System

The Signals Centre system of control was a zoning system of traffic circulation, under which traffic handling centres of varying sizes were set up throughout the country. These signals centres were provided with additional instruments in order to carry the increased load of traffic circulating through the centre to and from other centres. Generally the signals centre was directly associated with a switchboard and existed on the same site. Switchboards were usually installed at operational group headquarters with connections to other stations in the same area. The group administrative teleprinter room was made the signals centre for stations connected to its switchboards. A signals centre was defined as a teleprinter station that had been made responsible for all traffic emanating from the terminals of a particular switchboard which was for disposal to terminals of distant switchboards. The demand for junction circuits between switching centres was thus restricted in the main to the signals centres. This gave economy in line time, a saving in switchboard operating time, a more efficient use of junction circuits, and a consequent reduction in message transit time. In addition to the signals centres there were sub-signals centres, chiefly established where the volume of traffic handled was too large to circulate via a signals centre. Sub-signals centres could communicate directly with other signals centres or sub-signals centres. A station which did not come in either category was called a terminal station.[1]

All three Services found it necessary to introduce a booking procedure to guarantee some orderly form of securing connection and as a means of reducing the enormous volume of switchboard traffic which resulted from the continued repetition of calls. The booking arrangements at the central switchboard alone necessitated the allocation and consequent loss to general use of four switchboard positions per watch. Despite the introduction of this system, however, many priority calls booked during the evening were still outstanding even as late as 0800 hours next day, due to the immense volume of traffic and the fact that routine and other traffic was being transmitted although priority traffic awaited disposal. The impossibility of breaking down existing connections for the purpose of establishing priority calls was one of the most serious disadvantages of the switching system. Once a connection was established between two stations the only means of ascertaining the type of traffic in course of transmission was by monitoring. In view of the number of connections and the time involved, this was impracticable, and two connected stations could therefore clear low precedence traffic to the exclusion of high precedence traffic awaiting transmission at other stations.[2]

Several methods were introduced to try to overcome this difficulty, one of which was to disconnect existing calls in favour of calls of 'Immediate' priority and above. The chaotic conditions that resulted necessitated the

[1] A.H.B./IIM/B26/1A.
[2] A.H.B./IIE/252.

rule being immediately rescinded, and facilities for clearing the line were afterwards accorded only to messages of precedence 'Emergency' and above. Other measures taken included instructions to stations which had obtained connection as a result of a booked priority call to clear down on completion of transmission of priority traffic, regardless of whether either had further traffic for the other, and instructions to switchboard operators to monitor existing connections after fifteen minutes if priority calls for either station awaited connection, and to clear the connection unless priority traffic was still in the course of transmission. Both these measures were difficult to enforce and therefore had little effect.[1]

With through switching it was impossible to say at any time how much and at which stations traffic for any other station might be awaiting transmission. It might be that ten or twenty widely dispersed stations each having two or three messages for one particular station were all experiencing difficulty in obtaining connection. Before the introduction of signals centres, this state of affairs existed almost continually. It was almost impossible for all these stations to report to a central traffic control for instructions, and it would in any case have been extremely difficult to control so many widely dispersed stations. The only real relief afforded came with the introduction of the signals centres, collecting traffic as they did from a number of terminals. These signals centres had greater facilities than the average station and frequently had alternative outlets; access to the trunk network was limited to these centres. They generally had access to the traffic control section at Headquarters No. 26 Group, and the fact that the traffic was in bulk at one point enabled the traffic control section to deal with any congested situation, either by diversion via other offices or by despatch rider, etc.[2]

Switchboard Routeings

Having established the switching and signals centres, the next step was to arrange switchboard routeings: if this had not been done, it would have meant that unnecessary connections would be set up all over the country. If switchboard 'A' wished to reach switchboard 'B', to which it had no junction circuit, the connection could be patched via a third switchboard 'Z', which had circuits to both 'A' and 'B'. This might be satisfactory, but if 'Z's' direct circuit to 'B' was engaged it would extend the caller through to a fourth switchboard 'Y', knowing that 'Y' also had a direct circuit to 'B'. Such circuitous routeing could be performed almost *ad infinitum* and a dangerous state of affairs would exist, aggravating engaged conditions and delaying traffic. It was found essential to confine such switchboard routeings to the minimum required in setting up any connection, and this was generally restricted to two or three switchboards. Every D.T.N. switchboard was therefore provided with a routeing schedule, which

[1] A.H.B./IIE/252.
[2] A.H.B./IIE/252.

laid down a primary, a secondary, and in some cases a tertiary route to every other switchboard.[1] These circuits were arranged according to the circuits provided on each switchboard, and according to the loading of traffic, which was determined from statistics compiled at Headquarters No. 26 Group after an analysis had been made of the tapes returned weekly from each switchboard. A fairly representative assessment of the loading on junction circuits and terminals could be made by examining the switchboard tapes.

Every teleprinter station and switchboard was allotted a D.T.N. code or call-sign, by which it was known. These call-signs were as self-evident as possible and were allotted by Headquarters No. 26 Group to all the Allied Services. They were always used for setting up a call, and were fitted with automatic 'answer-backs' on each R.A.F. teleprinter. In order to assist in visual discrimination between the two types of circuit—terminal and junction—the terminal labels were coloured white and the junction labels yellow. Calls from terminal stations for stations on other switchboards could be connected via any one of the three assigned routes, but calls from junctions for other switchboards could be routed via the primary routeing only : if this was engaged the calling station was told and the line cleared down. Thus no connection could include more than the maximum of three switchboards. Any difficulties that arose in arranging routeings to conform with this limit were resolved by the three main switching centres and their attendant signals offices. The three main centres (Central, North-West Central and South-West Central) all possessed multi-position switchboards with junction circuits to the smaller switchboards within their area (such as the switchboards at group headquarters).[2] They had terminals to stations not directly connected with an operational group headquarters, and 'long tails' to the more important signals centres as required. 'Long tails' was the term given to a specially provided terminal connected to a distant switchboard in order to facilitate the disposal of traffic circulating between terminals on that switchboard and the distant terminal. The inter-switchboard junction circuits were thus short-circuited, relieving the load on those circuits and the load at the signals centres. 'Long tails' were only provided in special cases. They were used, for instance, to sub-signal centres which handled a large amount of traffic with a wide circulation, such as the Aircraft Equipment Depots (A.E.D.).[3] These depots were provided with ex-directory circuits, since a large volume of traffic was passed to and from them.[4] Only A.E.D. traffic was passed over these lines, resulting in an acceleration of disposal and a lightening of the load over normal channels. Such a segregation of certain lines from universal use was a necessary departure from the standard organisation; a similar arrangement was made for the R.A.F. and U.S.A.A.F. Transport Commands.

[1] A.H.B./IIM/B26/1A.
[2] A.H.B./IIM/B26/1A.
[3] A.H.B./IIM/B26/1A.
[4] Ex-directory circuits terminated on one switchboard and were not promulgated in the Teleprinter Routeing Directory (T.R.D.).

Multiple Address Messages

The three main switching centres were fitted with improved broadcast apparatus for the disposal of large multiple-address messages, such as messages addressed to 'All Home Units'. Up to the end of 1943, only Central had multi-broadcast equipment, and it was therefore responsible for all multi-address traffic, but in February 1944 similar equipment was installed at North-West and South-West Central.[1] Terminations were arranged on these boards so that there was an equitable distribution of traffic within each area. Broadcast circuits were generally routed via the normal D.T.N. switchboard and switched from one to the other as required. In many cases, where the volume of potential broadcast traffic was high to a particular station (such as a group headquarters), a special tied line from the broadcast switchboard was provided. Broadcast facilities on a smaller scale were also provided on the small D.T.N. switchboards usually provided at signal centres. These embraced all the local stations on that board to which broadcasts might have to be made. Hence a message addressed to 'All Home Units' was broadcast by one of the three main switching centres to the main signals centres, who in turn broadcast to the terminals on their own switchboard.

One of the chief difficulties in controlling signals traffic was the unequal flow over the 24 hours. The peak period covered about eight hours of the day, and certain delays were bound to accrue in that time, unless full facilities were provided to deal with the maxium period, which would have been uneconomic. Statistics were essential before requirements could be properly assessed, and certain returns were therefore made to Headquarters No. 26 Group by all teleprinter stations. The switchboard tapes have already been mentioned; in addition certain returns were made of check sheets and of the time taken in answering on switchboards. On the first Wednesday and Thursday in each month, every teleprinter station sent in a duplicate copy of its In, Out, and (in the case of signals centres) through check sheets. These provided valuable data in compiling statistics. A record was kept for each teleprinter station summarising the amount of traffic handled, the number of transmissions involved, and the number of priority and deferred messages handled in each category.[2]

The provision of teleprinters was based on the average traffic passed during 24 hours, although the majority of traffic was handled during an eight-hour period ending at about midnight. As a general rule the basis of provision was 250 transmissions (not messages) per machine. This again was dependent on the proportion of priority messages and the importance of the traffic handled. An attempt was made to reduce peak periods by introducing the 'Deferred' system. This was in many ways disappointing, since only about 3 per cent of the total traffic handled was marked 'Deferred'. Congestion during peak periods might have been eased by

[1] A.M. File CS.21928.
[2] A.H.B./IIM/B26/1A.

the use of automatic apparatus (i.e. auto-transmitter heads and reperforators) but owing to supply difficulties this type of apparatus was not used to any great extent. Other minor causes of congestion were the use of the D.T.N. for messages which could have been dealt with by postagram or letter, and the misuse of precedence markings. Abuses of this kind were closely watched by the traffic control section at Headquarters No. 26 Group.[1]

Traffic Handling

All D.T.N. stations in the R.A.F. were shown in C.C.O. 1 Part II Section A, which was known as the Teleprinter Routeing Directory.[2] This consisted of a preface, a list of switchboards, and a main body which showed the required routeings. The preface explained the manner in which the directory should be used and gave instructions for the disposal of multiple-address traffic. The list of switchboards indicated all those switchboards to which each was connected; this was purely for information and guidance and did not supersede the separate Switchboard Routeing Schedule. All the U.S.A.A.F. teleprinter stations were also included in the schedule, since these were incorporated within the D.T.N. and worked in close liaison with the R.A.F. Amendments to C.C.O. 1 were sent out daily by signal to all teleprinter stations.

Strict observance of the instructions on the handling of multiple-address traffic was essential if signals centres were to clear traffic with a minimum of delay. Multiple-address traffic divided itself broadly into three categories; that addressed to two or more stations, that addressed to all teleprinter stations, and that addressed to certain specific stations (such as stations within a command or group or special messages concerning particular units). To assist in the distribution of such traffic, the Multiple Address Responsibility Schedule was drawn up and became Section 'B' of C.C.O. 1 Part II.[3] The first part of the schedule contained a list of stations for which Central was responsible; these were mainly signals centres, each of whose responsibilities were set out in the second part of the schedule. When North-West and South-West Central broadcast facilities were opened in 1944 the scheme was sub-divided, but the principle remained that large multiple-address traffic went to a central distribution point for diffusion to the required stations. Special treatment was afforded to messages addressed to 'All Flying Units', which were often of an operational nature. The rule for disposal of traffic via the appropriate signals centres was only revoked when a long message or a number of messages were on hand for transmission to any one station, or when all traffic on hand for a particular signals centre was for disposal to one station on that switchboard. In this way additional transmissions were avoided where there was no advantage in disposing of the message or messages via a signals centre.

[1] A.H.B./IIM/B26/1A.
[2] A.H.B./IIM/B26/1A.
[3] A.H.B./IIM/B26/1A.

Generally speaking the instructions applying to plain language and cypher messages were the same, but in many cases, due to the lack of cypher facilities on some stations, different routeing instructions had to be applied for cypher messages. Stations with cypher staffs undertook responsibility for stations in their area with such staffs. This was by no means a simple matter and was often extremely difficult; the alternative was to arrange for a parent station or group to take over the task even though it was some distance away. Separate routeing for cypher messages was always shown in the Teleprinter Routeing Directory.[1]

Certain other schedules were issued in connection with traffic handling. These were the Emergency Schedule (C.C.O. 1 Part II Section 'D'), the Petroleum Board Schedule, and the Emergency Disposal of Security Messages. The Emergency Schedule provided alternative routeings for all teleprinter stations directly concerned with operations, and was brought into service automatically whenever a station became isolated from the teleprinter network. Stations not included in this directory had emergency routeings arranged for them by Headquarters No. 26 Group when required. The Petroleum Board Schedule was a facility conceded to the majority of the main Petroleum Board premises whereby use was made of the R.A.F. teleprinter network when there was a failure of normal communications. Finally there was a system for the emergency disposal of Security Service messages.

By March 1944 the volume of traffic on the home teleprinter network was saturating the system and causing heavy delay to all types of message. Additional lines, personnel and apparatus could only be made available in very limited numbers at this stage in the war, and in any case did not allow the provision of sufficient additional facilities to meet the increase in traffic expected as a result of 'Overlord'. It was therefore essential to reduce existing traffic in order to relieve the existing congestion and provide a margin of capacity for the forthcoming operations.[2]

A scrutiny of traffic at this time revealed that the network was carrying many communications more appropriate to the postal and despatch rider services. In addition, a number of messages dealing with subjects for which the use of the signals service was forbidden (such as requests for documents, messages dealing with accounts, mail and laundry, normal replies to correspondence, non-operational returns etc.) were still being originated for transmission by teleprinter.[3] It was realised in March 1944 that it might be necessary to introduce the 'Minimize' procedure laid down in 1941, and a study of this procedure was ordered so that personnel

[1] A.H.B./IIM/B26/IA.
[2] A.M. File CS.22075.
[3] Examples of correspondence not to be sent by signals channels were given in C.C.O. No. 135/1940, in A.P. 837 Section 3 para. 150, and in A.M.O. A.520/44, which is reproduced at Appendix No. 2.

concerned would understand it and be able to take the appropriate action should it be introduced.[1]

Prior to the invasion, the establishments of certain signals centres were reorganised, so as to provide adequate supervisory staff and properly-organised traffic offices and to allow sufficient personnel to operate known and anticipated requirements; the signals centres concerned were those at Central, North-West and South-West Central, Cardington, Chicksands 'B', and Birdlip.[2]

Signals Office Organisation

A copy of the instructions for operating on the D.T.N. was held by every teleprinter station. The document was a revised publication and conformed to the Combined Teleprinter Operating Procedure known as C.C.B.P.4.[3] It contained instructions for operating, fault reporting, and routine testing, and one of the essentials of good operating was a rigid adherence to these instructions. Such small points as the methods of calling and clearing, and vigilant attention to switchboard clearing lights, vitally affected the efficiency of the D.T.N. The same applied to the handling of a message. When a message was handed in for transmission at a signals office it was given an office serial number which remained with it throughout the course of its transmission. After entry in the check sheet the message was routed to the home signals centre responsible for that signals office, irrespective of the addressee, unless that addressee was at a terminal on the home switchboard (but if the message was addressed to several addressees which were terminals on the home switchboard, the small signals office with only one or two teleprinters would be involved in several transmissions; if this meant heavy delay on the message and general congestion the signals office was encouraged to pass the message to the home signals centre).

When the message was received at the home signals centre it was routed to the signals centre responsible for the addressee. All the routeings indicated by the Teleprinter Routeing Directory (T.R.D.) were marked on the message, also the routeing for direct disposal where this was applicable.[4] It was essential that all the routes given in the T.R.D. were marked, since each route had to be attempted in turn when engaged conditions were experienced. Common sense was the guiding factor in many actual routeings. If the message bore several addressees and its disposal involved three or more transmissions to distant signals centres, it was transmitted to Central (or North-West or South-West Central when these began operating) for disposal under the multiple-address responsibility schedule.

[1] A copy of the Office Instruction on 'Minimize' procedure is reproduced at Appendix No. 3.

[2] A.H.B./IIM/B26/I—H.G. No. 26 Group O.R.B., 1940-1944.

[3] The D.T.N. instructions were completely re-written in August 1943 in order to conform to the procedure agreed and revised by the Combined Communications Board, Washington. They were known as D.T.N. instructions (2nd Edition) and were brought into force on 3 October 1943. (A.H.B./IIE/253.)

[4] A.H.B./IIM/B26/1A.

The procedure for bookings was fully explained in the D.T.N. instructions. Messages below 'Emergency' precedence were booked if no free line was available, and the booking was marked on the message with the time and the initials of the booking operator. Special treatment was accorded to all priority traffic of precedence 'Emergency' and above: this was known as 'Clear the line' traffic and the procedure for dealing with such traffic was set out in D.T.N. instructions. Any terminal which had 'Clear the line' traffic was authorised to attempt direct transmissions, thus by-passing the signals centres. (Any terminal having a large number of messages or a very long signal might attempt direct transmission, but if engaged conditions were met it dropped the message or messages at its home signals centre.)

An important factor in handling traffic in signals offices was to separate priority messages from other traffic, since all types of precedence traffic had to be given preferential treatment. Various methods were used for drawing attention to such messages:—[1]

(a) Pinning coloured slips, marked with the degree of precedence, on the message.

(b) Chalking on a board those stations for which precedence traffic was awaiting transmission.

(c) Allotting special precedence pigeon holes where a traffic rack was used.

(d) Identification in a traffic rack by a coloured tab of those pigeon holes holding messages marked with a degree of precedence.

(e) Segregation in a separate rack or on a separate table.

(f) Allowing them to float on the teleprinters where the signals office was a small one.

All messages after being transmitted were checked and the serial number crossed off on the check sheets, although the checking did not extend to the actual text of the message, which was entirely the responsibility of the operator. Checking was confined to the preamble and the acknowledgments. Other facets of signals office working included batch-working, 'up and down' working, and duplex working. 'Up and down' working was especially useful for passing long signals which required checking before they were acknowledged. In duplex working, use was made of one circuit by terminating a teleprinter on each end of the sending and receiving legs at both stations; in this manner transmission was made on one machine and reception on the other. Duplex numbers were used and acknowledgments were given at the end of each hour, except in the case of messages of a precedence of emergency and above, which were acknowledged immediately. This method was invaluable where a large amount of traffic was passed between two points on a tied line.[2]

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[1] A.H.B./IIM/B26/1A.
[2] A.H.B./IIM/B26/1A.

Staffing

Close liaison was maintained by Headquarters No. 26 Group with Records Office, Gloucester, on the movements of teleprinter personnel. Returns were submitted each month from every teleprinter station giving full particulars of the staffing position; these returns were examined at Headquarters No. 26 Group, and adjustments were made as required and implemented by the Records Office.[1] Due to the shortage of manpower, however, the strength of operators could never be kept at par with the establishment, but where a shortage seriously affected the efficient working of a signal office every attempt was made to increase the strength.

All teleprinter operators were trained by the R.A.F. before being mustered to the trade. It was found, however, that many operators who reached N.C.O. rank, although efficient as operators, did not possess the basic knowledge of the D.T.N. system which was essential for efficient supervision. In order to rectify this a teleprinter N.C.O.s' course was initiated, so that a thorough knowledge of D.T.N. principles, traffic handling, and signals office organisation could be instilled in all N.C.O.s. After the course, which was of a fortnight's duration, N.C.O.s returned to their units with a far better grasp of the principles on which the D.T.N. was built and with broadened outlook, both of which were reflected in the more efficient working of signal offices.[2]

By the middle of 1943 the shortage of teleprinter operators had become acute, and it was further aggravated towards the end of the year by the installation of new switchboards and D.T.N. equipment in connection with the formation of the A.E.A.F., extreme difficulty being found in February 1944 in supplying the teleprinter operators to meet the many new commitments. Another difficulty was the parallel increase in the volume of traffic from month to month. With a view to relieving the acute shortage of operators, a survey of the less busy stations was undertaken by Headquarters No. 26 Group to ascertain which might be either closed or amalgamated with a neighbouring office, or placed on a restricted watch. The results of this review were most promising, and proposals were submitted to the Air Ministry which led in March 1944 to considerable economies in staff.[3]

Additional stations connected to the D.T.N., however, were averaging 20 a month in this period, and a further source of delay was the unsatisfactory standard of teleprinter operating. In May 1944 a letter was sent to all R.A.F. stations drawing attention to the urgent need for improving the standard of D.T.N. operating procedure and suggesting ways of effecting such improvement.[4]

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[1] A.H.B./IIM/B26/1A.
[2] A.H.B./IIM/B26/1A.
[3] A.H.B./IIM/B26/I. H.Q. No. 26 Group O.R.B., 1940-1944.
[4] A.H.B./IIM/B26/1.

Control and Liaison

A duty officer was always available in the Traffic Control section of Headquarters No. 26 Group to advise on routeings, and on diversions of traffic resulting from breakdowns of communications through enemy action or other causes; and to enable these duty officers to carry out their task a complete and up-to-date record was kept of the location of every unit in the R.A.F. and the U.S.A.A.F., both at home and overseas, a record of every available landline in the United Kingdom, and a record of all available wireless circuits.[1] Besides controlling the administrative teleprinter traffic organisation, advice and assistance was given on most matters pertaining to the organisation of teleprinter offices. Such matters as the lay-out of teleprinter rooms and traffic offices, and the planning of D.T.N. switchboard face-layouts, were subject to the recommendations of Traffic Control. A visiting officers' branch was also established with the object of maintaining as close a contact as possible with the conditions and difficulties obtaining in all teleprinter offices.[2] These officers made routine visits to stations to investigate the local organisation at first hand and to advise individual signals officers on the various aspects of traffic handling. Visiting officers' terms of reference included such matters as observance of standard signals instructions, correct routeings and efficient traffic distribution, elimination of waste of line time, correct teleprinter and switchboard operating, the adjustment of facilities to requirements, staffing and supervision, and general examination of traffic for misuse of the signals service. In addition to routine visits, special visits were occasionally undertaken to investigate outstanding traffic problems, or to assess requests for additional facilities. Only by ensuring a close liaison between signals offices and traffic sections was an efficient system maintained.

Comparison of Traffic Levels

In September 1939, the average number of messages passed daily over the D.T.N. was 2,000; of these some 500 were passed through the Central Exchange at Leighton Buzzard. By October 1941, shortly before the opening of North-West Central at Blackbrook, Leighton Buzzard was dealing with 6,000 messages daily, twelve times its 1939 figures. The pressure on Leighton Buzzard was considerably relieved when North-West Central opened in December 1941; in its first month of operating the new centre dealt with an average of 600 transmissions daily, rising to a peak average of 5,000 in May 1944. The position was eased still further in September 1943 with the opening of South-West Central at Hawthorn; this centre averaged 1,200 messages daily in its first month of operating, rising to a peak daily average of 4,200 messages in June 1944. In the quarter including D-Day, well over one million messages were dealt with, 'In', 'Out', and 'Through', on the D.T.N.[3]

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[1] A.H.B./IIM/B26/1A.

[2] A.H.B./IIM/B26/1A.

[3] The traffic returns of the three Central Exchanges, in quarterly totals, are illustrated in Appendix No. 4.

The level of traffic on the D.T.N. remained high following D-Day, and was about the same even after ' V.E.' Day, but had begun to show a steady decrease by August 1945.[1]

Summary

The major changes during the war years were due first to expansion, finally resulting in the opening of two new switching centres, and secondly to the introduction of a limited system of point-to-point working within the D.T.N. by the establishment of the signals centres, which helped to alleviate many of the disadvantages of the switching system, and which gave immediate benefit in traffic clearance.[2]

It remained the policy throughout the war years to encourage the use of teleprinter circuits instead of telephone circuits, chiefly because of the greater number of channels that could be provided with the same absorption of line plant.[3] Many of the facilities required were for the transmission of urgent operational messages, and had the D.T.N. not been available, telephone circuits would have had to be provided. Apart from the serious effect such a course would have had on the public telephone service, the use of the cheaper teleprinter facilities resulted in large economies, even though it was still necessary to rent telephone circuits on a large scale for purposes for which teleprinter working was unsuitable.

Landlines in Fighter Command

The expansion that took place in Fighter Command prior to September 1939 was continued in the early months of the war, and the procedure for demands for additional landlines for new and existing stations remained the same, requests continuing to be made by Headquarters Fighter Command through the Air Ministry.

The features of the expansion which took place in 1940 were the formation of No. 10 Group with Headquarters at Rudloe and the transfer of stations from one group to another to maintain an even distribution. Sectors that came under the control of No. 10 Group were Filton, Middle Wallop, St. Eval and Pembrey. The Group was formed in August 1940, at which time, in view of the transfer of the Middle Wallop sector from Uxbridge to Rudloe, Debden was transferred from No. 12 to No. 11 Group and Church Fenton from No. 13 to No. 12. A new sector station under No. 12 Group was opened at Coltishall in June 1940. The Headquarters of No. 12 Group was moved from Hucknall to nearby Watnall. A further new sector in this group was opened at Kirton-in-Lindsay. New sectors formed under No. 13 Group (Newcastle) included Dyce, Aldergrove and Ouston. In July 1940, a number of new fighter sectors were planned for the north-west coast. Landline circuits for all these stations were provided

[1] A.H.B./IIM/B26/2. H.Q. No. 26 Group O.R.B., 1945-1946.
[2] A.H.B./IIE/252.
[3] A.M. File S.37801/II.

to the standard scale in the command.[1] Emergency operations rooms were provided for all sector stations in the command.

Modifications to the System of Telling

It was decided in December 1940 to make certain modifications to the telling system employed in the filter room at Stanmore. Individual tellers were responsible for telling information to Nos. 11, 12 and 13 Groups, but the work load was uneven, and modifications were designed to increase general efficiency. The new principle was that a single teller should be responsible for telling information on a certain part of the filter room table, the information going simultaneously to everyone requiring to receive it. There were to be no areas on the table in which information was told by more than one teller.

Two multi-phone systems were available for telling radar information to Headquarters No. 11 Group and its sectors, but they could not be employed separately, as desired, with the existing allocation of lines so as to distribute the information correctly. Under the new system, it was necessary to sub-divide the area covered by the No. 11 Group teller, as this was far too large, and it was at the same time necessary to provide additional lines into Headquarters No. 12 Group and its sectors so that information in the No. 11 Group area which was essential to No. 12 Group should reach No 12 Group without being told by more than one teller. A number of new speech circuits were required to cover the new lay-out. The Air Ministry, however, pointed out a number of objections to the modified system. Although it was agreed that it was possible to provide the additional lines, it was thought that it might not be possible to maintain the new system in the face of damage to cables due to heavy air attacks. There had been occasions when No. 11 Group sectors had had to function on two lines connecting them to the Group Headquarters, and under these circumstances the lines were taken for multiphone and operations use. Under the new scheme, a minimum of two lines was needed for telling only. A still greater difficulty was apparent on lines to observer centres and to sectors outside No. 11 Group, as there were no reserves at all to cover failure of these circuits and it was impracticable to provide them; the passing of information to these stations would be interrupted by any landline fault or minor breakdown. Again, it was impracticable to provide sufficient circuits to put the new scheme into operation at the other fighter groups.

It was finally decided that the improvement of the method of telling radar information from No. 11 Group inherent in the new scheme was sufficient justification for its adoption. The G.P.O. were advised of the circuits required on 13 March 1941 and most of them were provided in the following month.[2]

[1] A.M. File S.3182/II.
[2] A.M. File S.3182/III.

One of the major problems of landline provision at this time was the increasing number of urgent requests for landline circuits. Urgent requests were made by signal, and complete details of the circuit required could not be given in a signal and it was therefore impossible for such requests to be properly checked at the Air Ministry before authority was given to the G.P.O. to proceed. The Air Ministry did not wish to withdraw from commands the right to make these urgent requests when necessary, but it was of vital importance that the facility should not be abused if it was to continue to function successfully. The Air Ministry therefore introduced legislation requiring the chief signals officers of commands to authorise all such requests personally, confirming them by letter with full particulars; all such requests were to be kept to a minimum.

The increased range of operation of fighter aircraft resulted in demands for additional Observer Corps landlines. As an instance, it became necessary for the southern sectors of No. 12 Group to have Observer Corps information of enemy aircraft flying over large areas of No. 11 Group not covered by the existing network of lines between the No. 12 Group sector stations and the No. 11 Group Observer Corps centres. A number of additional landlines were provided to meet this need.[1]

Group-to-Command Liaison Scheme

On 7 June 1941, Headquarters Fighter Command asked for the setting up of special direct speech lines to form a group-to-command liaison scheme whereby up-to-the minute information could be passed by the groups to headquarters. At this time the scheme had been in operation experimentally for one month, using existing lines; but this was causing delays, and special lines were wanted for Nos. 9, 10 and 12 Groups. No. 11 Group already had a special line for this purpose, and the amount of traffic for Nos. 13 and 14 Groups was light and could be handled on the existing lines.

In view of the number of direct speech lines already provided for various purposes between Fighter Command and its groups (seven to No. 9 Group, ten to No. 10 Group, and nine to No. 12 Group), the Air Ministry were reluctant to provide these additional lines. However, since the de-centralization to groups of filtering and plotting, Headquarters Fighter Command had been deprived of a good deal of information which they had previously received automatically. It was agreed by the Air Ministry that there was an operational requirement for facilities to enable Headquarters Fighter Command to keep in moment-to-moment touch with the progress of operations in the various groups.

The matter was examined at length, and in view of the necessity for giving the service, both at Stanmore and at the alternative Fighter Command Headquarters at Leighton Buzzard, and of its likely extension later to

[1] A.M. File S.3182/IV.

Nos. 13 and 14 Groups, it was decided to set up, as had already been done in Bomber Command, a liaison system between the groups themselves and the command headquarters; this was to be done by taking the most conveniently located group (Watnall) and setting up there a liaison operational P.B.X. with lines to the other groups and to command. Watnall was chosen because of the comparative immunity of its cable lines to the effects of enemy bombing. A P.B.X. was therefore set up there with lines to Nos. 9 and 10 Groups, a local line to No. 12 Group, and the line to Stanmore. Under this system, in the last resort, if both Stanmore and Leighton Buzzard were to be out of action, the operational side of Fighter Command would still be capable of carrying out a very considerable part of its function.

Liaison Officers were appointed at Headquarters Fighter Command and at each of the group headquarters concerned, in order to collect the essential information. Up to August 1941, existing communications were utilised in that the floor supervisor's line was made available for part-time use by the liaison officer (except at Headquarters No. 11 Group, where a special circuit was already provided). A stage was reached, however, at which these facilities proved inadequate, and on 19 August 1941, the G.P.O. were requested to provide additional circuits between operational switchboards, with extensions to the liaison officers. Investigation showed that, in order to provide these circuits, it would be necessary to appropriate further circuits from the public service, which was already suffering heavy delay through depletion to meet defence requirements. The G.P.O. suggested the use of Ministry of Home Security liaison circuits already provided over these routes in connection with the air route warning scheme. These circuits were relatively lightly loaded, and Fighter Command agreed to use them for liaison purposes.

Night Fighter Stations and Forward Airfields

The supply of teleprinters and the allocation of channels in the D.T.N. system did not permit the automatic inclusion of teleprinters in the communications planned for all stations. Each station was treated on its merits. However, on 28 November 1941, Headquarters Fighter Command asked for lines to be provided, where practicable, from night fighter stations and forward airfields direct to their group headquarters, on the basis of one teleprinter and one speech line for all such stations. A schedule of lines, covering some 20 night fighter stations and 15 forward airfields in the six fighter groups, was attached.

The majority of these types of station were connected to their parent sector by two speech circuits, with a teleprinter circuit to their group headquarters in some cases. Elsewhere, on operations lines, considerable difficulty was experienced with administrative and routine communications due to the limited periods at which these lines were free, and due also to the delay experienced in obtaining connection to the sector-to-group speech lines. It was therefore agreed by the Air Ministry, that, wherever provision was practicable, each forward airfield and night fighter airfield should have one speech and one teleprinter circuit direct to its group headquarters.

Due to the general shortage of line plant, it was only possible to establish lengthy private wires at this time by the appropriation of public service circuits; and in view of the important traffic carried by this service for the various government departments and supply organisations connected with the war effort, and the limited number of circuits available, the withdrawal of further circuits for the exclusive use of Service departments was only regarded as justified when the private lines were necessary for urgent operations concerned with the active defence of the country. The G.P.O. regarded the speech circuits requested for administrative traffic as lacking in the requirements necessary for exceptional treatment. They made alternative proposals which included the switching of other circuits or the establishment of prolonged trunk calls when normal communications were severed.

The Air Ministry replied that these night fighter stations and forward airfields were under the immediate control of parent sectors for operational flying, but were controlled in every other respect from their group headquarters; they were independent formations of a size comparable with that of a sector. Up to this point their speech communications with their group had been through their parent sector station, but this had overloaded the group sector circuits, and caused difficulties at the sector without providing what was needed at the forward and night fighter stations. The Air Ministry therefore requested that the telephone circuits be provided even at the expense of the public system. The G.P.O. reiterated their statement that these circuits could only be provided by appropriating further public circuits from routes where the demands of Service departments—chiefly the Air Ministry—had already caused serious deterioration in the standard of service available to government departments and war industries. The G.P.O. made further alternative proposals, including the use of teleprinters for this admittedly administrative traffic, and they also suggested that the requirement could be met by the daytime use of speech circuits between airfield and sector and between sector and group which were provided chiefly for operational use at night. Alternatively, the switching of suitable Observer Corps or anti-aircraft liaison lines during the day was suggested. But Headquarters Fighter Command rejected these suggestions on the ground that all these lines were in frequent use at all times.

The situation had thus reached a stalemate; on the one hand, Fighter Command and the Air Ministry were satisfied that these communications were essential, while, on the other hand, the G.P.O. felt that they did not measure up to the operational importance necessary to make further inroads into the public service justifiable. Correspondence had been carried out over a period of six months, and the matter was referred to a meeting of the Defence Services Line Telecommunications Board, who decided on 18 May 1942 that the original policy of routeing all administrative traffic through the appropriate sector should be reverted to. A new scale of speech circuits from sector to group was introduced, allowing two speech circuits to group for sectors with one forward and night fighter station, and three speech circuits for sectors with two or more forward and night-fighter stations.[1]

The adjustment of group boundaries, the transfer of stations from one command to another, and the revision of the function of certain stations, all caused changes in landline requirements. The Air Ministry delegated authority to Headquarters Fighter Command in November 1942 to approve and order short private-wire speech circuits not exceeding ten miles in length, requests being forwarded to Headquarters Fighter Command via the appropriate group headquarters; but all other requests were still channelled through the Air Ministry. A review of cable outlets from sector stations was carried out in September 1942, and these were increased where necessary. In order that communication to alternative airfields could be established at short notice, arrangements were made for prolonged uninterrupted telephone (P.U.T.) calls to be set up over the public network. Close investigation into all new landline requirements remained essential because of the general shortage of line plant, and investigations were also made into the necessity for all existing landlines at various times.

Friendly Fighter Plotting Organisation

It was considered necessary in September 1941 to set up an organisation known as the Friendly Fighter Plotting Organisation, first, to ensure that each fighter sector was fully informed of the movements of aircraft in other sectors which might enter its area, and secondly, to ensure that a sector which was controlling an aircraft was fully informed of the position of night-fighter aircraft in other sectors through which its own aircraft might pass in the course of a pursuit. Previously, such information had been passed by lateral circuits between sectors, but such circuits were inadequate in number and it was necessary for each sector to be connected to all other sectors adjacent to it. This called for a complicated network of circuits and led to difficulties in the interchange of information between sectors. Consideration was therefore given to the development of a system which would provide each sector with adequate information with the minimum landline provision. The only method which appeared to meet both requirements was for each sector to tell the positions of it's own aircraft to a central point where they could be plotted and told out to all other sectors simultaneously. It was proposed to put such a system into operation in No. 11 Group on a trial basis, using existing lines for telling and plotting. The G.P.O., however, while agreeing that facilities for a trial in No. 11 Group could be provided without undue difficulty, felt that, if the trial were successful, demands for similar facilities would arise in other fighter groups which, because of line plant shortage, could not be so readily met. They therefore suggested that

[1] A.M. File S.3182/V.

the system be designed on a basis of teleprinter working. The G.P.O.'s detailed proposals were agreed by the Air Ministry in October 1941.[1]

Landlines in Bomber Command

The growth of landline communications in Bomber Command during the war was immense, partly due to expansion and partly to the increasing control exercised by command and group headquarters as operations became more complex. The primary organisation of command-to-group-to-station-to-satellite, however, remained unchanged until 1943.

Up to the outbreak of war, the landline facilities for Bomber Command grew steadily on the basis of an accepted grouping of stations, but continued expansion resulted in a new plan being put into operation in September 1939 which completely altered the layout of Nos. 1, 2 and 6 Groups. The new signals requirements were met as far as possible on a short-term basis, but it was apparent that drastic reorganisation of signals facilities for these groups would be necessary. However, Air Ministry Signals did not feel justified in planning or making any wide changes as it was known that further expansion was in prospect and that the existing organisation was not permanent. The problems facing Air Ministry Signals at this time, including the very extensive nature of the landline requirements of the three operational commands, made it essential that planning take place a year in advance of the actual requirement. If sufficient notice of major reorganisation was not given, or if there were frequent changes of plan, special measures had to be taken, and these were often extremely uneconomical and even then did not always give the service needed.

Bomber Command's difficulty was that the location of a number of new stations in a particular area might so increase the load on one or more groups that it might become necessary to form a new group or at least alter the grouping of existing groups. Bomber Command liked to keep their groups on a functional as well as a geographical basis, and as long as they adhered to this policy, stations were always liable to be switched from one group to another as re-equipment took place.

The system of communications was generally a 12-channel system working back to command headquarters through Central from each group, and 4-channel systems working out from the group to each station. Until it was known how many groups there were to be, it was impossible to install the requisite apparatus at Bomber Command, and the same applied to the number of stations in each group. Air Ministry Signals went on pressing for some sort of finalised plan throughout 1940. The absence of such a plan during this period caused severe embarrasment to signals staffs, and was sometimes responsible for delays in connecting up new stations.

[1] A.M. File S.3182/IV.

Expansion

A memorandum on the expansion of Bomber Command up to December 1941 was eventually produced in November 1940. The proposals were made after consultation with representatives of the Director of Signals; and considerations of the availability of signals facilities exercised an over-riding factor in the selection of new locations, particularly for group head-quarters.

The new organisation placed the six operational groups at Doncaster, Norwich, Exning, York, Grantham and Huntingdon, and the three O.T.U. Groups at Abingdon, Wilmslow and Stratford. To provide teleprinter channels for the greatly increased traffic resulting from expanding opera-tional activities, the four heavy bomber groups were connected to Bomber Command direct by 12-channel equipment and the three O.T.U. groups plus Nos. 2 and 8 Groups by 4-channel equipment; this was in addition to the 12-channel linkage through Central. To provide rapid communica-tion between groups, 4-channel inter-linking equipment was provided on a lateral basis. For the increased communication which resulted in the maintenance and administrative units, which lay mainly in the west and north-west, direct linkage was provided from Headquarters Bomber Com-mand to the switching centres at Cheltenham, Preston and Liverpool. The schedule covering these and other lines and apparatus for Bomber Com-mand was prepared by the Air Ministry in December 1940, and the full landline schedule listed some 600 existing and 600 new circuits of all kinds; of the existing circuits, some 250 were due for recovery as the new organisation took shape. Private telephone wires were provided on the following basis:

(a) Groups with ten or more stations, one operational, one intelli-gence and two P.B.X.

(b) To smaller operational groups, and between groups and stations, one of each.

As a result of the advanced apparatus which had already been installed under the development programme, a very large proportion of the com-munications apparatus required was already in existence; but there remained a major installation requirement at the new Headquarters of No. 1 Group at Bawtry Hall, and to a lesser extent at two of the O.T.U. group headquarters.[1]

Other refinements carried out early in 1941 included the installation of operations switchboards at Command and group headquarters, and the provision of an alternative outlet cable route at each group headquarters, which allowed facilities for at least one circuit to Command and one to each station to be re-routed in emergency.

[1] A.M. File CS.10112/I.

The final location of No. 2 Group had been the subject of several changes of plan and continued to be unsettled. Norwich had originally been chosen, but its exposed position near the East Coast was not regarded as a desirable location for a group headquarters. The situation that had to be envisaged was that some of the stations on the East Coast might have to be evacuated or withdrawn; under these circumstances a headquarters located further west might still be able to exercise control of such stations by W/T or other means. Such control would be more difficult to maintain if the group headquarters itself had to move. The existing headquarters of No. 2 Group was at Huntingdon, to which it had been planned to move No. 8 Group Headquarters when No. 2 Group moved to Norwich, but it was decided in June 1941 to leave No. 2 Group at Huntingdon and to move No. 8 to a new headquarters at Brampton Grange.

By mid-1941, the scale of communications for operational satellite airfields came under review, and it was apparent that a considerable increase in communications would be necessary at these stations. The number of tie lines already in existence between parent and satellite stations was two; but it was decided that the needs of operational, administrative, meteorological and defence traffic demanded the provision of a third speech line. The connection of satellite stations to their parent station by teleprinter for operations and intelligence traffic was also desirable, but extensive G.P.O. commitments and the general shortage of landlines precluded this. It was decided that urgent operational traffic between station and satellite should be handled by despatch riders where the road distances did not exceed 15 miles. Three despatch riders were established for each link, non-urgent traffic being despatched by routine M.T. runs. It was rare for a satellite to be at a distance greater than 15 miles from its parent station, but where this occurred a teleprinter circuit was installed in lieu of the three despatch riders, together with sufficient teleprinter staff to maintain a 24-hour watch. The inclusion of satellite stations in the W/T standby point-to-point organisation was not considered essential, and the result of this policy was a considerable economy in signals and cypher personnel.

At this time, the further expansion of Bomber Command under a series of successive ' target forces ' was being planned; and as this expansion progressed it became of increasing importance that the Air Ministry Signals Branch be kept fully informed so that they could make their own plans accordingly. The increasing number of stations demanded a major adjustment to the organisation, and it was at first decided to increase the number of operational Bomber groups to eight, and subsequently as revised targets became known, to nine. Headquarters sites for the three new operational groups thus envisaged, plus a site for the third O.T.U. group headquarters, were chosen, and the whole lay-out of operational groups in Bomber Command was reorganised on the basis of seven ' clutches ' in each group, each clutch to consist of one parent and two satellite stations. But with the entry of America into the war in December 1941 and the resultant planning of their future contribution to the overall bomber effort, further major reorganisation was necessary. The U.S.A.A.F. began to move to stations in the No. 8 Group area in the spring of 1942, and when this area was filled to capacity they occupied two of the three new group areas planned. They subsequently expanded into the No. 3 Group area, No. 3 Group being reformed at Morton Hall, near Swinderby, in the third new Group Headquarters. The two headquarters for the Americans were not ready at once, and a temporary headquarters had to be provided at Old Catton, Norwich, formerly proposed as the headquarters site for No. 2 Group. The target date for the occupation of the two new headquarters (Marks Hall, near East Colne, and Elvedon Hall, near Huntingdon) was August 1942. The target date for the move of No. 3 Group to Marks Hall was September 1942. It was decided that the final total would be seven British bomber groups and six American.

Bomber ' Base ' Stations

The probability of the need for further reorganisation in Bomber Command was evident throughout 1942, and in November, final plans were crystallised and a Telecommunications Instruction issued by the Air Ministry.[1] Under the new organisation, the principle of the Bomber ' base station ' was established. The seven operational group headquarters each controlled five bases, each base comprising a total of three stations. This involved a considerable increase of responsibility at the base station. The situation at the group headquarters was little changed, but the establishment of the base stations required considerable reorganisation. The increased circuit requirement was met by a fresh basis of provision at bases of 28 pairs in the main outlet and 20 pairs in the alternative outlet. Stations other than bases had one outlet, generally of 20 pairs.[2] Arrangements also had to be made for additional outlets by Headquarters Bomber Command, where main underground networks reached saturation point. Bases were located at existing parent stations and the old satellite stations were brought up to full station status. The organisation began to come into force straight away but was not fully equipped until 1944.[3]

The final scale of circuit provision in the private-wire network in Bomber Command was :—[4]

Command to Group	2 Ops.	2 Admin.
Group to Base	1 Ops.	4 Admin.
Base to Station	2 Ops.	2 Admin.

The majority of these circuits were 4-wire amplified circuits with an overall transmission equivalent of 3 decibels. Long-distance teleprinter circuits were provided to the following scale:—

[1] A revised Instruction dated 7 December 1942 is at Appendix No. 5.
[2] A.M. File CS.10112/I.
[3] A.M. File CS.10112/II.
[4] A.H.B./IIE/76A.

Command to Group	2 Ops.	3 Admin.	
Group to Base	2 Ops.	3 Admin.	1 Met.
Base to Station	1 Ops.	1 Admin.	1 Met.

Speech and teleprinter facilities were also given from Command and group headquarters to one or more of the main switching centres, and Command was connected to the Air Ministry and to other Services and commands. In order to facilitate the provision of the long-distance network, D.T.N. centres were established at Command and at each group. At Headquarters Bomber Command the signals equipment was accommodated in a protected underground building, while at groups the equipment was accommodated in surface buildings of many types. Many difficulties were experienced in finding suitable accommodation at group headquarters, wooden huts, converted stables, and specially designed brick buildings all being used. Eventually, in order to obtain a building which could be quickly erected with a minimum of labour, it was decided to use a 30-foot Nissen hut, which gave a reasonably satisfactory layout. This hut was erected in the immediate vicinity of the main headquarters building. The layout of the equipment and facilities was designed by mutual co-operation between the Post Office and the R.A.F. to meet the particular traffic requirements of each formation.

Alternative routeing had always been the policy, and each D.T.N. centre, and many of the airfields, had at least two outlet cables to the main network, travelling by separate routes. Similar arrangements to these were adopted at group headquarters. The routeing of private wires was so effectively designed that at no time were the communications from Command to any of the group headquarters completely cut. Mobile D.T.N. and operational equipment was available to facilitate the restoration of communications in emergency.

The maintenance procedure followed for the private wire network conformed to standard practice for all normal circumstances, but a special procedure was used in the event of a major breakdown to ensure that the restoration of communications required for current operations was as expeditious as practicable. Under this scheme, all major failures were reported to Headquarters Bomber Command, who were in a position to assess the comparative urgency of the repair work in accordance with the current operational requirements. When the necessity arose, Headquarters Bomber Command allotted a priority for restoration and advised the Air Ministry of the situation. The Air Ministry then reviewed the requirements of all commands and arranged with the G.P.O. for the essential circuits to be re-routed. The use of this procedure was rigidly controlled at Headquarters Bomber Command and it was rarely necessary to request re-routeing as administrative private wires were diverted to replace faulty operations circuits as far as possible. This was liable to produce congestion on the administrative network, and under these circumstances special steps were taken to restrict the volume of administrative traffic.

The Headquarters Bomber Command P.B.X. installation was originally a 5-position one, but this was later extended to twelve positions plus facilities for a supervisor and an enquiry desk. At group headquarters a 3- or 4-position P.B.X. was sufficient. Bases had a 3-position P.B.X. and operational and O.T.U. stations 2-position. Enquiry traffic on these exchanges was dealt with by providing an extension telephone to the supervisor.[1]

At the beginning of the war, the operations speech network was terminated on keyboards at command, groups and stations. Two keyboards were provided at each formation, one for the operations staff and one for the intelligence staff. The keyboards were operated by the respective operations or intelligence controllers, and gave good service until 1941, when it was decided, for a number of reasons, to provide an Ops. P.B.X. Traffic had increased to such an extent that controllers had difficulty in performing their duties in the time left to them between telephone operating; the keyboards were not designed for the interconnection of private wires and no supervisory facilities were provided; the increase in the number of officers engaged in operations matters made it necessary to provide additional local extensions beyond the capacity of the keyboards; greater circuit efficiency could be obtained by providing a centralised P.B.X. service to both operations and intelligence; and conference facilities had become essential. In the early days of the war, successful conferences were held by throwing a number of line keys on the Ops. keyboard to bunch the required circuits. The transmission equivalent of the private wires was such that this arrangement met the requirement so long as the maximum number of lines did not exceed six; but with the expansion of the bomber force it became necessary to introduce conference amplifiers, and this was done at the same time as the provision of the Ops. private branch exchanges. The first amplifier installed was unsatisfactory, and eventually a 32-way conference amplifier with key switching was introduced in 1942. Further improvements in design, permitting the holding of two simultaneous conferences, were introduced in 1944. At group headquarters, 8-way conference amplifiers were installed to enable conferences to be held with bases, but it was found that this did not fully meet the requirements of the operational groups. The requirement was eventually met by the provision of new equipment known as Flight Planning Conference equipment, providing full intercommunication facilities between three telephone points at group headquarters, one telephone point at each base, and one at each station. Loudspeaker reception was provided at group, base and station.

Intruder Warning System

In order to land returning aircraft of the bomber force at night, it was necessary to use the airfield lighting system, and this invited the attention of the intruder. The success achieved by the enemy in this form of warfare did not compare with that achieved by the R.A.F., but even so, the enemy

[1] A.H.B./IIE/76A.

intruder was a potential danger at all times. A number of schemes were therefore evolved to warn airfields of the approach of intruders and to divert returning bomber aircraft, and the final intruder warning scheme relied on information from R.O.C. centres and Fighter groups being passed to the relevant Bomber group so that information could be broadcast to stations and aircraft diverted where necessary. Communication to the R.O.C. centres was established by so-called prolonged uninterrupted trunk calls (P.U.T.), since the facilities were only required in the hours of darkness. The information was passed to the stations over the flight planning conference network, where this existed, and otherwise was broadcast over the administrative private wire network.

Airfield Communications

The size of airfields increased considerably in the course of the war and the policy of dispersing both aircraft and living quarters involved considerably increased cabling work to provide the necessary communications.[1] The cabling work to be provided comprised, first, an outlet cable, or where practicable two outlet cables on different routes, to give access to the airfield from the G.P.O. cable network to provide private wires and exchange lines. These cables were either 28-pair, 20-pair and 14-pair on alternate routes, or a 14-pair for satellite airfields. The cables were usually several miles long. Secondly, a distribution network was required to serve local extensions, also a perimeter cable to serve aircraft dispersal points, defence posts etc. This perimeter cable was 10-pair originally, but was later increased to 20-pair and finally became 38-pair for all new airfields. The layout of the cable was the subject of much debate and a standard arrangement was finally agreed in which blocks of pairs were allocated for the various services and all of these pairs were taken in and out of each point at which the service was required; for example, four pairs were allocated for the airfield controller and all were made available at the end of each runway. Thirdly, remote control cables were required to the wireless transmitting station and to the H.F. D/F station or stations.

Landlines in Coastal Command

In 1939, a new Coastal Command Headquarters was sited at Eastbury House, Northwood, Middlesex. After discussion with the G.P.O. and examination of the cable facilities available, it was decided to lay a cable from Northwood to Watford of approximately 150 pairs to cover the requirements of the new Headquarters and those of the G.P.O. The Air Ministry rented 100 pairs between Northwood and Eastbury House and 100 pairs between Eastbury House and Watford, the remaining pairs being available for the public service. At Northwood, access was available to the Air Ministry Central Exchange at Leighton Buzzard, the West of England, Midlands, and the North via Aylesbury, to Bentley Priory via Hatch End.

[1] A.H.B./IIE/76A.

and to London. Coastal Command's teleprinter requirements were met by physical tails off R.A.F. repeater stations Nos. 1 and 2 at Bentley Priory and Uxbridge in Phases 1 and 2 of the D.T.N. This gave all the required circuits to Chatham, Plymouth, Donibristle, the Orkneys etc.[1]

The General Reconnaissance (G.R.) groups in existence at the outbreak of war were No. 15 at Plymouth, No. 16 at Chatham and No. 18 at Donibristle. Because of the vulnerable position of the headquarters at Chatham, a scheme was introduced in November 1939 for the control of No. 16 Group communications in the event of Chatham and its communications being damaged beyond immediate repair. In such an emergency the group was to be re-formed at Northwood, and circuits were provided to allow skeleton control of the group from this location.[2]

The first Area Combined Headquarters were formed at Donibristle, Chatham and Rosyth, and the scale of landline and teleprinter provision was laid down by the Air Ministry Landline Committee before the war. The standard provision between an Area Combined Headquarters and each unit was one speech and two teleprinter plus one meteorological teleprinter circuit.

In June 1940, it was decided that control of the Western Approaches both north and south should be vested in the C.-in-C. Western Approaches, Plymouth, with a small headquarters operating under him at Greenock. A small R.A.F. wing headquarters was formed at Greenock, controlling stations at Aldergrove, Oban, and Stranraer. Circuits connecting Greenock to Plymouth were pooled between the Services. In September 1940, it was decided to move the C.-in-C. Western Approaches and the Headquarters of No. 15 Group to Liverpool, and teleprinter and speech circuits were re-routed as necessary. In consequence of the move of No. 15 Group Headquarters, it was decided in December 1940 to form a new Coastal Group Headquarters, No. 19 Group, at Plymouth, to control G.R. stations in the west, including Pembroke Dock, St. Eval and Mount Batten. No. 15 Group at Liverpool controlled stations at Aldergrove, Benbecula, Eglington, Hooton Park, Limavady, Oban, Port Ellen, Stornaway, Stranraer, and Tiree. No. 16 Group at Chatham controlled Bircham Newton, Detling, Felixstowe, North Coates and Thorney Island. No. 18 Group, now at Pitreavie, controlled Dyce, Invergordon, Leuchars, Sullum Voe, Sumburgh, Thornaby, and Wick. The transfer of Area Combined Headquarters and Headquarters No, 18 Group from Donibristle to Pitreavie took place towards the end of 1940, a schedule of lines to be transferred being given to the G.P.O. and the circuits being transferred in three stages.

The standard allotment of landline communications for stations in Coastal Command was accepted up to September 1941 as being one speech circuit and one four-channel Voice Frequency (V.F.) telegraph circuit (or equivalent Tariff 'A' circuit) from station to group. The speech circuit was allotted as

[1] A.M. File S.48120.
[2] A.M. File S.48852.

the reserve V.F. telegraph circuit. This scale of provision was felt to be too small. The taking over of the only speech line to maintain the telegraph circuits left a station with no operational communications, and it was the experience that the small scale of provision led to considerable difficulties when there were cable breakdowns, stations frequently being completely isolated. The addition of a further line for each Coastal station had been under consideration for some time, and it was left to Coastal Command to decide whether they preferred a new speech line from each station to its parent group or to one of the main inter-Service exchanges. To connect all these lines to Central would have meant very long lines in most cases and would also have clogged lines outwards from Central. Coastal Command asked for these circuits to be provided from station to group by a different route from the existing speech circuit, to minimise the effect of local damage to cable. Each station was discussed separately, and where a direct station-to-group line could not be easily provided, a connection was made to a convenient main inter-Service exchange. Arrangements for the laying of the second speech line, which acted as a reserve V.F. telegraph circuit, were completed by the G.P.O. in January 1942.[1]

Other Coastal Command responsibilities included a training group—No. 17—at Gosport, and stations in Iceland. Stations in No. 17 Group included Abbotsinch, Calshot, Catfoss, Chivenor, Greenock, Gosport, Helensburgh, Silloth, and Squires Gate. The siting of the headquarters at Gosport, in a group where the majority of the stations were in the north, raised considerable communications difficulties, and the headquarters was later moved to Edinburgh, and stations in the south relinquished. The main outlets from the new headquarters were via the switching centre at Cambuslang. This was not always satisfactory and led to serious delays. A number of new stations were opened in No. 17 Group in 1942/43, including Crosby, Castle Kennedy, Cranwell, East Fortune, Haverfordwest, Invergordon, Long Kesh, and Turnberry. A teleprinter circuit was provided for each station.

Iceland was placed under the operational control of No. 15 Group, Liverpool, to fit in with the new area controlled by C.-in-C. Western Approaches. The arrangements necessitated an increase in operational and point-to-point landline and W/T facilities for No. 15 Group. A number of transmitters were allotted at Symington for Headquarters No. 15 Group, with remote control circuits linking Liverpool and Symington.

Considerable expansion took place in Coastal Command in the course of 1942, new stations being built at Talbenny, Banff, Skitten, Holmesley South, Zoyland, Wig Bay, Dunkeswell, Mullaghmore, Davidstowe Moor, Langham, Dallachy and Tain. Dates for the opening of each station were notified to Air Ministry Signals, who arranged provision of standard speech and teleprinter facilities with the G.P.O.[2]

[1] A.M. File S.3181/III.
[2] A.M. File S.3181/IV.

In 1942, a new signals and operations block was built underground at Northwood. The existing operations room was retained and the underground operations block designated an emergency operations room, enabling the existing emergency operations room to be relinquished. The administrative switchboard, the D.T.N. switchboard, and the teleprinters were all moved into the new underground block. Remote control lines, D.T.N. keying circuits, and other appropriate lines were extended from the existing to the new underground block in February 1943.[1]

A marked increase in the volume of traffic followed the opening up of the new stations, and was swelled by an increase in P.R.U. traffic and intensification of the anti-submarine campaign. Duplex teleprinter facilities were therefore provided between Northwood and the operational group headquarters at Liverpool, Pitreavie, and Plymouth, in 1943.

When the standby W/T organisation was generally suspended in January 1945 it was still retained as a standby to landline to the outer isles of Scotland. No. 18 Group had stations at Stornoway, Sumburgh, and Sullum Voe. Under normal fault conditions it was possible to restore the line communications serving these stations on a reduced scale within a few hours, but under abnormal conditions stations were liable to become isolated.[2]

Transport Command

Prior to the outbreak of war, signals facilities had been set up throughout the world for a rapidly expanding network of Civil air-routes. About 100 radio stations were in operation along the British Empire Routes alone, whilst in Europe some 500 miscellaneous installations had been established by 1939. On the overrunning of Europe and the entry of Italy into the war, British external air services were curtailed, or diverted through territories in which there had been little need to establish civil signals facilities before the War. At the same time an expansion of the R.A.F. overseas signals organisations occurred and the Air Force assumed general control of telecommunications, portions of the civil signals system being employed to serve R.A.F. operational purposes, including reinforcing and delivery routes. The position on the formation of Transport Command in March 1943 was that control of the telecommunications for British civil and military air transport services was in the main vested in the R.A.F. and requirements were met by a combination of R.A.F. and pre-war civil aviation installations. In addition, the British Overseas Airways Corporation (B.O.A.C.) had been permitted, where no other course lay open, to erect and operate certain stations on an agency basis on behalf of the proper authorities.

Hitherto the major signals planning and organisation for British reinforcement and delivery routes had been undertaken by the Air Ministry, because the various sections of the routes lay under the authority of different R.A.F. commands (and partly because of the remote location of R.A.F. Ferry Com-

[1] A.M. File S.48120.
[2] A.M. File S.3181/VII.

mand in Canada). As for the routes operated independently by B.O.A.C., responsibility rested with the Director General of Civil Aviation (D.G.C.A.) in conjunction with D.G. of S. With the setting up of Transport Command in England, and by virtue of the provisions of the White Paper issued at that time defining the responsibilities of the Command with respect to B.O.A.C., the procedure for planning, organisation, control and operation of telecommunications for reinforcing, delivery and air transport routes was revised.

In order to regularise the position regarding communications for Civil Aviation and to provide a signals system to cover the needs of Transport Command, the aim was the provision of a signals organisation to serve British Transport routes during the war and the immediately ensuing period, the organisation to be capable of adaptation to the probable requirements of Civil Aviation in peacetime. Considerable expenditure on stations and equipment had been incurred in the past by Dominion, Colonial and Foreign administrations in building up a signals organisation for Civil Aviation, and it was clearly uneconomic not to consider them in the signals requirements for Transport routes. In certain territories (e.g. Bermuda) the local government had accorded to Cable and Wireless Ltd. a monopoly of civil telecommunications and the company was in possession of first-class cable and wireless facilities. Due regard was therefore paid to the part which Cable and Wireless could play in the air transport signals organisation. In providing communications for B.O.A.C. on routes which crossed or terminated in neutral countries, special problems arose, and negotiations were required with which it was inexpedient for military authorities to deal. Point-to-point and air/ground communications had to be maintained between British and neutral ground and aircraft stations, and these could only be carried out by British civil stations. Control of civil signals stations in the United Kingdom was exercised by the Air Ministry (D.G. of S.).

To ensure a homogeneous organisation, the planning of the signals organisation for Transport Command and Civil Aviation services operating over routes under the control of the Command was made the responsibility of Headquarters Transport Command, these plans being agreed with Air Ministry (D.G. of S.) to enable co-ordination of arrangements to be made with other commands and other governments. Detailed planning of requirements within the United Kingdom to meet Transport Command and Civil Aviation services was also the responsibility of Headquarters Transport Command. The planning of stations and their requirements took into account existing R.A.F. stations, Dominion and Colonial stations and the facilities available from civil communications companies. The facilities afforded by these stations, and their strengthening to meet requirements, were examined for inclusion in the plan before consideration was given to the planning of new stations.[1]

[1] A.H.B./ID/21/3/S.43.

Landlines for Regional Control Stations

The landline facilities afforded to regional control stations in 1940 were one speech line to the No. 1 H.F. D/F station, one speech line to the No. 2 H.F. D/F station, one speech line to station signals, two speech lines to the station P.B.X. and one speech line to the meteorological section. Experience in the operation of these stations, however, showed that rapid communications between individual regional control stations were absolutely essential if the safety of aircraft returning from operational flights was to be secured, especially when aircraft had to be diverted away from their home stations as a result of local or general deterioration of weather conditions. It was considered that the function of these stations in assisting aircraft in distress through navigational errors, fuel shortages, or diversion, could only be fulfilled if tie-lines were provided between individual stations. The ideal was for all these centres to be directly interconnected, as all operational tie-lines were already subject to heavy demands, and delays were frequent. Unfortunately the heavy demands which operational needs were making on G.P.O. line construction in general made the laying of direct tie-lines between regional control stations prohibitive. A compromise was reached in which three additional circuits connecting regional control centres were provided, together with the introduction of a special priority for use by regional control officers when passing urgent calls: this priority took precedence over 'Immediate' calls but not over 'Most Immediate' calls.[1] There were eleven regional control stations in existence at this time, and tie-lines connecting them were still regarded as being ultimately necessary.

The regional control scheme was revised in July/August 1940, giving a small increase in standard telephone facilities; and later a 10-line magneto switchboard was authorised for all regional control offices. But great embarrassment to the efficient working of the system continued to be caused through the lack of direct tie-lines between centres. As an instance, on the night of 16/17 October 1940, fourteen heavy bombers crashed on their return from operations against the Atlantic ports, mainly as a result of encountering unexpectedly adverse weather conditions in Yorkshire and East Anglia: the weather at St. Eval was favourable, and had there been reasonable telephone facilities available between the groups concerned and St. Eval it was considered that a number of the aircraft affected could have been safely diverted and several crashes avoided. In the event, calls to St. Eval using control priority were almost impossible to get through, and the diversions could not be made. However, it remained impossible to provide any more landlines before January 1941 at the earliest, and it was therefore arranged for regional control traffic to be given priority on the administrative tie-line between St. Eval and Headquarters No. 10 Group, Rudloe, it being possible to provide at once a direct line linking Rudloe with the regional control station at Boscombe Down.

Early in 1941, a requirement arose for a loud-speaking intercommunica-

[1] A.M.O. A.166/1940.

tion system to enable the W/T operator on aircraft safety guard duties at regional control stations to pass messages direct to the control officer in an adjacent room without leaving his seat. To meet this requirement, Ediswan speaker-phones were supplied and installed by the G.P.O. Later, in April 1941, a requirement arose for similar communications between the regional control officer and the H.F. D/F stations under his control; and at the same time the operator on aircraft safety guard was moved to one of the H.F. D/F stations. As a result, a master loud-speaker was installed in regional control offices with an extending speaker at each D/F station.

Up to April 1941, communications for regional control purposes were set up mainly on the R.A.F. administratve network. In order to improve these facilities, it was proposed to make the movement liaison service network of communications available to regional control stations, and with this object in view, a number of circuit rearrangements were made by the G.P.O. in June 1941. Keyboards were now required for each main (Type 1) regional control station, and later, in September 1941, smaller keyboards were installed at Type 2 stations. The primary purpose of the keyboards was to avoid the use of a large number of separate telephone instruments in the regional control room.

Communications for eight new regional control stations were planned in August 1941. In most cases outlets to the movements liaison service already existed, or could be provided easily. Loud-speaker facilities remained standard at all Type 1 stations. By the end of 1941, there were over 30 Type 1 regional control stations in all commands and just under 30 Type 2 stations. By March 1942 it was the policy that every airfield in the country, with the exception of relief landing grounds and a few others, should have regional control facilities, the great majority (about 400) being Type 2 stations. The release of H.F. D/F fixer and H.F. R/T relay stations by Fighter Command, on the general fitting of V.H.F. in that Command, resulted in many of these stations being transferred to provide H.F. D/F facilities for regional control purposes, with an attendant transfer of lines. Ten-line keyboards were provided at the Type 1 stations and 5-line keyboards at the Type 2.[1]

Landlines for Cathode-Ray D/F Stations

In December 1939 it was found necessary to give long-distance bomber and reconnaissance aircraft improved facilities, and this was done by means of Cathode-Ray D/F stations. The greatly increased range of the latest type of operational aircraft necessitated the baselines of these D/F systems being long, to make the angle of cut of the D/F bearings as large as possible at long range. Owing to the length of these baselines it was decided to link their extremes by wireless rather than landline. Remote control circuits, however, were needed to the associated transmitters. The chief landline requirements were:—

[1] A.M. File S.59743/I.

(a) Telephone lines from each D/F station to the nearest suitable radio transmitting station.

(b) Keying lines from each D/F station to its associated transmitters.

(c) Telephone lines from each D/F hut to the local exchange.

(d) Telephone lines from each control D/F point to the Headquarters of both Bomber and Coastal Commands, either direct or via the nearest communication point.

(e) Base-line linkage. This was given by the use of T.1087 transmitters, for which keying lines were required.

To maintain communication with aircraft at long range, powerful W/T transmitters were required, and the housing, power supply, and aerial systems for these transmitters were the chief factors in deciding their location. The main control centre was fixed at Butser; this site was selected because it gave a good D/F location and short landline connection to a convenient W/T station at Stubbington, near Lee-on-Solent, where accommodation existed for the installation of two high-power transmitters. The third Butser transmitter was located at Dagnall, and two more transmitters were located at St. Eval. The results of plots were communicated by Butser, by landline, direct to Headquarters Bomber Command and via Gosport to Headquarters Coastal Command; and by St. Eval, to Headquarters No. 15 Group at Plymouth and thence to Headquarters Coastal Command.

The cathode-ray D/F system was reorganised in February 1943, first because the introduction of radar aids in Bomber Command had taken the place of cathode-ray D/F in that Command, and secondly, because long-range D/F facilities were required for the newly formed Transport Command. A central control plotting station was formed at St. Helens, with cathode-ray D/F stations at Sandgerdi, Dyce, Ballywattick, St. Eval and Butser. The control station at St. Helens was linked to the North-West Central switching centre by speech and teleprinter circuits, for communication with the parent groups and stations of the aircraft concerned. St. Helens was also provided with reception facilities on all the air-to-ground frequencies in use on the system. Adequate speech and teleprinter circuits were provided between North-West Central and Transatlantic Aircraft Control (T.A.C.) Prestwick, Overseas Aircraft Control (O.A.C.) Gloucester, and Headquarters No. 15 Group. Later, St. Helens was connected direct to Headquarters No. 15 Group.

By October 1943, the passing of bearings from the cathode-ray D/F stations to the control station at St. Helens by point-to-point W/T had become congested, and direct landline circuits to St. Helens from Dyce, St. Eval, Butser and Ballywattick were requested. These circuits were provided in 1944, and a combiner unit was installed at North-West Central from which a single line was taken to St. Helens. In order to avoid congestion on this line, all cathode-ray D/F lines were extended to teleprinters at St. Helens.

The cathode-ray D/F system was again reorganized in June 1944. In order to operate the new organisation, four voice-frequency channels were provided between St. Helens and each group of cathode-ray D/F stations (Dyce, Ballywattick, St. Eval, Butser); one speech circuit was provided from St. Helens to each of T.A.C. Prestwick, O.A.C. Gloucester, and Headquarters No. 15 Group; and two telephone circuits were provided from St. Helens to T.A.C. Prestwick and one to O.A.C. Gloucester and Headquarters No. 15 Group. The W/T point-to-point circuits provided were one medium power H.F. circuit from St. Helens to Sandgerdi (for which there was no landline available) and standby circuits for all the landline reporting circuits. The system of air-to-ground communications was also revised under this reorganisation.

Remote Control Lines

Prior to the war, the Air Ministry were operating a number of wireless stations for communication to overseas R.A.F. stations and for communication with aircraft. Most of these were small stations having both receiving and transmitting sections in the same area, the connecting cable for remote control being provided by the Works Department of the Air Ministry. At the more powerful stations, however, where the separation distance between the receiver and transmitter had, for technical reasons, to be greater, circuits for remote control were hired from the G.P.O. With the growth of these stations, both in power and number, and the need for control over longer distances, together with the advent of the D.T.N., it was desirable that the G.P.O. should supply and fit the necessary remote control lines and apparatus. The immediate requirements in May 1939 were concerned with the new W/T stations at Leighton Buzzard, Dagnall and Dunstable. Control of the transmitters at Dagnall was required at Leighton Buzzard and at Dunstable, and also at Headquartes Bomber and Coastal Commands and at Bomber and Coastal groups, the routeing of these lines to be over the D.T.N. into Leighton Buzzard, at which point the channels would be switched to control the transmitter or transmitters required. This meant a switchboard at Leighton Buzzard to which all lines to Dagnall were connected, a relay rack at Dagnall to carry the relays controlling transmitters, and a small jack field at Dunstable for permanent lines and apparatus. Cable provision was made and apparatus supplied and maintained by the G.P.O.[1]

Normally, each group headquarters controlled its own transmitter, but it was realised that, under conditions of emergency, it might become necessary for any group to take control of transmitters usually associated with other groups. A new scheme was therefore devised in June 1940 which necessitated a changeover panel at groups. D.T.N. channels between groups and a central switching point at Leighton Buzzard were earmarked for remote control purposes, but so that they should not remain idle when not required for remote control, they were connected to the D.T.N. switchboard via the

[1] A.M. File CS.22974.

changeover panel at groups and the jack field at Leighton Buzzard. The methods of keying transmitters by remote control were not standardised, and as a result a meeting was held at the Air Ministry on 31 October 1941 to discuss the various methods of remote keying and control then in use with a view to deciding on a standard method in order that simple interchange between controlling stations and controlled transmitters would be possible.

Originally, double current keying had been used, but due to severe interference from key clicks, this system was abandoned in favour of impedence keying, which became more or less the standard system. Impedence keying, however, was only satisfactory up to a maximum of about two miles, and because transmitting stations often had to be sited more than two miles from receiving stations, difficulty was experienced in making the impedence system work satisfactorily in all cases. Towards the end of 1940, a new system was designed by the R.A.E. using tone-to-line keying. This system was at first put to use at two or three stations only, but in October 1941 it was proposed to make it the standard system. It was essential that some form of standard control be introduced as soon as possible at all big Air Ministry W/T stations; and as nothing so far had been arranged for the control of transmitters at the new station at Winstone, it was a convenient moment to introduce whatever system was finally decided, starting with Winstone and bringing existing installations into line with the new system subsequently. The types of control necessary at Birdlip were :—[1]

(a) Control of various types of transmitter at Winstone from receiver positions at Birdlip.

(b) Control of high power transmitters only, from any part of the country, via the D.T.N. system with terminal equipment at Birdlip.

It was agreed at the Air Ministry meeting of 31 October 1941 that the new tone-to-line keying system would be the best method of meeting the first requirement, while the second requirement was met by devising an inter-connecting unit to go between the output of the D.T.N. equipment and the receiving end of the tone-to-line system. Both systems employed the double current method, the D.T.N. being transferred to double current before coming up on the jack field.

Up to this time, no standard jack field had been provided to cater for complete flexibility of connection between D.T.N. and tone lines, and a scheme was therefore devised which involved the following features :—

(a) Every transmitting and receiving station requiring both tone and D.T.N. keying was fitted with a remote control panel.

(b) Every transmitting and receiving station was fitted with a remote control panel on which cross connections between transmitters and lines were carried out in the normal manner.

[1] A.M. File CS.22974.

(c) Each receiving position at the receiving station was fitted with a special type control unit for tone keying purposes and also an auxiliary jack for D.T.N. keying.

(d) At D.T.N. centres where the switching of lines for remote control was necessary, a small changeover panel was fitted to facilitate rapid inter-connection of D.T.N. lines (this type of panel was only installed where there was no receiving or transmitting station nearby).

All control circuits terminated on the standard jack field, and all signals passing through were double current. To cater for full flexibility a larger number of channels were required, which were used to carry alternative teleprinter traffic, being routed in such a manner as to allow them to be picked up at a moment's notice on the jack field.

It was some time before the installation of the new standard equipment could be completed, and in May 1942 Headquarters No. 26 Group complained of the delay and pointed out that installation had become a matter of extreme urgency, upon which depended the rapid and successful carrying out of any diversions of W/T services in emergency. Agreement on the proposed system, using double current throughout, and on the details of circuits and the supply of equipment, was reached in June 1942, and the new system was first tried out on the Birdlip/Winstone control link. Subsequently the larger Air Ministry W/T stations used these two basic types of remote control only—keying via D.T.N. and keying to tone.

At the end of the war, the standard installation for the remote control of all small local continuous wave (C.W.) and R/T transmitters remained tone-to-line keying, using the control unit Type 88 at the receiving station and control unit Type 10 at the transmitting station, multi-power cable being provided between the operating room and the transmitting station at the rate of one pair per transmitter. At main W/T inter-command stations, and at transmitting stations at which individual transmitters might need to be keyed by any one of several receiving stations or formations (especially if these keying positions were widely separated from their associated transmitters), the double current system, employing 80 volt negative and 80 volt positive for mark and space respectively, was used. All the R.A.F. inter-command transmitters at home were keyed in this way, the result being that any main receiving station in the U.K. could key any of the transmitters at any of the main inter-command transmitting stations if required. Similarly, Bomber Command group transmitting stations could key the transmitters of any other group as occasion demanded.[1]

Telephone Lines at New Stations

It was decided in January 1942 to delegate the responsibility for arrang-

[1] A.M. File CS.22974.

ing the detailed provision of local telephone and landline facilities at new R.A.F. stations to Headquarters No. 26 Group and instructions to this end were given by the Air Ministry on 10 February 1942, to be brought into force on 15 March 1942.[1] As soon as a new site was selected for consideration, D. of Tels. notified the G.P.O., forwarding a location plan, in order that any serious objections on the grounds of inaccessibility, necessity for diversion of main cable routes etc. could be stated. The G.P.O. then indicated all overhead routes existing within one mile of the tentative boundary of the new airfield and any main cables which might require diversion, either if the boundaries remained as planned or if the runways were extended at some future date. The G.P.O. also indicated the most suitable area for the termination of their cable; the terminal point was normally in the technical area, or the operations block if this was sited away from the technical area. If necessary, the G.P.O. gave reasons why they would prefer to avoid any particular area. They also advised the Air Ministry which telephone manager would be concerned with the actual installation work if the site was accepted.

As soon as possible after the site was accepted and its function decided, Air Ministry gave the G.P.O. a site plan showing the proposed location of the technical area and operations block together with details of the main requirements :—

(a) Outlet cable.

(c) Size of P.B.X. switchboard.

(b) Perimeter cables.

(d) Maximum number of exchange lines likely to be required, including provision for the resident engineer in advance of the opening of the station.

(e) Particulars of any overhead telephone or telegraph routes in the vicinity which were flying obstructions and which must be diverted or placed underground.

(f) Any available information regarding extensions of runways likely to affect the proposals for the diversion of overhead routes or main cables.

(g) Particulars of operations room requirements (keyboard or special P.B.X. etc.), except in the case of fighter sector stations, which were dealt with separately in view of their complex character.

Five copies of the site plan, together with a copy of the letter to the G.P.O. giving the main requirements, were sent to Headquarters No. 26 Group, who forwarded three of these copies, together with details of the local telephone requirements, to the telephone manager. One copy of the plan, and of the letter to the telephone manager, was sent to the command under whose control the new station fell. Every effort was made to include

[1] A.M. File CS.12488.

in the particulars sent to the telephone manager the details of all remote control circuits, as these sometimes affected the size of the outlet or other cables: to this end, wireless stations were generally sited if possible in the early stages. Other responsibilities of No. 26 Group included arranging meetings on site with the local G.P.O. representative to decide layout details and to watch progress, maintaining liaison with commands, and advising the Air Ministry of any major difficulties.

Particulars of the agreed facilities at all types of station were promulgated in March 1942.[1] Variations in detail were permitted but additions to the provisional establishment needed Air Ministry authority.

Communications for the American Air Force

The scale of communications at formations and bases of the U.S.A.A.F. was, broadly speaking, the same as that agreed for British formations and bases of a similar nature. The major requirement was for the VIII Bomber Command, and in the course of 1942/43 the Americans were in the process of setting up a number of air divisions, the equivalent of R.A.F. Bomber groups. The plan was to form four air divisions in all, each controlling five or six combat wings (the equivalent of Bomber Command base stations), which in turn controlled a clutch of three groups (the equivalent of Bomber Command sub-stations or satellites). The chain of operational and administrative control was :—

(a) Air divisions exercised control over combat wings, and each combat wing over its three groups.

(b) Administrative control was direct between air divisions and groups through the administrative facilities of the combat wing.

An Engineering Instruction was issued by the Director of Telecommunications, Air Ministry, on 19 June 1943, giving full details of the telecommunications arrangements for VIII Bomber Command.

American stations were joined to the D.T.N. in exactly the same way as R.A.F. stations. However, the production of the British type of teleprinter by Creed's was not sufficient to satisfy the demands of both Services, and at an inter-Service meeting held at the Air Ministry on 7 December 1942, a Technical Sub-Committee was formed to investigate the difficulties to be overcome in working American teletype machines to the British Creed teleprinter. This Committee was subsequently taken over as a Sub-Committee of the British Joint Communications Board. It was essential that complete flexibility of working between the types of machine be achieved, as they could not be segregated in the various theatres of war, due to distribution and maintenance difficulties. Modifications to the American teletype machine were carried out so as to make it operate satisfactorily at the speed of the British teleprinter. The only other diffi-

[1] The provisional telephone establishments at the two biggest types of operational station—bomber stations and fighter sector stations—are shown at Appendix No.6.

culty involved traffic procedure; and joint procedure regulations were laid down in 1943.[1]

Meteorological Service

Under the arrangements existing in 1938, the teleprinter circuits over which meteorological reports were collected by the meteorological office and distributed to R.A.F. and civil airfields terminated at a Meteorological Communications Centre situated at the Air Ministry. However, it was regarded as essential to afford similar safeguards to meteorological communications as to other forms of landline communications, and a new centre outside London was therefore proposed. Also, in view of the new main telecommunications centre in the process of being built at Leighton Buzzard, it was obviously more economical to site the Meteorological Teleprinter Centre as near as possible to the main D.T.N. Centre. In November 1938 it was decided, for reasons of security, economy and ease of cable communications, to site the Meteorological Centre near Leighton Buzzard, though not so near as to make the two centres a combined target. A site was chosen near Dunstable, and plans for permanent buildings were prepared. These were under discussion in July 1939 when it was decided, on grounds of urgency, to erect temporary buildings so as to have the centre in operation at the earliest possible date. These so-called temporary buildings were occupied early in 1940 and remained in use throughout the war.[2]

The old meteorological centre in London had its reserve centre at Birmingham; this was already established before the outbreak of war. In spite of the decision to erect only temporary buildings at Dunstable, the accommodation was not ready when the war began, and in view of the expected concentration of air attacks on London, the Meteorological Communications Centre there was closed and moved to the reserve centre at Birmingham. The work at Dunstable was pressed forward, and the transfer of circuits from Birmingham to Dunstable was eventually carried out on 4 February 1940, with only a ten-minute interruption. Birmingham was retained for the moment in its original role as a reserve centre.[3]

Receivers for the reception of international meteorological information were set up at Dunstable and Leighton Buzzard. The receiving room at Dunstable was laid out to accommodate a minimum of ten receivers. The aerials installed were half-wave dipoles, directional on the stations required, which included Washington, the Middle East, Europe, etc.[4]

The meteorological broadcast system extended to all stations at which flying took place, and by January 1941 the increase in the size of the Meteorological Teleprinter Network (M.T.N.) necessitated the modification of existing procedure in order that information could be passed to and from

[1] A.M. File CS.17979.
[2] A.M. File S.45519.
[3] A.M. File S.47372.
[4] A.M. File S.3373.

all meteorological stations with the least possible delay.[1] It was decided that the required increase in the rate of transmission should be given by the installation of a second teleprinter circuit between all meteorological centres (generally situated at group headquarters) and Dunstable, the second channels utilising the existing teleprinter at Dunstable and the existing channels to terminate on the Dunstable broadcast switchboard. Thus two teleprinters were necessary at all groups. The additional machines were to be fitted with a key strip in order that the following facilities could be provided:—

(a) The second group teleprinter could obtain direct communication with Dunstable or any single out-station without interfering with the general broadcast from Dunstable to the group and station except the out-stations connected on the individual transmission.

(b) Both group machines could collect information simultaneously from the out-stations, thus halving the time for the collection of synoptics during breaks in transmission from Dunstable.

(c) Broadcast transmission from the group to its out-stations could incorporate transmission back to the associated Dunstable teleprinter (the second group machine and also the broadcast circuit from Dunstable being idle during this period.)

Enquiry from the G.P.O. showed that insufficient cable pairs were available between Leighton Buzzard and Dunstable to provide the scheme immediately, and an interim scheme was devised utilising a second teleprinter and associated switching panel at groups. The additional machine gave the following facilities:—

(a) Transmission from the second teleprinter at the group to Dunstable and transmission and reception with Dunstable on the existing group teleprinter when no broadcast was being sent out.

(b) The second teleprinter was able to collect information from any out-station during a broadcast or when the first teleprinter was performing a similar function.

(c) Broadcasts from existing group machines to all out-stations to incorporate transmission back to Dunstable.

(d) So that existing procedure could be reverted to on the failure of either machine, a key was fitted on the group switching panel to operate the single facility.

A list of groups at which these modifications were to be carried out, together with an order of priority, was sent to the G.P.O. on 20 January 1941.

There was, however, considerable delay in the provision of the new facilities due to shortage of the equipment required to modify the existing switchboards and build new-type switchboards. The policy was to replace

[1] A.M. File S.67572.

the existing switchboards with the new type at the most important centres, and to modify existing switchboards elsewhere. Most of the groups were operating with two teleprinters by the end of 1941. Modifications were later made to enable groups to broadcast on the second channel to any one out-station while Dunstable was broadcasting on the first channel, and also to enable a duplicate broadcast from Dunstable to be made on the second line to groups.[1]

In order to provide facilities for incoming meteorological reports to be collected in the event of landline failure, it was agreed at a meeting of the C.S.O.s of all commands, on 30 July 1940, that the standby W/T point-to-point organisation could be used in emergency for passing these reports. The first two minutes in every third hour were therefore reserved, subject to operational requirements, for the transmission of these reports, and instructions to this effect were issued in September 1940, and later embodied in C.C.O.1/1941.[2]

Following a minor breakdown of landlines in February 1941, further discussions were held at the Air Ministry between Signals, Operations and Meteorological staffs, to discuss the collection of meteorological reports by W/T in the event of teleprinter failure. A new procedure for the collection of reports was agreed at this meeting, and co-operation between Group, Signals, and Meteorological offices was arranged.[3] The new procedure was that, in general, if a teleprinter breakdown occurred, endeavour was made to pass station reports by landline or despatch rider to a station on the M.T.N. whose communications were not interrupted, or direct to Dunstable. If this proved impracticable, the reports, after being encyphered, were passed by means of the standby W/T organisation. Stations were then divided into two categories, those which passed their reports direct to Dunstable, and those which passed their reports to the group centre, or Type I Meteorological Centre, as it was now known. Full instructions for the passing of meteorological reports under all foreseeable circumstances were issued in June 1941. Subject to urgent operational requirements, a period of three minutes was now allowed on the W/T standby system for the passing of meteorological reports at or immediately after every third hour. In this period the group W/T station collected reports from individual stations in a pre-arranged order, each station transmitting its report after the preceding station had completed its transmission.

Another safeguard was provided in April 1942, when arrangements were made for the provision of a low-power standby transmitter at the Meteorological Centre at Dunstable, to come into use in the event of a breakdown of remote control lines between Dunstable and Dagnall or other outside transmitters. A frequency was allotted and an organisation drawn up which included all commands and operational groups. Additional receivers were

[1] A.M. File S.67572.
[2] A.H.B./IIE/25.
[3] A.M. File S.58106.

required in some cases. Weekly exercises were carried out and a suitable cypher was selected. The instructions issued in June 1941 were revised in August 1943, by which time there were 275 reporting stations on the M.T.N., 59 of which reported direct to Dunstable.

The provision of teleprinters and lines for meteorological communications for the 8th U.S.A.A.F. was started in July 1942, and on 9 September 1942 a meeting was held at the Air Ministry to discuss requirements. In view of the shortage of teleprinters, it was necessary to determine the general order of priority of all the known requirements, American and British, so as to agree on a procedure for allocating teleprinters as they became available. Only about 75 teleprinters were expected to become available in the ensuing four to five months. A month-by-month list of priorities was drawn up, and the Air Ministry undertook to arrange the provision of the required circuits with the G.P.O. so that as far as possible the teleprinters could be connected up as soon as they were available. Provision continued on this basis.[1]

Meteorological Broadcasts by W/T

The transmission of meteorological information by the W/T broadcast method to certain overseas stations, and the reception of reports from overseas, was a routine commitment at Dunstable from its earliest days. From 26 August 1942, broadcasts of meteorological information were made in accordance with a new schedule covering four British stations, plus Iceland, Faroes, Greenland, Spain, Azores, and Canadian and American stations. These transmissions were made in confidential meteorological code. Units at Gibraltar, Lisbon, Iceland, the Faroes, and G.H.Q. Home Forces received the broadcasts regularly, and other units from time to time. The transmissions were known as 'Alfig Issues', and were specially designed for the use of meteorological stations overseas and for mobile stations. On the introduction of the new schedule, separate provision for emergency broadcasts from Dunstable in the event of landline failure was abandoned and it was arranged that, if a major breakdown occurred, the scheduled 'Alfig' broadcasts would continue but would be made in a cypher of more general distribution, and would thus be available as an emergency service pending the restoration of the M.T.N.

'Alfig' broadcasts were timed to fit in with special and 'K' broadcasts so as not to overlap. By September 1943, 2nd T.A.F., United States 8th Air Support Command, Malta, the Middle East, North African Air Force, and the American Forces in North Africa, Bathhurst and Rabat Sale were also receiving the 'Alfig' broadcasts.

In October 1943, proposals were put forward and agreed for meteorological communications for the American and British Transport Commands. The new arrangements provided facilities for a 'North Atlantic' broadcast from

[1] A.M. File CS.16209/I.

Prestwick, the broadcasts from Dunstable remaining as before. For the new service, Prestwick acted as the controlling station broadcasting to and receiving information from Gloucester, St. Mawgan and Harrow, these stations acting as the backbone of the system. A number of other stations received a part of these broadcasts as a matter of routine.[1]

An examination of the meteorological services for A.E.A.F., carried out in April 1944, showed that an extra schedule of W/T transmissions in addition to the existing 'Alfig' schedule would be required for the A.E.A.F mobile stations. A suitable transmitter at Dagnall (a T.1190), with keying facilities from Dunstable, was provided in May 1944. The new schedule, which covered reports from Canada and America, the Mediterranean, Iceland, Spain, Greenland and Great Britain, was known as 'Bulfex'.

With the move of Headquarters M.A.A.F. units into the south of France in August 1944 under Operation 'Dragoon', the information contained in the 'Bulfex' transmissions was also required in this area. An SWB8 at Hartlebury was allotted, to be keyed simultaneously with the T.1190 at Dagnall on a frequency suitable for reception in Southern France. The new transmitter began operating on 18 September 1944. Many units experienced great difficulty in receiving the 'Alfig' reports at night, and as a result a B.B.C. transmitter at Brookmans Park, which was tuned to 583 kc/s and was used for a broadcast service during the day, was used for the transmission of 'Alfig' reports outside broadcasting hours, and proved satisfactory. French collective messages were introduced into 'Alfig' in November 1944.[2]

Landline Circuit Maintenance

The danger of the isolation of units from the command and control of their parent formations through damage to landline communications under wartime conditions was always a serious one. Before the war, when the landline systems were being built up, the system of W/T communication between units (which had preceded landlines) was retained as a standby, and with first the threat and then the actuality of war, a W/T standby system was kept in being. However, there were few illusions about the potentialities of this emergency system; it was recognised that it could not be expected to carry more than a tiny fraction of the vast traffic handled daily by telephone and teleprinter. The precise vulnerability of the landline system to enemy bombing was unknown, but the G.P.O. were confident that there would be few cases where lines could not be re-routed or restored within 24-48 hours. Nevertheless, the fear of a serious disruption in communications remained; and it was recognised that such disruption was likely to take place at times when good communications were particularly desirable.

With the collapse of France and the withdrawal of Britain's forces within her own frontiers, a further danger threatened—that of the cutting of com-

[1] A.M. File CS.16209/I.
[2] A.M. File S.58106.

munications by the direct action of enemy forces in areas invaded by sea-borne or airborne troops. This danger in fact never materialised; but it remained present for some years, and was a factor in the retention of the W/T standby system, besides prompting the introduction of emergency W/T and R/T systems such as 'Beetle' and 'Panda'.

However, the makeshift nature of all these emergency systems only served to underline the importance of prompt and well organized servicing and maintenance of landlines. This was the responsibility of the G.P.O.; and one of the functions of the G.P.O. liaison officers appointed to the staff of all command and group headquarters was to serve as the advisory link between the R.A.F. and the G.P.O. when landlines were interrupted for any reason. But although the responsibility for the physical maintenance and repair of landlines lay with the G.P.O., the advice of the R.A.F. on priorities was continually needed. This to some extent might be provided by the C.S.O. of the command concerned; but in any major landline breakdown, more than one command was affected, and the work of assessing the relative importance of circuits and allocating priorities as between one command and another could only be undertaken by the Air Ministry.

In July 1940, the Air Ministry warned all commands and units at home of the damage to landlines which might be expected to result from operations within the United Kingdom, bringing the failure of teleprinter and telephone communications. If such failure occurred the W/T standby point-to-point system was to be brought into use; but since this system was capable of handling only a small proportion of normal signals traffic, it was to be used for urgent operational messages only, the length of which was to be reduced to a minimum. A Despatch Rider Letter Service to cover all units in the United Kingdom was also brought into use; this service was normally used for ordinary non-urgent administrative messages, but in emergency it was to carry all administrative and non-urgent operational messages. To overcome possible cyphering delays it was foreseen that urgent operational messages sent by the W/T standby system might have to be transmitted in plain language, time rather than secrecy being the overriding factor.[1]

A number of exercises were carried out to test the capacity of the standby system to maintain a fair measure of contact. One such exercise was carried out in Bomber Command on 18/19 July 1940, in which the teleprinter service between Command H.Q. and the operational groups was regarded as out of action. Urgent operational reports were sent by W/T; and one of the principal objects of the exercise was to ascertain the effect on the W/T and cypher organisation of a heavy load of traffic. No special restriction was placed on telephone traffic, except that routine messages normally sent by teleprinter were not allowed to be passed over the telephone. Some important reports were sent by air.

[1] A.H.B./IIH/241/3/391.

The exercise proved a success, and was followed by a suggestion that a similar exercise should be carried out in which telephone links were also regarded as cut. It was thought, however, that the complete failure of the whole landline system, both telegraph and telephone, was hardly possible, except by enemy occupation of the whole area concerned, since all main teleprinter circuits had alternative routeings, and main telephone and teleprinter cables ran on separate routes. The most serious danger lay at the main terminals (i.e. at group headquarters) where in some cases all communications ran in a common route between the nearest G.P.O. centre and the headquarters. To cover this danger, exercises were held in which telephone lines were regarded as out of action for short periods. Generally speaking, however, the difficulties attending the running of exercises side by side with operations did not allow for the exercises to be held in number or duration sufficient to give useful results. One fact that did emerge was that the average time spent in sending an average-length message of ninety groups by W/T, including cyphering, transmitting and receiving, and decyphering, was two hours and forty minutes. Headquarters Bomber Command therefore decided to rely primarily on an extended D.R.L.S. in the event of a major breakdown in landline communications, employing W/T for short urgent messages only.[1]

The practice of the G.P.O. of laying their main trunk route lines to follow main roads led to severe damage to communications when the enemy began the bombing of cities and towns along these roads, and to overcome this, lines were subsequently laid along less vulnerable routes, large ring cables being laid around cities, and cables being fed from protected switch boxes to the main exchanges.[2] But the first effects of enemy bombing were felt before these precautions had been completed. The first serious damage occurred in the Kenley sector of Fighter Command on 18 August 1940, resulting in the G.P.O. Liaison Officer at Headquarters Fighter Command being called upon for a report.[3]

The main concern of the R.A.F. Signals Branch was for the rapid restoration of important circuits, leaving the question of how this was to be effected to the G.P.O.: but it soon became apparent that overall control of the situation was essential at Air Ministry level. Restoration of landline circuits was rendered necessary by three general conditions:—

(a) One line failing due to a routine fault (the line being sufficiently important to warrant restoration over an alternative route before the fault was cleared).

(b) A number of lines to one station failing as a result of damage to a main or local cable (some of the lines being sufficiently important to warrant alternative routeing before the damage was permanently repaired).

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[1] A.H.B./IIH/241/3/391.
[2] A.H.B./IIM/B26/1A.
[3] A.M. File S.7048/I.

(c) All lines to one station failing as a result of damage to a main or local cable (in this case some lines had to be routed alternatively in order to allow the station to operate).

Action to restore landlines differed according to the three main conditions. First, in the case of a minor fault, if there was no alternative communication (such as an administrative line), and the responsible officer insisted that immediate restoration was necessary, the G.P.O. engineer at the controlling station arranged for alternative routeing. In the case of a number of lines failing due to damage, the G.P.O. Regional D.T. Control ascertained which lines had to be restored and arranged alternative routeing. In the case of a complete failure, the G.P.O. liaison officer reported the position to the Engineer-in-Chief, G.P.O., who decided, in consultation with the Air Ministry (Signals 3), which lines had to be restored, and made arrangements accordingly.

It had always been understood at the Air Ministry, and indeed had been confirmed by the G.P.O., that damaged cables would normally be repaired within 24 hours, and that even in difficult cases there would be a maximum interruption of 48 hours. However, during the Battle of Britain, fault durations were often very much longer, and several times fighter operations were seriously hampered by prolonged faults.[1] Some of the difficulties encountered by the G.P.O. may perhaps be mentioned. The electrical characteristics of a damaged line had to be determined, and the line had to be replaced over another route by a line of similar characteristics; this might necessitate taking a circuit from the public service between two exchanges and connecting it to the undamaged sections of the faulty line, or a complete alternative line might have to be set up. For the longer circuits, usually four-wire circuits, great care was necessary, and numerous instructions had to be issued by telephone to the various exchanges or repeater stations *en route*. Some time was bound to elapse before an alternative line could be set up, and the number of lines to be restored at any one time was an important factor. Complete restoration of a damaged cable presented varying problems. The men engaged on repair work were often severely hampered by the presence of large quantities of sewage. The clearing of debris and the consolidation of road surfaces was another source of delay. Information as to the location of fallen bombs was not always available, and it was sometimes necessary for G.P.O. engineers to make extensive surveys to determine whether G.P.O. plant was affected; in one case a bomb fell almost immediately over a main cable route but the crater was filled in before a G.P.O. inspection could be made. Unexploded bombs were another difficulty: areas were sometimes roped off and delays of several days occurred before access could be granted. The G.P.O. was not consulted before the detonation of unexploded bombs, with the result that damage was caused to G.P.O. plant which might have been avoided or considerably lessened. Escaping gas was another source of delay. No undue

[1] A.M. File S.7048/I.

lighting restrictions were imposed, but it was often impracticable to carry out repair work at night.

Further serious cable damage occurred in September 1940, and experience showed that insufficient information was being received at the Air Ministry on the extent of the dislocation caused. Consequently, it was not possible to draw the attention of the G.P.O. to the more urgent aspects of the repair work necessary or to give them comprehensive instructions on the priority of restoration. After consultation with the G.P.O., a new procedure for the reporting of landline failures was therefore introduced in all home commands on 1 October 1940. Under this procedure, when there was a general failure in the landline communications at an R.A.F. station, the station signals officer first established from the local G.P.O. engineer whether the damage was in local cabling to the station or whether it was caused by a major breakdown in the G.P.O. system. If the former, he ascertained the probable time of repair of the cable and notified the group duty signals officer; this officer notified command, who in turn notified the Air Ministry, for information only. If the latter—that is, if a major breakdown was involved—the station signals officer notified group that his communications were affected by a breakdown beyond the control of his local G.P.O. engineer, stating the circuits out of action.[1] This information was passed by group through command to Air Ministry Signals. The command duty signals officer, in passing the information to the Air Ministry, commented on the degree of urgency of the repair work and gave a priority list of the circuits out of order. Air Ministry Signals were thus in a position to gather information together from all commands and deal with the G.P.O. headquarters on the repair work in a general way, indicating where necessary which work was to have precedence and keeping a check on the speed of restoration. Concurrently with this procedure the G.P.O. reports of cable damage were also passed to Air Ministry Signals so that information from the two sources could be collated and used in detailing repair work.

The new system effected considerable improvement, but in mid-October the Air Ministry was still worried by the slow rate of repair of main cables after damage by enemy bombing. In the main, groups and stations were connected by more than one circuit, routed through a variety of cable so that a single cable breakdown could not put a vital link completely out of action; the system was working well generally and there had been few instances of a station being completely cut off. The danger was, however, that if damaged main cable routes were not restored within four or five days, the insurance of having more than one circuit entirely disappeared, and further damage might disrupt even the most vital communications—including those on which the defence of London depended.

On 2 November 1940 there were in Fighter Command over a hundred

[1] A major breakdown was defined as one in which 50 per cent of a station's lines were out of action.

circuits which had been out of action for a week or more, and 132 circuits out of action in all. The G.P.O. was unable to keep pace with the requests for restoration, and on 3 November, as a result of a survey made by the Air Ministry, all outstanding requests for the urgent restoration of circuits were cancelled and new priority lists substituted.[1] In general, first priority was given to R.D.F. reporting circuits and operational control circuits such as controller to controller between groups and squadrons or stations. Secondly, also with a high priority, came the replacement or repair of the main circuits carrying multi-channel V.F. teleprinter channels, and thirdly, the restoration of administrative circuits.[2]

For the repair and re-routeing of circuits which were faulty due to normal causes and not to main cable breakdown, it was the considered practice of the Air Ministry to include these circuits in all priority lists for two reasons: first, because the Air Ministry did not necessarily know, without causing the G.P.O. considerable trouble in investigation, whether a particular circuit was faulty due to a cable breakdown or to a routine fault; and secondly, because the repeater station staffs responsible for the re-routeing of circuits faulty due to cable breakdowns were the same staffs as those responsible for locating and rectifying normal faults and therefore needed to be informed of the relative importance of these normal faults as against circuit re-routeing in connection with cable breakdowns.

The areas most affected by damage to cables were the Chatham area and south-east England generally, due to the persistent bombing of cables within ten miles of Central London. These areas were of great importance as Chatham was the Headquarters of No. 16 Group, Coastal Command, the group responsible for the protection of shipping in the Channel and North Sea, and many of the fighter stations concerned in the defence of London were situated in this area. In the latter part of 1940 some 50 per cent of the total circuits serving these formations were affected for long periods, and urgent action to provide a separate outlet from Central London was requested by the Director of Signals on 18 November 1940. The provision of a new cable along a separate route, however, could not be achieved quickly in the prevailing conditions, and when the situation was studied by the G.P.O. it was decided to provide a cable through the completed pilot tunnel of the deferred Dartford—Gravesend tunnel, thus giving a new and valuable line from north to south of the Thames. Circuits interrupted on one side of the river could thus be re-routed from London on the other side and then across the river via the new cable. The laying of a 200-pair cable was completed in February 1941.

Meanwhile, however, further serious damage to cables in south-east England occurred in the last few days of 1940, 124 R.A.F. circuits contained in 12 cables being put out of action on 29 December. Thirteen of the most vital circuits were given to the G.P.O. for re-routeing, but of

[1] A.M. File S.7048/I.
[2] A.H.B./II/E/25.

these only three had been restored by 2 January, and only 31 of the total of 124 circuits were restored over a week later. Action by the G.P.O. to improve the overall situation included the Dartford—Gravesend cable, V.H.F. wireless links between Rochester and Brentwood, the laying of cables in tube railway tunnels, and a special cable tunnel under Whitehall to give government offices direct protected cable access to these tube cables at Trafalgar Square. The whole situation was fully discussed at a meeting at Headquarters Fighter Command on 10 January 1941, the main outcome of which was a decision that each group should prepare a list of vital circuits which they wanted re-routed in the most secure cable available, the list being restricted to the absolute minimum of circuits necessary for operational purposes. These lists were forwarded to the Air Ministry by Headquarters Fighter Command on 20 March 1941.[1]

Bomber and Coastal Commands were also asked to submit a statement of the minimum number of circuits in the various classes which would meet essential operational requirements in emergency, pending the restoration of full-scale facilities, giving the relative priority; Bomber Command produced a list ten days later and Coastal Command in the following September. The system remained that there was permanently on duty at Signals 3, Air Ministry, an officer to whom the commands reported breakdowns in their landline communications; this officer used the lists of essential circuits compiled by the three operational commands as a guide. One command to group and one group to station speech line were first priority in each case, and other vitally important lines included lines to other formations, remote control lines to W/T stations, lines for regional control stations, and movement liaison service lines.[2]

Although the procedure that reports were made to the Air Ministry by Commands only remained generally in force, exceptions to this rule increased. Already Leighton Buzzard was reporting direct on behalf of the A.M. W/T stations in its area, and No. 11 Group was also allowed to report direct to the Air Ministry, by-passing Headquarters Fighter Command. The opening of new switching centres resulted in a decision to handle information on landline breakdowns occurring at these centres at Headquarters No. 26 Group, who reported direct to the Air Ministry, passing a summary of the landline position with recommendations. The establishment of the R.A.F. Traffic Control Section at Headquarters No. 26 Group gave this group a special ability to advise on the effect of landline breakdowns and indicate to the Air Ministry where the greatest difficulties lay.

In the early stages of the German bombing offensive it was Fighter Command's communications which suffered most, and naturally this command received first priority in the restoration of circuits. However, it was recognised that the interruption of Bomber Command communications

[1] A.M. File S.7048/I.
[2] A.M. File S.7048/II.

during an operation might result in serious loss of aircraft and crews, and this fact was underlined when Headquarters No. 3 Group lost all their communications and were isolated from their stations through bomb damage at the Newmarket exchange in February 1941. Following this incident, the Air Ministry raised the question with the G.P.O. of the alternative routeing of circuits from Bomber Command to groups and from groups to stations; such alternative routeing was already provided satisfactorily in Fighter Command. A survey of existing lines was needed, but this was delayed by the pressure of work on the G.P.O. in the provision of lines to new stations and in the transfer of various operational establishments to new accommodation. In January 1942 the G.P.O. prepared a review of the communications between Bomber Command and its groups, as a result of which the Air Ministry pressed for and later obtained several additional circuits and the diversion of others.[1]

When the Americans began to operate in the United Kingdom in 1942, the procedure followed in the R.A.F. for the restoration of faulty and damaged landline circuits was explained to them and their concurrence in the scheme obtained. The prime function of fault control at the Air Ministry remained to liaise between the air forces and the G.P.O. for the prompt restoration of essential and urgent lines, with a G.P.O. liaison officer at the commands and groups and equivalent U.S.A.A.F. formations to deal with circuit failure under normal conditions.[2]

Another source of damage to cables, unrelated to enemy action, was the damage caused at air force stations by contractors and other working parties; this became particularly severe in 1943. In order to assist the local Works representative, a scheme was brought into force whereby all stations kept an up-to-date set of plans suitably marked with the G.P.O. cable runs, and close liaison was maintained between the local Works representative and the station signals officer.

A meeting was held early in 1944 to discuss the landline maintenance policy for A.E.A.F.; it was attended by representatives of the G.P.O., Headquarters A.E.A.F., the Admiralty, the War Office, and the Air Ministry. At this meeting it was reiterated that re-route and repair priorities in the United Kingdom would be decided by the three ministries only, and later, on the continent, by S.H.A.E.F. At home, many other commands besides A.E.A.F. were involved, the scheme had worked well throughout the blitz periods, and the Air Ministry had gone to great lengths to have exhaustive records compiled, including a system of quick appraisement charts. A fault control was established at Headquarters A.E.A.F. in the United Kingdom, which also absorbed that of A.D.G.B., but this fault control continued to work through the Air Ministry (the responsible branch was now Tels. 3a), where there were special circuits and facilities available for this purpose. This in no way cut across the local work of the G.P.O. liaison officers.[3]

[1] A.M. File S.7048/II.
[2] A.M. File S.7048/III.
[3] A.M. File S.7048/IV.

The overall effect of the wartime expansion of the whole landlines system, the reinforcement of main routes and the ring system of cables round cities was particularly noticeable during the V1 and V2 blitzes of 1944, in which very little inconvenience was caused to communications.

Communications in Northern Ireland

Up to June 1940, the landline communications serving the R.A.F. units based in Northern Ireland were provided exclusively by the G.P.O. The R.A.F. units were mostly training units, but they included a Coastal Command operational station at Aldergrove, and might be expected to include Fighter and Bomber squadrons in the event of an invasion of Northern Ireland or Eire. It was felt that, in the event of hostilities in Northern Ireland, the existing methods of provision would be unreliable, and that the situation might become such that the Army would have to take over all landline communications. Again, if forces were required to move down into Eire, there was a likelihood that a considerable reconstruction of lines would be necessary. In order to secure landline communications it was therefore decided with the fall of France to send one of the two Air Formation Signals Units returning from France to Northern Ireland. Line and Wing Signals Sections of the A.F.S. were sent subsequently, making the function of the A.F.S. in Ireland :—[1]

(a) To provide the necessary Army signals personnel to discharge the Army responsibility of providing, operating and maintaining landline communications in an air component in the event of invasion.

(b) To assist in the provision, maintenance and operation of existing landline communications.

The main R.A.F. requirements in Northern Ireland were communications between Headquarters No. 61 Group, Maintenance Command and the Air Ministry; between Headquarters No. 61 Group and Bomber Command; internal communications between the various units; communication between Aldergrove and Dunstable for the meteorological system; W/T and D/F for aircraft; and communication from Aldergrove to Headquarters Fighter Command and from Aldergrove to Greenock and Headquarters Coastal Command. To meet these requirements the following were provided or expanded :—

(a) A landline teleprinter and telephone system.

(b) A standby W/T system.

(c) An A.D.L.S. system between Northern Ireland and England to supplement (a) and (b).

(d) W/T, R/T and D/F facilities for aircraft.

Schedules of landline and W/T circuits were prepared in July 1940. The G.P.O. continued to serve Northern Ireland as a region in exactly the

[1] A.M. File S.5304.

same way as any other G.P.O. region in England. Mobile pack sets (T.1083/R.1082) were provided initially for the standby W/T circuits. In mid-1940, the standard of operating and procedure with these circuits was distressingly low, and in an effort to improve the situation, concentrated W/T practices were held, until at length the system was made to work satisfactorily. The exercises served the dual purpose of training personnel and of keeping the mobile equipment serviceable.[1]

In the latter part of 1940, the security communications in Northern Ireland caused great concern, and at a sub-committee meeting of the Defence Services Line Telecommunications Board on 8 October 1940, the establishment of an Inter-Service Signals Centre for Northern Ireland was suggested. The weakness of the existing system was that the main underground cables in Northern Ireland, although few in number, all centred on Telephone House, Belfast; and, in addition, all cables from the mainland were terminated in this building. If this centre were destroyed, either by enemy bombing or by sabotage, communications to and within Northern Ireland would be completely dislocated.

In any case, it was apparent that the growth of the R.A.F. in Northern Ireland made it essential to establish a major Signals Centre at a convenient site, with teleprinter and telephone switchboards serving all R.A.F. stations and linking in Naval and Army Centres. It was therefore decided, in January 1941, to establish a new centre at Dundonald, five miles outside Belfast. It was considered that this area would be reasonably secure from bomb damage, and would be easier to guard than a building in the centre of Belfast. A site was chosen and buildings and power supplies planned. However, by an extraordinary coincidence, a stray high explosive bomb dropped by an enemy plane blew a large crater in this carefully selected site, resulting in a delay in the commencement of work while the site was levelled out again. Further delays followed due to an unsatisfactory contractor, and at length the original contract was cancelled and a new contract let. The new centre was opened in 1942, and known as the Dundonald Signals Centre. It was considerably expanded over and above the original plan as a result of increasing commitments in Northern Ireland.[2]

The original requirement for W/T, R/T and D/F facilities for aircraft was met by the installation of low and medium power equipment. However, a requirement soon arose for high power W/T facilities for long range aircraft, first, for Coastal Command reconnaissance and escort and, later, for Ferry Command. Following a reorganisation of units in Northern Ireland, a new W/T station was built at Eglington. where two Marconi SWB8's were installed.

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[1] A.M. File S.5304.
[2] A.M. File CS.7837/41.

CHAPTER 5

INTER-COMMAND WIRELESS

Prior to 1926, there was no official organisation in existence for a co-ordinated system of point-to-point wireless telegraphy between the various commands of the Royal Air Force. Each command had its own internal W/T point-to-point system, but until the introduction of the short-wave technique, the only inter-command W/T organisation in existence was a long-wave routine split into two systems, as follows:—

(a) Inter-command (European system). For this system the Air Ministry carried out four routine periods daily with Kalafrana (Malta) and 4100 and 4800 metres, and Kalafrana had four routine periods with the Army W/T station at Cairo on 4800 and 3000 metres, the Army station handling the Headquarters R.A.F. Middle East traffic experimentally.

(b) Inter-command routine (Asiatic system). Regular routine inter-command communication was established daily between Headquarters Middle East and Headquarters Palestine, Headquarters Middle East and Jerusalem, Headquarters Iraq and Jerusalem, and Headquarters Middle East and Amman.

From this it will be seen that the only direct inter-command communication afforded to the Air Ministry was to Kalafrana (Malta). This was due to the limitations imposed on long distance communications by the high power and expensive aerial arrays required for the long wave-lengths then in use. Nearly all important Air Ministry traffic was sent by cable, long-wave communication was just possible with Egypt at night, though not sufficiently reliable for use as a regular means of passing traffic, and all telegrams for Aden and India were automatically sent by cable.[1]

Short-wave Experiments

By 1923, amateurs all over the world had discovered the uses to which the shorter wave-lengths could be put, and to meet requirements in Iraq chiefly connected with reconnaissance reports from frontier outposts, a Flight Lieutenant Durrant, then stationed in Iraq, constructed a short-wave set, and also communicated with various amateurs. At about the same time, a Flight Lieutenant Rodney was working on similar lines at Cranwell, and the pioneer work of these two men was followed almost immediately by similar work by various W/T personnel at home and abroad. These men quickly got into W/T contact with one another, and it soon became apparent that traffic could be passed under certain conditions where the existing long-wave organisation was unable to give service. W/T personnel throughout the Service began making up sets at their

[1] A.M. File S.28105.

own expense and exchanging signals outside normal duty hours. At first, communication was only possible during the hours of darkness, but in 1925 daylight working was established using what were then known as ultra-short wave-lengths. An N.C.O. from Mosul, trained in short-wave work, was posted to India, where he installed similar apparatus and carried out further experiments with Iraq and the United Kingdom. Two more experimental stations were opened up in Palestine and Malta in 1925. The situation was appreciated early on the the Air Ministry, and the R.A.E. was approached and asked what wave-lengths they thought would be most suitable for a point-to-point service. It was apparent at this stage, however, that suitable waves, if they existed, would only be found by trial and error, and by keeping watch over lengthy periods.[1]

It was undesirable for W/T personnel to continue on the existing basis of keeping watch after normal duty hours, and it was suggested by Headquarters Middle East that in order to make full use of the short-wave W/T system for inter-command working, a definite organisation be introduced. Short-wave stations were in the habit of communicating with amateurs in various countries on various wave-lengths, as a result of which these stations were sometimes not available when Service traffic was waiting to be passed. It was therefore proposed by Headquarters Middle East that each headquarters short-wave station be allotted a certain wave-length and period of watch, during which only Service stations should be communicated with.

Meanwhile in England, Flight Lieutenant Rodney was collecting information and carrying out experiments with the object of developing inter-command communications. Beginning with Malta and gradually extending eastwards to India, very satisfactory results were obtained, and a large number of official telegrams were transmitted and received under an Air Ministry short-wave organisation laid down in March 1926. Finally, in June 1926, communication was established with Australia. By 30 July 1926, the R.A.F. had the following short-wave stations working on a daily routine:—

Great Britain ...	Cranwell, Gosport, Leuchars, Lee-on-Solent, and Flowerdown.
Malta	Ta Silch
Egypt	Cairo (later Ismailia)
Aden	
Palestine	Ramleh and Bir Salem
Transjordan	Amman
Iraq	Baghdad, Basra
India	Delhi, Simla

The R.A.A.F. were now being worked daily from Cranwell, their station being at Melbourne. It was found that serious interference was encountered on wave-lengths above 40 metres, and the 34-39 metre band was found more

[1] A.M. File S.28105.

suitable. In July 1926 nearly all the short-wave stations were operating on wave-lengths between 35-37 metres.[1] A considerable saving was being effected in cable rates. Services to Canada, South Africa and New Zealand were being planned, and the service to Canada opened up later in the year.[2] During the whole of this period, apparatus in use at the various short-wave stations, both at home and abroad, was of local construction and was privately owned, except for transmitting valves and H.T. generators, and no extra personnel were provided to maintain watches.[3] In addition to the R.A.F. short-wave services operating from the Air Ministry to stations in the Middle East, India and Australia, and the inter-command network within the Middle East, the Admiralty had been assisted, at their own request, with their communications to central China during the operations in Hankow. The short-wave transmitter at Kidbrooke was used for direct communication between the Air Ministry and Shanghai and also for communication via Australia. War Office traffic was also handled, and in addition to the strategic value, considerable saving resulted in cable charges.[4] This was generally true of all short-wave communication; a record kept for a period of three months in the second half of 1926 showed that an average of £300 per month was being saved in cable charges through the operation of the R.A.F. short-wave services, and the appreciation of the Air Council was conveyed to a number of officers and N.C.O.s who had pioneered the work.

In order to continue experiments in a manner likely to furnish reliable data, it was essential to have a transmitter and receiver of standard design at the various stations engaged in the work.[5] Early in 1925, orders had been given to the R.A.E. to proceed with the development of a standard short-wave set, following a conference at which the general details were decided. The Type 'A' short-wave set was the outcome.[6] The original design of the Type 'A' short-wave transmitter, receiver and wavemeter aimed at simplicity, ease of manipulation, the use of as few non-Service components as possible in manufacture, and standardisation. Flight Lieutenant Durrant,[7] who was posted back to the United Kingdom in 1925, having been sent first as an instructor to the Technical and Wireless School with orders to continue short-wave trials, was posted to Kidbrooke to supervise the construction of the Type 'A' set. By October 1926, 12 transmitters, 12 receivers and 12 wavemeters were being constructed at Kidbrooke to designs developed by Flight Lieutenant Durrant. The first completed model was shipped to Malta, where some time was devoted to tests between 20 and 30 metres in order to determine the optimum wave for daylight work. It was realised that Malta formed an important link station for the east. On 1 October 1926, the new Type 'A' transmitter was operated successfully

[1] A.M. File S.25137.
[2] A.M. File 907692/29.
[3] A.M. File 728439/26.
[4] A.M. File S.28105.
[5] A.M. File S.25137.
[6] A.M. File S.25137.
[7] A.M. File 728439/26.

by remote control from Kingsway, and good contact was maintained with Malta, Egypt and Baghdad. In addition to the installation at the Air Ministry and Malta, the new sets were subsequently installed at Ismailia, Baghdad, India, Aden, Shanghai, Australia and New Zealand, and a series of tests was carried out.[1] The most gratifying result of the tests was that communication was regularly established with low power between points not in direct W/T contact before the introduction of short-wave working, i.e. England, Baghdad and India, Aden and Ismailia, Khartoum and Ismailia and the Far East, England and Australia, and England and Canada. It was found that a lower wave-length was required for daylight working than at night. With the new equipment 23 metres was used in daylight and 42 metres at night. Communication at night was reliable, but daylight working suffered from a considerable weakening of signal in the middle of the day.[2]

Organisation for Overseas Working

In 1927, a detailed organisation for overseas working was drawn up and subsequently included in Confidential Communication Order No. 1 for 1929. The daily short-wave traffic was now reaching such proportions that it could not be handled at Kingsway, and reception was carried out at Kidbrooke. A temporary building was secured and remote control land-lines laid. The policy now was to develop the inter-command short-wave system to provide a channel of rapid communication available at all times between the Air Ministry and R.A.F. commands overseas.[3]

By 1929, the situation was that a 24-hour guaranteed service from the Air Ministry to Malta was in force all the year; Malta was in continuous contact with Egypt also. A 24-hour service from the Air Ministry to Egypt was operated from January to April and from October to December; between May and September, direct working was liable to be interrupted for about two to three hours at midday owing to absorption by the Heaviside layer. A direct service was possible from the Air Ministry to Baghdad, India and Aden after sunset, and a direct service with Australia for four periods in each 24 hours, of two to three hours in each case, the exact times varying according to the time of year. The Air Ministry was also in constant touch with R.A.F. troopships through short-wave equipment; this followed a suggestion made by Flight Lieutenant Durrant in 1926. A considerable saving of time and money was thus effected, all telegrams regarding personnel, postings, instructions from O.C. Records etc., being transmitted by short-wave.[4]

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[1] A.M. Files S.24300 and S.28105.
[2] A.M. File S.25137.
[3] A.M. File S.26411.
[4] By the end of 1927 the amount of traffic passed by short-wave would have cost £6,000 to £7,000 a month had it been transmitted over the cable routes.

Improved Transmitters

Various modifications were incorporated in the new standard transmitter and receiver, with a useful improvement in performance. The chief modifications were high-frequency amplifying attachments for the receivers, remotely controlled transmitters which gave greater efficiency, and the use of a new type of dipole aerial, first produced at Aden and later copied by all inter-command stations, giving greatly improved results.

By 1931, a second experimental transmitter, the T.27, was in use for inter-command short-wave services and long distance short-wave services with aircraft, but already this equipment had been declared obsolescent, the intention being to replace it with the Naval type T.26 medium power short-wave inter-command transmitter, which incorporated six spot crystal-controlled frequencies and a standby master-oscillator-driven circuit variable between 18,750 and 5,000 kc/s. In addition, a high-power automatic high-speed short-wave transmitter was under consideration for installation at the Air Ministry and Ismailia to accelerate communication.

Because of its central position geographically, Ismailia was now designated control station on inter-command frequencies. All R.A.F. main high-speed channels operated on 13,500 and 6,750 kc/s. An additional high-speed channel on 13,900 and 6,950 kc/s was operated by the Air Ministry, Ismailia, Singapore, Melbourne, New Zealand, and South Africa. The inter-command equipment at Malta, which included both the T.27 and the Type 'A' set, was now remotely controlled at Valletta. In Iraq, an inter-unit short-wave routine was operated between six stations in the command, using Type 'A' transmitters. A Type 'A' transmitter was in use for inter-command services at Aden. Communication on 13,500 kc/s was successfully established between Hong Kong and Singapore, using the Type 'A' and locally manufactured short-wave apparatus, in 1931.[1]

Multi-channel working was introduced on the main circuits in 1930, because of the volume of traffic, and the new T.26 transmitter was generally introduced, after considerable difficulties due to low-power, in 1933. New receivers and amplifiers, the R.64 and A.65, were issued in 1932, but the new receiver had a high noise level and was insufficiently selective on the low and medium frequencies, and a new general purpose receiver, the R.52, was developed in 1934.[2]

Directional Aerials

By the beginning of 1935, the improved transmitters and receivers were beginning to provide more reliable inter-command communications. The end of the first stage of the task of providing inter-command communications was thus in sight. It was clear, however, that jamming, either intentional or unintentional, could disorganize the existing system completely, and some

[1] A.M. File S.24828.
[2] A.M. File S.24828.

solution to this problem was therefore sought. The most likely method seemed to be the use of highly directional receiving aerials and associated apparatus. Such aerials and apparatus, often costly and elaborate, were already being used by commercial companies, but because of their static nature, and for reasons of economy, it seemed desirable to avoid their use in the Service if possible. However, since the use of highly directional receiving aerial systems seemed practically the only technical solution, it was intended that opportunity should be taken of the erection of new arrays at Cardington to make experiments. Another suggestion, to work in conjunction with the use of directional arrays, was to make use of relay stations in order to avoid the transmission path passing over possible enemy countries. For instance, for communication between the United Kingdom and Malta, whatever the type of receiving system used, there were great advantages to be gained from using Gibraltar as a relay station. It was thought practicable that discrimination against interfering signals could be aided by the use of Adcock direction finders at Gibraltar and Malta, and tests were carried out at Waddington which confirmed this.[1]

A conference was held to discuss the general problem at the Air Ministry on 17 November 1936, at which it was agreed that directive aerials were essential for inter-command purposes. However, it was not possible to lay down hard and fast rules on the type and disposition of aerial systems without precise knowledge of local conditions. Each inter-command station had to be treated separately, and it was therefore decided to send an R.A.E. representative to overseas inter-command W/T stations to collect and collate the necessary local information to enable the appropriate aerial systems to be installed. A representative of the R.A.E. left England in February 1937 on a tour of the Middle East (including Aden and Iraq), India, and the Far East, his tour lasting for six months.[2]

Further tests carried out at Cardington early in 1939 to see to what extent the use of directional receiving apparatus would prevent deliberate jamming of the inter-command system showed that considerable immunity would be provided. It was eventually decided to establish an H.F. D/F installation near the main wireless receiving stations at Leighton Buzzard, Ismailia, Khartoum, Malta, Habbaniya, Aden, Singapore, and Ambala. These installations were to be used only to overcome jamming, and were independent of the normal inter-command service and also of the D/F service to aircraft. In September 1939 a contract was placed with Marconi's, and the Air Ministry informed the respective overseas commands that H.F. D/F installations Type D.F.G. 12 were being provided for erection as near as possible to the inter-command receiving stations, for directional reception to overcome interference. The C.S.O.s of the overseas commands concerned were instructed to select suitable sites in open places about 300 yards clear of metal obstructions and aerials. Unprotected buildings were provided at Malta, Ismailia, Khartoum and Habbaniya, and protected buildings at Aden and

[1] A.M. File S.35049.
[2] A.M. File S.40022.

Singapore. By April 1940 the sets for Leighton Buzzard and Khartoum had been installed and those for Ismailia, Malta, Habbaniya, Aden and Singapore had been despatched. The set for Ambala was despatched later in 1940.[1]

In order to satisfy the demand for reliable two-way inter-command communication between the Air Ministry and all R.A.F. commands overseas, it was found necessary in the face of increasing interference on the high frequencies to equip inter-command stations with controlled frequency transmitters having an aerial input 2.5 to 3 kW. By 1937, the types in use, in addition to the T.26 were the Marconi SWB8 and the Standard Telephones M.15. The 13,500 and 6,750 kc/s frequency bands remained in use for day and night working respectively, a 5 kc/s separation being observed between channels. To facilitate the supply of spares, the two main types of transmitter were redistributed so that all commands east of Suez had the T.26 and west of Suez the SWB8. No further transmitters of the obsolescent T.26 type were made, and those used east of Suez were gradually replaced by the SWB8.[2]

The distance between Ismailia and Khartoum necessitated the use of a medium power transmitter at both stations to ensure reliable communication, and in 1937 it was decided to equip Khartoum with an SWB8. This not only met the requirement for communication between Egypt and the Sudan, but also made it possible to bring Khartoum into the inter-command organisation in the event of Ismailia being put out of action by deliberate jamming or other cause. At the same time, a second medium power station was provided for Ambala, which although intended primarily as a standby, provided an additional channel for certain inter-command traffic and an improved local service. A further standby service was provided by the medium power transmitters coming into use for long-range communication with aircraft; these had become necessary because of the increase in the number of long distance cruises undertaken by land-based aircraft and flying-boats, satisfactory reception at long range being guaranteed by the use of inter-command types of transmitter. These sets were for the most part located at inter-command stations, where they also functioned as a standby for the main transmitters.[3]

At the outbreak of war, the inter-command network consisted of a total of 104 circuits of which 20 terminated at the Air Ministry. Those 20 circuits were operated without the use of a linking station, direct contact being maintained with Singapore, Melbourne, Habbaniya, Ambala, Wellington, Malta, Khartoum, Ismailia, Aden, Ottawa, and Pretoria. Links via Ismailia were available to the French stations at Tunis and Algiers. The remaining circuits were linking circuits between overseas commands.[4]

[1] A.M. File S.2060.
[2] A.M. File S.34961.
[3] A.M. File S.34961.
[4] A.M. File S.4340.

Automatic High Speed Channels

An automatic high speed channel between the Air Ministry and Ismailia, to operate on frequencies of 10,000 and 9,970 kc/s, was first suggested in 1931. Various other frequencies were tested, and subsequently special automatic equipment was ordered from Marconi's. This was delivered in the spring of 1934, and tested up to 200 words per minute between the new Air Ministry W/T station at Greenford and Ismailia. But the service was not established permanently until April 1939. By 1937, however, owing to the expected increase in traffic that would result from an emergency, and the need for the speedy disposal of traffic during the limited working periods possible with some commands, the possibility of introducing the automatic system of transmission and reception on all main inter-command channels was considered at the Air Ministry.[1] The provision of 25 special W/T receivers for automatic high speed morse communications was arranged by letting a contract to Murphy's early in 1937, and orders for further supplies of the Marconi SWB8 were placed.[2] However, the only automatic channel in operation at the outbreak of war was that between the Air Ministry and Ismailia.[3]

On 13 July 1940, Headquarters Middle East suggested that, because of the pressure of traffic on the automatic Air Ministry to Ismailia service and the lack of any standby service, a direct automatic high speed service should be provided between the Air Ministry and Headquarters Middle East. Equipment for use at the Middle East end of the channel was hired locally from Marconi's, and by October 1940 the new channel was operating satisfactorily.[4]

However, the service to the Middle East was only a part of the problem. The enormous increase in the volume of traffic on the main R.A.F. inter-command W/T channels during the early months of the war necessitated the early provision of automatic high speed morse equipment at all the main inter-command stations. Serious delays in mail services to overseas stations further aggravated the problem. It was also expected that the auto system would assist in neutralising enemy interference and contribute to keeping the ether as clear as possible.[5] In the first place, effort was concentrated on completing an efficient and up-to-date installation at Leighton Buzzard, where expert technical advice from a number of specialists was available. The next problem was to introduce similar equipment in the overseas commands and to provide specialised technical assistance while the new equipment was being installed.

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[1] A.M. File S.34961.
[2] A.M. File S.4780.
[3] A diagram showing the Air Ministry inter-command channels in use in 1940 is at Appendix No. 8.
[4] A.M. File S.4873.
[5] A.M. File S.2766/I.

Proposals for the introduction of automatic communications on all R.A.F. main W/T channels were formulated in October 1940.[1] It was decided that, in the first instance, the system used would be high-speed morse signalling, using perforated tape for transmission and ink recording by undulator for reception; a system of direct printing over radio links was to be considered for introduction later, but first it was regarded as essential to establish the automatic high speed morse circuit on a reliable operating basis. The W/T stations to be equipped were:—

Air Ministry (Leighton Buzzard, Cardington, Dunstable, Birdlip, Whitehall).

Cairo	Habbaniya
Ismailia	Ambala
Khartoum	Singapore
Malta	Ottawa
Aden	

The Air Ministry W/T station at Leighton Buzzard had already been fitted with apparatus to enable all these circuits to be operated, and the channels to Cairo, Ismailia and Ottawa were already operating. Arrangements therefore had to be made for the provision of automatic W/T operating rooms at the remaining stations. Automatic operating rooms were normally sited in the main W/T receiving stations adjacent to the traffic office. In order that all the commands concerned should have advance knowledge of the scheme, the type of apparatus to be used, and the method of working, an introductory letter was prepared, together with appendices and drawings and despatched to commands in October 1940.[2] The main equipment was still on order from manufacturers in the United Kingdom. There had been considerable difficulty in the execution of the contract for the 25 Murphy receivers, and as no sets were forthcoming, it had been decided in May 1940 to purchase eight high grade Marconi RC.67 (R.A.F. Type R.1164) receivers so that the immediate needs of the automatic services could be met. The order for the Murphy sets remained, and these sets (Type R.1129) were finally delivered in January 1941, whereas the Marconi RC.67 receivers were even further delayed. The initial model was unsatisfactory and had to be re-designed and it was not until September 1941 that the first really satisfactory model was delivered.[3]

Various other types of instruments required for automatic W/T working were selected and manufacturers visited and given detailed information; arrangements were also made for the despatch of the necessary stationery and materials—chiefly undulator and perforator paper, message forms and undulator ink. Among the instruments ordered were keyboard perforators, automatic morse transmitters and relays from Creed's, substantial deliveries of which were not obtained until August 1941; also undulators, and a better and more expensive type of morse transmitter, from Marconi's, the produc-

[1] The provisional organisation is shown at Appendix No. 9.
[2] A.M. File CS.10696/I.
[3] A.M. File CS.10696/I.

tion of which was delayed due to enemy action, so that the undulators were not delivered until July 1941, and none of the new transmitters before 1942. It was therefore impossible to supply all the stations in the scheme with even the minimum quantity of gear required before the second half of 1942.[1]

In December 1940, however, the especially urgent need for automatic W/T installations at Malta and Singapore was realised, and arrangements were made for the minimum amount of apparatus required to equip these two stations to be procured from Marconi's and Creed's. The equipment was shipped in January 1941, and Malta came into operation as an automatic W/T station late that year. The equipment for Singapore did not arrive there until the autumn of 1941. The minimum requirements for Habbaniya and Aden were despatched in August 1941, and the bulk of the apparatus required by the other stations was sent in late 1941.

In March 1941 a post was established for a travelling inspector to assist with the development and installation of the automatic W/T stations in the Middle East. The assistance of a Marconi engineer was also enlisted, in the Middle East and Far East.[2] The R.A.F. travelling inspector went to the Middle East in May 1941 and gave assistance in improving existing automatic installations there pending the delivery of equipment at Malta. Meanwhile a case had been put by Headquarters Middle East for a permanent establishment of a technical adviser to assist with the installation and testing of automatic equipment at the various stations concerned; this establishment was agreed on 31 May 1941.[3] Subsequently the travelling inspector went to Malta to arrange tests and establish the automatic-circuit between that station and the Air Ministry, and in December 1941 he flew to the Far East to supervise the final installation of the SWB8's and rhombic aerials at Tengah.[4]

The only automatic circuits working at the end of 1941 were the United Kingdom—Malta, Cairo and Ismailia circuits, which were working on a 24-hour basis, each carrying 30,000-50,000 groups per day; the United Kingdom—Ottawa circuit; and the United Kingdom—Melbourne circuit, which was working on an 8-12 hour basis, although inward working on this circuit was largely at hand speed owing to the fact that Melbourne had only a comparatively low-power transmitter available. The state of progress varied at the other stations. At Singapore the auto W/T apparatus and transmitters were in the process of being installed, under the guidance of the Marconi engineer, and rhombic aerials were being erected. Three auto-mechanics had already arrived in Singapore and the first batch of seven auto operators was on the way. Apparatus and transmitters for Aden, Habbaniya and Ambala had been shipped some months earlier but not all of it had arrived and in other cases there was delay in locating it.[5] One of the major difficulties

[1] A.M. File CS.10696/I.
[2] A.M. File CS.10696/I.
[3] A.M. File S.6249.
[4] A.M. File CS.10696/I.
[5] A.M. File CS.10696/I.

lay in effecting the final delivery of apparatus. This also occurred in the Middle East, where large dumps consisting of hundreds of cases of stores were piled up in the open desert, making identification extremely difficult; usually crates had to be opened before it could be discovered what was inside. In one case, some twelve signals were exchanged over a period of two and a half months before six special typewriters *en route* for Ismailia were located. Information was extremely hard to come by, many hours being spent in telephoning maintenance units, and in obtaining shipping details. Arrangements were later made to create machinery by which departments were supplied with the requisite information automatically. Of the apparatus sent in 1941, all the Murphy receivers sent to Malta and the Middle East (there were five at Headquarters Middle East, three at Ismailia, and two at Khartoum) were damaged in transit, and as a result their performance was generally poor. Several were out of action due to lack of spares.[1] Most of the new services, however, came into operation early in 1942.[2] Great efforts were made to complete the installations at Khartoum and Habbaniya as soon as possible, so that automatic communications could be maintained with the United Kingdom should the Middle East campaign go against us. While the new automatic services were still in the development stage they were controlled by the Air Ministry, who had carried out all the planning and experiments up to this time. When the services were working on reliable and well-established bases, control was handed over to Headquarters No. 26 Group.[3] The three bottlenecks in the completion and expansion of the automatic W/T services were the production of apparatus other than the actual transmitters and receivers, shipping time—this was

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[1] A.M. File CS.10696/I.

[2] The new services were:—

	Day	*Night*
Air Ministry to Ambala and Singapore	17,345	8,770
Ambala to Air Ministry	17,495	8,660
Singapore to Air Ministry	17,535	8,926
	(17,345 and 8,770 had already been used for trial purposes at hand-speed)	
Air Ministry to Habbaniya and Aden	17,995	8,545
Habbaniya to Air Ministry	17,645	8,815
Aden to Air Ministry	17,910 or 16,325	9,225
Air Ministry to Malta and Khartoum	14,920	8,715
Malta to Air Ministry	12,910	6,383
Khartoum to Air Ministry	12,910	6,383
	(The Air Ministry to Malta circuit was already working forked with Ismailia on a limited basis)	
Air Ministry to Melbourne and Wellington	11,615	8,080
Melbourne to Air Ministry	11,655	7,950
Wellington to Air Ministry	11,695	8,170
	(The Air Ministry to Melbourne circuit was already working on a limited basis)	
Air Ministry to Pretoria	18,095	9,495
Pretoria to Air Ministry	17,574 or 17,748	8,787 or 8,874

(A.M. File S.6249)

[3] A.M. File S.6249.

the worst of all—and personnel. One watch on an automatic circuit involved the employment of seven airmen.[1]

Operation of Automatic W/T Equipment

Automatic reception consisted of recording transmitted signals on a paper tape, a recording instrument known as an undulator being operated by a special wireless receiver. Recording apparatus, however, did not possess the high degree of discrimination of the human ear, and signals that sounded quite strong did not record well if the noise level was high. For this reason aerial arrays were generally used with automatic reception circuits, the favourable ratio of signals to noise level, rather than the actual gain, being the important factor.[2] The audio signal produced by the receiver was fed into a signal rectifying unit which converted it into D.C. impulses which in turn operated an undulator. The requirement on the transmitting side was that it must be possible to key a transmitter some distance away either with a hand key or an automatic transmitter fed with perforated tape. The perforator operator perforated the message on a Creed keyboard perforator, an instrument with a keyboard like a typewriter which, when actuated, produced perforated morse signals on a paper tape. By receiving this tape through the auto-transmitter, the relay of the wireless receiver at the distant station was actuated. An auto-key switch allowed keying of the transmitter by hand when required.

Automatic working between two or more stations called for a modification to the existing standard procedure and operating, and full instructions were circulated. Whereas in hand operating, the whole channel was under the eyes of two operators, one at each terminal, with automatic working a group of operators were located at each terminal point. The group consisted of the following:—

(a) Perforator operator—to perforate the message received for transmission on to a perforator slip, together with the preamble and time of origin.

(b) Key operator—to control the automatic transmitter, maintain the log, operate the hand key, and to keep the transmitter slips rolled up in order of transmission.

(c) Receiving operator—to obtain the best possible signals on the undulator recorder, to keep the receiver log, to inform the distant station of conditions by means of a signal service message, and to roll up received slip in order of reception. This operator received all signals made by hand by the distant station.

(d) Slip typist—to transcribe messages from the received undulator slip.

[1] A.M. File CS.10696/I.
[2] A.M. File S.6249.

(e) Check clerk—to check the number of groups, operate the check sheet, stamp priority markings where applicable, and originate signals messages and queries on received messages.

Where the receiver was located adjacent to the automatic set, the receiving operator could maintain the receiver at the best settings, but another operator (who could attend to several receiving channels) was necessary where these conditions did not obtain.[1]

Up to the beginning of the war there were no training courses for automatic W/T operators or mechanics, the only stations in the R.A.F. using automatic equipment being those at Leighton Buzzard, Ismailia, and Cheadle. Shortly after the outbreak of war, when it was decided to send two mobile high speed W/T stations to France to operate with Headquarters B.A.A.F.,[2] a number of experienced operators were withdrawn from Leighton Buzzard and Cheadle to help man these two stations and, in addition, a number of men were lent by the G.P.O. to fill the gap. Subsequently a number of civilian operators were engaged for Leighton Buzzard on a temporary basis.[3]

Training of Personnel

The first batch of 80 automatic W/T operators trained for the original 'Blue Trains' were lost to automatic working; they were absorbed into the Service for other work, their documents had not been annotated, and all efforts to recover them for the automatic services failed.[4] However, with the more general introduction of automatic high speed telegraphy planned in October 1940, it was essential to make early provision for the training of suitable wireless operators to handle the highly specialised apparatus and procedure used. The need was to superimpose on a fully trained wireless operator the following additional qualifications:—

(a) At least 30 words per minute on teleprinter and keyboard morse perforator; touch typing was essential.

(b) Undulator morse slip reading and direct typing at 30 words per minute.

(c) Experience in handling high-speed-type W/T receivers and associated equipment.

The total requirement as envisaged in March 1940 was expected to be some 200 operators and 50 mechanics in the ensuing year, plus some 40 W.A.A.F. morse slip readers, who would replace airmen at home.[5] Arrangements were made for 70 operators at a time to be trained by Cable and

[1] A.M. File S.6249.
[2] These were known as 'Blue Trains'. An account of their formation and operation is included in Chapter 11—'Mobile and Transportable Signals Units'.
[3] A.M. File S.2188.
[4] A.M. File CS.10696/I.
[5] A.M. File S.2766/I.

Wireless on four-month courses, and this covered the requirement for the ensuing year. Cable and Wireless also accepted four wireless electrical mechanics for training as auto-mechanics. The W.A.A.F. slip readers were trained at the London Radio College. Regular visits were paid to the Cable and Wireless School by a representative of the Air Ministry Central Exchange at Leighton Buzzard to ensure that training was proceeding on the right lines. At the same time, an automatic W/T course for signals officers was begun at Leighton Buzzard. The course lasted eight weeks, of which three were spent at the transmitting station at Dagnall. Provisional establishments for specially trained wireless operators and wireless electrical mechanics for the Air Ministry W/T stations and the overseas inter-command stations were laid down by the Air Ministry in November 1940.

It was established in March 1941 that in addition to the airmen and air-women already trained or in the course of training (some 300 in all) there was a further requirement for another 300 by June 1942, of whom 100 would be W.A.A.F. This would cater for all the inter-command circuits planned plus four heavy mobile automatic W/T stations (these four mobile stations, numbered 1 to 4, included the original No. 1, which had gone to Headquarters Middle East, and the original No. 2, which had been sent to Northern Ireland). Arrangements were made to train the additional 300 personnel at Cable and Wireless and at the London Radio College, but the Cable and Wireless School was bombed and severely damaged on the night of the 10/11 May 1941, and this made new arrangements essential.[1] Training for airmen was transferred to the London Radio College, but it was arranged that after completing their training the airmen should be attached to Leighton Buzzard and employed on automatic circuits until they were considered proficient, when they were drafted overseas to fill the various vacancies. The scheme did not work well at first, but improved when taken over by Headquarters No. 27 Group.[2]

The automatic W/T scheme depended to a great extent on the efficient maintenance and adjustment of the apparatus. Unfortunately the position with auto-mechanics was even worse than with operators, as although a tentative plan had been made, no mechanics had been trained up to the end of 1940. Records were unable to supply any suitable mechanics to take the course, and in February 1941 Cable and Wireless were asked to pick out the most promising operators on the operators' course and train them as auto-mechanics. When Cable and Wireless were bombed out in May 1941, a small course in maintenance and adjustment of equipment was arranged at Leighton Buzzard. A first-class instructor, a former civilian wireless mechanic, was available at Leighton Buzzard, and excellent results were obtained.[3] As a result of this course the despatch overseas of automatic W/T apparatus in 1941 was followed by the posting of specially trained mechanics. These mechanics were posted to Malta (two), Middle

[1] A.M. File S.2766/I.
[2] A.M. File CS.10696/I.
[3] A.M. File CS.10696/I.

East (four), Iraq (two), and Singapore (two), in September 1941. This was particularly valuable as instances had already occurred in which automatic W/T apparatus was damaged due to unskilled personnel attempting its adjustment. Mechanics were subsequently posted to Aden and India.[1]

By the end of 1941, the requirement for automatic W/T operators had considerably increased. Four more mobile units were to be formed; an automatic circuit linking Prestwick with Iceland was opened; and Headquarters Middle East were to have a telecommunications centre (T.M.E.) similar to that at Leighton Buzzard. In all, it was calculated that an additional 200 male operators were required. Furthermore, a considerable number of the W.A.A.F. slip readers were subsequently commissioned and thus lost to automatic working. It was decided in January 1942 that, from the opening of No. 7 Signals School in April 1942, the new school would cater for the training of airmen, leaving the London Radio College to cater exclusively for the W.A.A.F. In the interim period, R.A.F. personnel only were trained at the London Radio College.[2] By early 1942, the requirements for R.A.F. and W.A.A.F. personnel, including those already trained, amounted to about a thousand in all by early 1943, but there was still a serious shortage of operators due to Records having been unable to keep courses full. New arrangements were made in an endeavour to keep courses well supplied.[3]

Further Expansion of Inter-Command W/T Services

Owing to the expansion of the R.A.F. overseas, and the consequent increase in the volume of overseas traffic, the existing point-to-point facilities were proving inadequate, and additional facilities were also required for aircraft reinforcement routes.[4] A thorough check was kept on the situation at Leighton Buzzard, where reports were received three times daily on the overseas W/T traffic position, and once a day a special report was compiled. In December 1941, because of pressure on the existing link, a second automatic high-speed channel was established from the United Kingdom to the Middle East. Another major development, the outbreak of war in the Far East, resulted in all channels serving this area being extremely active. The cable service, although restricted, remained open to Government priority traffic, and this was used as an alternative to the hand-speed W/T channels during periods of bad W/T conditions. Singapore closed down on inter-command channels on 4 February 1942.[5]

By this time, an appreciation of the overall position on the overseas point-to-point services had been made at Headquarters No. 26 Group. The first and most pressing need was for the improvement of the inter-

[1] A.M. File CS.10696/I.
[2] A.M. File S.2766/I.
[3] A.M. File S.2766/I.
[4] A.M. File S.2766/II.
[5] A.H.B./IIM/26/1.

command services to and from West Africa. Traffic between West Africa on the one hand and Gibraltar, the United Kingdom, Canada, South America, and the Middle East on the other, was analysed and a plan drawn up and submitted to the Air Ministry, who approved it and began putting it into effect. The plan called for a main inter-command station at Accra, in succession to Takoradi, which was the existing centre and operated hand-speed channels only. Later it was decided to build only a comparatively small station at Accra and to establish the main station for this command at Freetown, to which the main services were transferred early in 1942.[1]

The United Kingdom—Gibraltar—Malta services were studied primarily with a view to improving direct communication between Gibraltar and Malta. As a result, Malta was taken out of the existing Leighton Buzzard—Gibraltar—Malta hand-speed circuit and a new direct circuit between Gibraltar and Malta was opened. West Africa was brought into the Birdlip—Gibraltar—Headquarters No. 19 Group section in order to afford communication between Gibraltar and West Africa. There was a big increase in traffic early in 1942 between the United Kingdom and Australia, calling for a revision of communications on this route. It was arranged for traffic to be routed via Iraq, and a new circuit between Iraq and Australia was set up, as a result of which a big increase in the hours of working to Australia was obtained.[2]

In March 1942, Headquarters No. 26 Group produced a plan for the entire overhaul of the main inter-command services. The plan included proposals for the general dissolution of the inter-command hand-speed channel system working on 13,500 and 6,750 kc/s. However, the Air Ministry decided to retain this system.[3] Some other criticisms of the plan were offered and amendments made, but the general plan of expansion was approved by the Air Ministry on 11 May 1942 and issued on 19 July, the existing system forming the basis of the plan.[4] The provision of the new station at Cairo, to be known as Telecommunications Middle East, was finally agreed, comprising 11 automatic and 5 hand-speed channels, using SWB8 transmitters. New main stations were established at Khartoum and Pretoria, Khartoum being a focal point for reinforcement aircraft and Pretoria being convenient from the labour and material point of view and well suited to act as a link between the United Kingdom and the Far East in the event of our losing the existing link through Egypt, as seemed possible at the time. The circuits operated from Pretoria were to the United Kingdom, Khartoum, Mombasa, and the Indian Ocean Islands. A new main W/T station was provided at Shaibah, which joined the inter-command hand-speed channel in August. A second main inter-command station for India, in addition to Ambala, was opened at Delhi, also in August 1942. The circuit was not entirely satisfactory at first but made gradual improvement. At this time Wellington was attempting to work

[1] A.M. File CS.14545.
[2] A.H.B./IIM/B26/1.
[3] A.M. File CS.14545.
[4] A.M. File S.2766/II.

two-hour periods daily with Leighton Buzzard, staggered with the Melbourne schedules. Wellington was at first equipped with hand duplex, but automatic equipment was later installed.

The volume of traffic to be expected on each individual circuit was carefully assessed in order to decide whether simplex, duplex, or high-speed automatic working was required. The Air Ministry worked out the new establishments necessary in conjunction with Headquarters No. 26 Group, and the C.S.O.s of the overseas commands issued instructions to implement the plan locally.[1] By January 1943 the site for T.M.E. had been acquired and contracts were being negotiated. The intention was to allow Ismailia to fall into disuse as an inter-command station, while retaining a certain amount of the equipment there for standby use. The equipment for T.M.E. was in the main shipped direct from the U.S.A.[2]

The requirements for automatic personnel were further expanded to cope with these increases, a total of over 2,000 R.A.F. and W.A.A.F. personnel being called for;[3] but the plan of July 1942, although accurate at the time, did not represent a final requirement. In the twelve months following, several new commitments appeared. North Africa came into the picture, and during November 1942 Birdlip and Leighton Buzzard began listening watches on frequencies to be used by the forces involved in the ' Torch ' operation. A direct W/T channel Birdlip—Algiers was established, first as a simplex, then duplex, and eventually as an automatic circuit.[4] The entry of the Allied forces into North Africa opened up a new reinforcement route to the Middle East, and several new circuits were opened for aircraft movements traffic. New stations were also planned in the United Kingdom.[5] A W/T circuit usually began as a hand simplex circuit requiring one W/T operator per watch at each of its terminals. As the volume of traffic grew this developed into a hand duplex circuit requiring two operators per watch at each terminal. When the traffic to be handled increased beyond the capacity of a hand duplex circuit, it was replaced by a high-speed channel, and there was an immediate increase in the personnel requirement to man it. However, there was an ultimate economy in personnel in that an automatic circuit was capable of handling 100,000 groups in 24 hours, five times the capacity of one hand duplex circuit. But the airmen wireless operators employed on automatic high-speed working had never been properly established for this kind of work. The airmen concerned were simply normal wireless operators given a high-speed course and, after annotation of documents, posted against establishment vacancies. Early in 1943, however, approval was given for the introduction of a new Group I trade of ' high-speed telegraphist ', the duties of which included the

[1] A.M. File S.2766/II.
[2] A.M. File CS.14545.
[3] A.M. File S.2766/II.
[4] A.H.B./IIM/B26/1.
[5] A diagram showing the inter-command channels in use at D-Day, 6 June 1944, is at Appendix No. 10.

manning of both automatic and hand channels.[1] W.A.A.F. personnel, who were still employed exclusively in the United Kingdom, belonged to the special trade of morse slip reader, in which a knowledge of aural morse was not required.[2]

Aerial Arrays

Early in 1943, the policy concerning the provision of wireless ground stations overseas, particularly those used for long distance point-to-point communications, was under review, and in March 1943, it was decided that commands overseas should continue to be largely responsible for the development of their main, as well as their airfield, W/T stations. The most important single factors at this time were the securing of the maximum improvement in the technical standard of the main installations, because of the more exacting requirements of the automatic W/T service *vis-à-vis* the audio W/T services, and the need for expanding the daily periods of reliable communications.[3] Automatic working required a far more favourable signal-to-noise ratio than hand-speed working with audio reception, and in order to fulfil this requirement, high gain aerials were essential. It was originally intended to use Kooman's arrays overseas, but in many cases this was not practicable owing to the difficulty of procuring high steel masts in wartime. Generally speaking, overseas W/T stations were left to produce high gain arrays as best as they could. Single rhombic arrays were used at most stations.[4] It was in an effort to promote improvement in general technical standards that the Air Ministry issued at this time a new handbook giving concise and accurate information on various aspects of short-wave communications.[5]

Communication on all long distance circuits, particularly on the automatic services, was in most cases capable of considerable improvement. Since transmitters of standard design were used, the field for improvement lay mainly in the selection of suitable aerial arrays to give optimum results. The selection of an array was generally influenced by the size and contour of the site, the availability of materials, and sometimes by the lack of skilled personnel. It was not always possible to control these circumstances from the United Kingdom, particularly as rapid changes were sometimes necessary, and responsibility for the technical arrangements at overseas terminals belonged to the C.S.O.s of the command concerned.

It was axiomatic that the transmitting station should give the receiving station the strongest field possible within the limits of transmitter power and aerial sizes, and that receiving stations should erect arrays to provide satisfactory reception. In the case of a one-bay, one-tier Kooman's aerial (in effect a dipole having an overall length of one wave-length), the aerial would

[1] A.M.O. A.92/1944.
[2] A.M. File S.2766/2.
[3] A.M. File CS.18225.
[4] A.M. File CS.10696/I.
[5] A.P. 2514—R.A.F. Short Wave Communications Handbook.

have a certain predictable gain over a half-wave vertical aerial. When this system was doubled and made into a two-bay, one-tier array, an additional gain of approximately three decibels was obtained. In order to get a further three decibels the system was doubled again, becoming a four-bay, one-tier array. Above this the increase in the number of elements was out of proportion to the small additional gain. The largest and highest gain array considered practicable was the four-bay, four-tier Kooman's with reflector, giving 17 decibels.

Having radiated the best signal, the problem of reception remained, complicated as it was not only by natural interference noises but also by various other interference factors, accidental and deliberate The difficulty was that no amount of gain at the receiving end could improve the signal to noise ratio, and therefore receiving arrays were necessary. These arrays acted as a sort of funnel, collecting the stream of energy coming from the direction of the distant station, by reason of their polar diagram, and rejecting unwanted energy coming in from other directions. It was this discrimination, or favourable signal-to-noise ratio, which was required from receiving arrays, as much as the actual gain.

The second method of improving reception was by the provision of diversity reception to mitigate the effects of fading. The phenomenon of fading was chiefly caused by the fact that the rays of transmitting energy arriving at the receiving station by different paths were sometimes in phase and sometimes out of phase, causing the signal to become weaker or to fade. Signals differing in frequency by a very few cycles differed with regard to fading, and to take advantage of this fact the two chief long-distance point-to-point transmitters, the SWB8 and the ET.4750, were provided with so-called 'frequency wobblers'. By wobbling the carrier over a narrow band of about 600 cycles at a frequency of 500 times per second, fading was rendered less troublesome. The fading of a given signal also varied at different sites; the signal might be momentarily weak at a given place, but quite strong a few hundred yards away at the same moment. To take advantage of this phenomenon, diversity reception was used. Two or three receivers were connected to two or three well-spaced aerials respectively, and the output circuits were so connected that the receiver with the strongest signal at any one moment predominated. If fading was very bad, triple diversity was used, but in many cases dual diversity was sufficient. The spacing of aerials for diversity reception was a function of the wave-length and decreased as wave-length increased.

In order to achieve simplification it was desirable to keep the number of types of aerial employed down to a minimum, and to this end the Air Ministry issued a list of recommended types in March 1943, as follows :—

For Transmission

Kooman's 4 bay, 4 tier, with reflector.
4 bay, 2 tier.
2 bay, 2 tier.
1 bay, 2 tier.

Rhombic.
Marconi-Franklin, with reflector.

For Reception

Kooman's arrays as above, with reflector.
Rhombic.
Fishbone array.
Marconi-Franklin array, with reflector.
Horizontal dipole, with reflector.

Presuming the availability of materials, labour, and no limitations inherent in the site, the choice depended first on whether the frequency was a settled one or likely to be varied. In the first case the best type of aerial was the tuned array, preferably the four-bay Kooman's with reflector, the number of tiers depending on the angle of radiation desired. But an array of this type lacked frequency flexibility, and if the frequency of the circuit was likely to be varied, the rhombic aerial was generally used. Sometimes, in the case of a circuit using four frequencies, when it was not practicable to erect four Kooman's arrays, a Kooman's array was erected for the frequency serving the longest period of the day and a rhombic aerial provided to cover the other frequencies. The Marconi-Franklin aerial was useful because it was simple to erect and feed and occupied very little space. It was usefully employed at sites where many frequencies had to be worked or where space was limited.[1]

Direct Reperforating and Printing

As a result of an Air Ministry decision in January 1943 to adopt direct reperforating and printing on the main automatic circuits as soon as possible, orders were placed with Creed's for the necessary equipment.[2] The method was designed to eliminate manual operation and to reduce signal handling time and the number of errors caused by the human factor. The principle of this method was that the incoming signal operated a reperforator as well as an undulator, which produced an exact replica of the perforated tape passed through the transmitting head.[3] The method was only possible, however, on high-power circuits employing very favourable methods of reception. Power of the order of 11 kW. was required, and even then diversity methods of reception and fairly highly directive aerials were needed. When circuit conditions deteriorated, discretion had to be used as to whether this method could be continued, or whether typing from slip or another method known as the gummed slip method should be used.

Creed morse reperforators and printers were sent to Headquarters Middle East, India and Melbourne in 1944. Mechanics specially trained at Creed's in the maintenance of the Creed reperforator and printer were also sent.

[1] A.M. File CS.18225.
[2] A.M. File CS.19510.
[3] A.M. File CS.19510.

Reperforating and printing was in use on a number of circuits, including Air Ministry to T.M.E., Air Ministry to Caserta and Caserta to T.M.E., in 1945.[1]

The Gummed Slip Method

A meeting was held at the Air Ministry on 27 January 1944 to decide if the time was ripe for the introduction of gumming as opposed to slip typing. In the existing method, the morse signals of a message were received on an undulator tape, transcribed on to a typewriter by a morse slip reader, and subjected to more typing processes by teleprinter and Typex cypher operators. Consideration was given to the possibility of eliminating one or more steps, in order to reduce delay, remove sources of error, and ultimately to effect an economy in personnel.[2] It was decided that direct reading from the gummed-down undulator tape should be introduced on an experimental basis as soon as possible, subject to certain conditions. Arrangements were made to train cypher personnel to enable them to decypher on the Typex direct from the gummed-down undulator slip, and C.S.O.s of overseas commands were asked to select and train locally as many cypher personnel as possible and to introduce the scheme on an experimental basis.

The new method was given a prolonged trial at two stations in the United Kingdom and, on 28 March 1944, it was explained to overseas commands. The trial period at home had shown that a message reached the teleprinter room or cypher office 15 minutes earlier than by the normal method. After a reasonable amount of training, teleprinter and cypher personnel were able to teleprint or decypher from the undulator slip at speeds comparable with those obtained from Roman character copy.

The treatment of multiple address traffic by this method presented some difficulty, until an efficient device should become available for producing rapidly a number of copies of the message while it was still in the form of a gummed-down undulator slip. For this type of traffic it was necessary to reintroduce the morse slip reading/typing method at the appropriate stage, though since the message would by then have been converted into a single, easily-handled sheet and also checked, the typing could proceed at a good speed.

Difficulty was experienced in the general introduction of the new method mainly in the training of existing personnel in the reading of the undulator tapes. Overseas commands were, however, urged to make every effort to train sufficient personnel to introduce the scheme on selected channels. The gumming-down process could not be wholly replaced when the direct reperforation and printing gear was introduced; there would always be periods when direct reperforating and printing were not possible, and on some circuits it was uneconomic in any case.[3]

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[1] A.M. File CS.21793.
[2] A.M. File CS.21793.
[3] A.M. File CS.21793.

The training of 20 cypher officers and clerks code and cypher was carried out in March at No. 5 Radio School, Oxford, in the transcription of morse undulator slip on to the Typex machine in place of the normal typed copies of signals. Pupils had to learn the morse symbols, learn to touch-operate the Typex machine, and carry out transcription of high-speed auto W/T signals from the morse recorded on the undulator tape — three new operations for them. All but four were regarded as suitable at the end of a 23 days' course.[1]

Courses were also started at the Middle East Signals School, and the first batch of 21 clerks G.D. (code and cypher) were made available to M.A.A.F. in June 1944, and were posted to Headquarters M.A.A.F. Signals Centre, Caserta, where the new system was put into operation. Training began within No. 10 Signals Centre, Algiers, in May, and in three weeks the staff there were sufficiently advanced to begin taking messages. Steps were taken to train R.A.F. operators in gummed slip reading, and for these airmen to replace the A.F.S. personnel manning No. 10 Signals Centre. Teleprinter and teletype circuits at Headquarters M.A.A.F. Signals Centre, Caserta, were largely manned by U.S. personnel.[2]

No more personnel were available in the Middle East for posting to cypher courses after the first 21, and efforts were made to train cypher and W/T personnel at stations in the Middle East where auto reception was employed, but results were disappointing. Both teleprinter and cypher personnel were under establishment, they could not be withdrawn for courses, and spare time was limited.

The situation at the various stations in the Middle East handling auto traffic in September 1944 was : —

(a) *T.M.E.* 35,000—40,000 groups per day (plus 15,000—20,000 received by reperforation and printing). Of this the majority went to the typex room. Only about 6,000 groups went to teleprinters, and this included a large proportion of the printed traffic. The obstacle to the introduction of the gummed slip method was the training of cypher personnel.

(b) *Khartoum.* 8,000—12,000 groups per day, two-thirds of which were retransmitted at hand speed by W/T. Since the training of wireless operators in this method was a simple process, this station was the best placed to introduce it; but no progress was made.

(c) *Habbaniya.* 5,000—8,000 groups per day, nearly all of which went to cyphers. Level of traffic too low for any benefits to result from the introduction of the gummed slip process.

Later, in November 1944, training was being continually interrupted by postings etc., and in the whole Middle East the only use of the gummed slip

[1] A.M. File CS.21793.
[2] A.M. File CS.21793.

method was for incoming traffic at T.M.E. from Habbaniya, about 6,000 groups daily.[1]

The introduction of the gummed slip procedure also led to many difficulties at home with the employment of airmen in various trades, and in May 1944 it was decided to introduce a new Group II trade, which would be complementary to the new Group I trade of high-speed telegraphist, to be known as Telegraphist II. The qualifications required were aural reception and hand transmission of morse, ability to type direct from aural morse, and knowledge of hand-channel procedure; reading of undulator civil perforator morse slip, the operation of perforators, and auto-channel procedure; teleprinter operating and procedure; and sufficient technical knowledge to be able to tune receivers and to set up automatic circuits. Personnel for the new trade were recruited from W/T operators (M.S.R.), who were given conversion courses, and W/T operators ex *ab initio* training, for whom it was necessary to arrange full-length courses. The first conversion courses were undertaken at No. 1 Radio School, Cranwell, and by mid-1945 courses were also being held at No. 3 (Compton Bassett) and No. 5 (Oxford) Radio Schools.[2]

Single Side-Band (S.S.B.) and Frequency Shift (F.S.) Equipment

By early 1944, the requirements of operations and of Transport Command indicated that multi-channel links working on radio teleprinter between the United Kingdom and India and the United Kingdom and Egypt had become necessary. This was in addition to the high-speed automatic working already in use, which would continue to carry the bulk of ordinary traffic. It was intended that the radio teleprinter links would provide direct means of communication between Chiefs of Staff in the United Kingdom and Commanders-in-Chief overseas, and would also provide a means of connecting the D.T.N. to the teleprinter networks of the new overseas commands.

A method of working was arranged known as the single side-band suppressed carrier system, by means of which six separate channels were carried on one radio link. A contract was placed with Marconi's for the development and production of the high power transmitting equipment, while the G.P.O. produced the receiving equipment and the associated landline apparatus.[3] Two Marconi engineers were engaged to supervise installation of the single side-band equipment in the terminal stations at New Delhi and Cairo, and to set up the circuits in the overseas W/T terminal at Air Ministry, Whitehall. Two R.A.F. Signals officers were given special training at Dollis Hill, and they assisted the Marconi engineers on the maintenance side; and another two officers and 18 other ranks, following similar training, assisted in installing the equipment, and subsequently took over the running and maintenance after the installation had been completed.[4]

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[1] A.M. File CS. 21793.
[2] A.M. File C.26349/45.
[3] A.M. File S.2766/II.
[4] A.H.B./IIM/B26/1A.

It was regarded as too early to lay down a definite policy for future ground communications, due to the uncertainty of supply of equipment and its untried nature; but in January 1945 it was regarded as probable that all main inter-command links, and all tributary channels other than hand-speed links, would be fully operative on the radio teleprinter within 18 months.[1] It was thought unlikely, however, that much of the existing equipment could be dispensed with before the end of the war, and a long interim period, during which a few main links operated as S.S.B. and only a few tributary links on the radio teleprinter, was unavoidable. Requirements for auto-high-speed equipment were reviewed with the idea of cutting down the quantities in favour of the radio teletype system. Teleprinting on radio links required even more power than that required for direct reperforating and reprinting, and this gave rise to serious production problems.[2] However, main links between United Kingdom—Cairo and United Kingdom—India were expected to be operating on S.S.B. in the latter part of 1945.[3]

The introduction of radio teleprinting on the tributary links by the use of frequency shift equipment was still in the planning and provisioning stage in the early part of 1945. Only small modifications to the SWB8 transmitter were necessary. Items common to both the S.S.B. and F.S. systems were the cyphering equipment and the traffic handling equipment. The first batch of 'Rockex' equipment was brought into use for special traffic, and the production of eight Service trial models of the new GP.28 cypher machine was in hand. No design had yet been begun for the traffic handling equipment.[4]

Inspectorate of Inter-Command Telecommunications

The Inter-command Telecommunications Inspectorate and Development staff was formed within Headquarters No. 26 Group, in July 1944, to provide overseas commands with advice and assistance in the planning, siting, engineering and operation of overseas main communication centres. It was also responsible for the development and control of all associated specialist equipment. The establishment included a High-speed and Typex Development Section which incorporated the existing Typex Development Section at West Drayton, which had been formed for the purpose of developing existing cyphering and automatic signalling systems and modifying and adapting such apparatus to meet new requirements. A party representing the new Inspectorate began the first tour of overseas inter-command stations on 15 September 1944. They carried with them triple diversity receivers for a number of stations, beginning with New Delhi. After spending six weeks in India and Ceylon, the party proceeded to Cairo, and later to Malta and Caserta (Headquarters M.A.A.F.), where they also installed a triple diversity receiver and assisted in the design of transmitting and receiving aerial arrays for the automatic high-speed W/T station there. The party's sub-

[1] A diagram showing the full schedule of services planned is at Appendix No. 11
[2] A.M. File CS.19510.
[3] A.M. File C.26349/45.
[4] A.M. File S.2766/I.

sequent reports dealt chiefly with the introduction of new signals methods in the overseas commands visited.[1]

Technical Monitoring Section

A Technical Monitoring Section was established at Leighton Buzzard in February 1945.[2] Its main functions were:—

(a) The monitoring, by means of a check undulator, of all inter-command auto W/T sets terminating in and emanating from the United Kingdom.

(b) The examination, by means of a cathode ray oscilloscope, of signal formation on these circuits.

(c) The examination of line conditions.

(d) Recording and analysis of operating and circuit conditions.

(e) Advising radio terminals and remote receiving stations on frequency changes necessary to maintain communication.

(f) Ensuring that, as far as possible, optimum signals were being received and transmitted.

(g) Forwarding to Headquarters No. 26 Group any information required affecting security, signalling discipline and technical operation.

(h) Maintaining and operating the frequency checking organisation (already established at L.B., now incorporated in the Technical Monitoring Section).

General Review of Inter-Command Circuits—1944-45

In the latter stages of the war, the inter-command wireless system had become a vast network of circuits connecting the Air Ministry with R.A.F. forces in all theatres, connecting one command to another, and, in A.C.S.E.A., connecting widely separated units on a point-to-point system exactly similar to the inter-command network. During 1944 the function of some of the Air Ministry W/T stations changed considerably. Commitments in some stations increased, but decreased in others to such a point that it became no longer economic to operate them. The courses of instruction in progress at Leighton Buzzard had always tended to overcrowd this station, and to interfere to some extent with its operational function, and in the course of 1944 the auto-maintenance and S.S.B. instructional facilities at Leighton Buzzard were transferred to Cardington. At the same time, all W/T operational circuits and their associated teleprinter outlets were removed from Cardington and re-established at Leighton Buzzard, while a number of hand-speed circuits were transferred from Leighton Buzzard to Birdlip. The reorganisation was completed by February 1945.[3]

[1] A.H.B./IIM/B26/1A.
[2] A.H.B./IIM/B26/1A.
[3] A.H.B./IIM/B26/1A.

A large number of circuits were provided for Transport Command, operated mostly from Prestwick, Winstone and Hartlebury. The chief circuits were to Montreal, Gander, Iceland, Gibraltar, T.M.E., Headquarters No. 216 Group, Rabat Sale, Castel Benito, the Azores, and later, circuits to the continent. All these circuits, apart from the Prestwick-Iceland circuit, were operated at hand speed. There were also a number of automatic circuits opened to the Continent in 1944 in support of 'Overlord', to Headquarters 2nd T.A.F., to the Base Signals Centre, to A.E.A.F. Main, and to S.H.A.E.F. A circuit from the United Kingdom to Moscow was also opened, which Habbaniya joined when help was required in keeping contact.

During 1944/45 a great deal of auto equipment was sent to B.A.F.S.E.A., and by May 1945 some twenty auto terminals were operating in India. The progress of the war in the South-East Asian theatre demanded the provision of many new circuits, and there was a period of extreme difficulty due to shortage of equipment and spares. The collapse of the Japanese after Hiroshima only served to increase the demand for equipment, as existing communications had to be maintained and new links were necessary to areas taken over from the Japanese.[1] In the United Kingdom and Middle East, however, the end of hostilities resulted in a number of circuits being closed or reverting to hand-speed operation.

Signals Facilities in Iceland

Following the British Government's decision to occupy Iceland, an advance party arrived in Reykjavik early in 1941 and moved on down to Kaldadarnes, where, with the help of the Royal Engineers, an airfield was constructed. The first channels of communication with the United Kingdom, using T.1087's and simple aerial systems, were established by the end of March 1941.

The three main signals needs in Iceland were the collection and dissemination of meteorological information, the provision of radio aids to navigation, and aircraft W/T control. The internal landline system was fairly extensive but was generally of the common-user type, and was unreliable and unsuitable for Service use.[2] It consisted almost entirely of overhead lines liable to frequent breakdown in severe winter conditions. Siting difficulties for W/T stations were immense. Owing to its geographical position, Iceland was liable to severe and sudden high frequency black-out periods; and the geological composition was such that ground conductivity was poor. W/T had of necessity to be in the vicinity of aircraft bases and as there were only two or three areas from which landplanes could operate, W/T stations were mostly located on the sloping side of fields, resulting in almost complete aerial screening. The majority of operations in the east and north of Iceland were carried out by flying boats and float-planes using the long narrow fjords as anchorages. Owing to the mountainous country it was not always possible

[1] A.M. File A.788663/45.
[2] A.H.B./IIM/B26/1A.

to site D/F stations near to the bases they were to serve. Another problem was accommodation. In most cases none existed in the vicinity of the airfields planned, and buildings and power facilities had to be provided.

The communications requirements included a fixed operational service to the United Kingdom and a fixed automatic service for meteorological and administrative traffic, fixed services to Newfoundland and for internal point-to-point traffic, and various aircraft and navigational aid services. The internal point-to-point, aircraft control and navigational aid services were provided in varying measure at a number of bases. The transmitters used were, in the main, the SWB8 for long distance and the T.1087 for point-to-point and ground-to-air communications; the receiver used was the R.1084.[1]

Shortly after the first temporary transmitting station had begun operating, a new transmitting station was built; but no sooner had it been completed than it became obvious that the ever increasing demands of Atlantic operations and the North Atlantic Ferry Route would exceed its capacity. A third station was therefore built and the second station used solely for aircraft services. It was not until 1944 that these changes crystallised into a W/T organisation which could be said to be wholly satisfactory.[2]

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[1] A.H.B./IIE/25.
[2] A.H.B./IIM/B26/1A.

CHAPTER 6

SIGNALS IN FRANCE 1939-1940

Conversations and detailed correspondence took place with the French in the course of 1938 on the accommodation in France of an Advanced Air Striking Force (A.A.S.F.) of the R.A.F. in the event of hostilities. The force was to consist of twenty bomber squadrons, which were to be established in the Rheims/Nancy area. The provision of communications formed an important part of these exchanges. The Advanced Air Striking Force was to operate from 10 main, 10 satellite, and four refuelling airfields, and one depot airfield. The establishment of a communications organisation on these bases was dependent on the following: —[1]

(a) Landlines for telephone and teleprinter services between the airfields allotted to the A.A.S.F. and their satellites, the refuelling and depot units, and the United Kingdom.

(b) Telephone exchanges and internal telephone systems at the selected airfields.

(c) Telephone and telegraph lines, to carry not less than two speech and two teleprinter channels for the sole use of the A.A.S.F., between the Base Area (Nantes) and Headquarters, A.A.S.F. (Rheims).

(d) W/T services at airfields in the event of landline failure.

(e) The availability of French D/F stations.

(f) The accumulator charging facilities, the nature of power supplies, etc.

(g) The availability of French signals and D/R personnel pending the arrival of R.A.F. and Air Formation Signals units.

(h) The allotment of frequencies for aircraft and point-to-point services.

The French authorities confirmed that telephone, telegraph, radio and electrical facilities would be ready for use at each main, satellite, and refuelling airfield. All such airfields would be connected to the general French telecommunications network, and it would therefore be possible to communicate from any one of them with all the others and with England by means of the existing Paris-London cable. Only a part of the telephone lines serving the selected airfields, however, would be suitable for teleprinter working. The question of cable communications between the two countries had been considered by the Imperial Communications Committee in 1937, when attention was drawn to the vulnerability of existing cross-Channel

[1] A.M. File S.44933/I.

cables in the neighbourhood of Dover and Calais. New G.P.O. cables were in the course of being laid to the Channel Isles, and these were extended to France.[1]

The French authorities went ahead with the installation of an internal telephone system at the selected airfields, with French operators. Each airfield had an underground telephone exchange, with six lines to the local exchange and with the possibility of more. All lines to the airfields were buried. The French authorities asked for an interpreter to be provided at each airfield exchange to overcome language difficulties. They confirmed that two speech and two teleprinter circuits would be available between the Base area and Headquarters A.A.S.F.

For W/T services the French offered a signals and communications detachment of the French Air Force at each main airfield to operate the field radio and D/F stations, which would be placed entirely at the disposal of British units. In addition, two despatch riders and two liaison cars were provided together with personnel, for communications between airfields. The French suggested that this W/T section should, for technical reasons, be taken over by the R.A.F. when the British formations were established. It was eventually decided to transfer pack and aircraft sets for field communications, with personnel, from the United Kingdom at the same time as the transfer of squadrons.[2] The French authorities promised that the telephone communications would be established at Headquarters A.A.S.F. and at each airfield by D-Day plus 1. A teleprinter was to be flown to France and installed at Headquarters A.A.S.F. for cross-Channel working on D-Day plus 1, or as soon as possible thereafter. No provision was made for cross-Channel W/T communications during the early days of an emergency.[3]

Air Raid Reporting Systems

Another matter discussed with the French authorities in 1938/1939 was the linking up of the British and French air raid reporting systems. Early in 1939, an air raid reporting liaison service was formed with sections at Headquarters Fighter Command, Rouen, Lille and Dunkirk. The role of this organisation was to ensure that British information of any hostile raids which might affect France was passed immediately to the French authorities, and vice versa. To enable information to be passed quickly, special circuits were provided between Stanmore on the one hand, and Rouen, Lille and Dunkirk on the other. The system was also used for the passing of aircraft movements traffic, etc. A short test of this co-ordinating machinery was made on 19 July 1939. For this purpose, the six scheduled telephone lines allocated to the liaison scheme were taken up for two hours by the G.P.O., linking the three French centres to Headquarters Fighter Command.[4]

[1] A.M. File S.44933/III.
[2] A.M. File S.44933/I.
[3] A.M. File S.44933/III.
[4] A.M. File S.2544.

Air Component Field Force

In addition to the Advanced Air Striking Force, an Air Component was required for the specific task of the air defence of the British Expeditionary Force in France. This was known as the Air Component Field Force (A.C.F.F.). A meeting was held in Paris between French and British Staff Officers on 28 August 1939 to discuss the British plan for this component. The French authorities concurred in the British plan, which required nine airfields and three satellites in the initial stage, concentrated in the area St. Omer—Lille—Valenciennes—Beauvais—Dieppe. The main communications required for implementing the first stage of this plan were summarised in the form of schedules of operational and administrative lines. These lines connected the wing operations room at Amiens with fighter sectors at Havre and Rouen, plus various information and administrative circuits.[1]

Two T.1087/R.1084 mobile sector R/T stations were operated with the Air Component, one with No. 1 Squadron and one with No. 73. The T.1087's were converted to crystal control in December 1939. The vehicles had been designed for W/T point-to-point work, but they were successfully employed in this R/T capacity. The R/T was strong and of good quality. The sets were remotely controlled over up to six miles of French telephone line.[2]

In order to ensure close co-operation between the British and French signals services of all arms, a Franco-British Telecommunications Committee was established in October 1939. The W/T Board had been considering the methods by which the communications requirements of the Allies could best be co-ordinated and a Committee with representatives of the Chairman of the W/T Board, the Director of the Signals Department Admiralty, the Deputy Director of Staff Duties (Signals) War Office, and the Director of Signals Air Ministry, together with their opposite numbers in France, was formed. The Committee had the power to co-opt other interested parties and to invite representatives from other Allied countries. The functions of the Committee were :—[3]

(a) To allocate frequencies of all British and French services with a view to limiting interference.

(b) To establish common regulations relative to the routine aspects of signals.

(c) To allocate to the armies outside the zone of operation the necessary means of communication.

(d) To exchange all information of a military or technical nature concerning telecommunications.

The principal problems affecting the R.A.F. discussed by this Committee were the arrangement of frequencies to ensure freedom from interference, the landline requirements in France, and R.D.F. in France.

[1] A.M. File S.44933/III.
[2] A.M. File S.4365.
[3] A.M. File S.2465.

Nos. 1 and 2 Air Formation Signals

As soon as they were established in France, Nos. 1 and 2 Air Formation Signals Units became responsible for R.A.F. landline requirements, providing and maintaining all such lines down to and including squadrons and their dispersal points. They also manned all telephone exchanges down to squadron exchanges, which were manned by the Royal Air Force.[1] Point-to-point W/T communication was only used as a standby to landline, and then only for urgent traffic which could not be passed by other means. Periodic tests were carried out, however, using sites at first not less than 20 to 25 miles and, later, not less than 10 miles from any operational headquarters or station. As a precaution against direction finding by the enemy, these tests were never carried out at the normal sites. Mobile and transportable T.1087/R.1084's and T.1083/R.1082's were used.[2]

When Headquarters British Air Forces France (B.A.F.F.) was formed some degree of centralisation of the standby W/T organisation was necessary. Headquarters A.A.S.F. and Headquarters A.C.F.F. continued to arrange communications to their lower formations and units and to their aircraft, but centralisation was achieved by the introduction on 1 February 1940 of a point-to-point organisation controlled by Headquarters B.A.F.F., which linked Advanced Headquarters North B.A.F.F., Advanced Headquarters East B.A.F.F., Headquarters A.A.S.F., Headquarters A.C.F.F., No. 2 Base Area, Nos. 1 and 2 Heavy Mobile W/T stations (local point-to-point only), No. 3 Mission, and Headquarters Bomber Command.[3] The final organisation comprised 13 sections, two controlled by Headquarters B.A.F.F. covering all major formations, one controlled by A.A.S.F. covering four wing headquarters, one controlled by each wing headquarters covering three to four squadrons in each case, two controlled by A.C.F.F. covering its groups, wings and formations, and one each for these groups and wings covering their squadrons, etc. There were also a number of training sections.[4] None of the sections comprising the organisation was operated regularly, however, and one of the outstanding lessons of R.A.F. experience in France was the rapid deterioration of the W/T operating standard owing to lack of practice.[5]

Heavy Mobile Automatic W/T Stations

Two heavy mobile automatic W/T stations were provided in October 1939 as an insurance against the possibility of a serious interruption of landlines and cables between the United Kingdom and France. A service of this nature was first provided in October 1939 by a duplex short wave automatic high-speed circuit between Leighton Buzzard and the Eiffel Tower W/T station. This service was superseded by the heavy mobile W/T

[1] A.M. File S.5304.
[2] A.H.B./IIH2/192.
[3] A.H.B./IIH2/199.
[4] A.H.B./IIH2/210.
[5] A.M. File S.5304.

stations later in the same month. The heavy mobile W/T stations were produced by Marconi's at very short notice, the first being provided in nine days and the second in six days.[1] The serviceability of the cross-Channel cables was good, however, and these stations were rarely used for the purpose for which they had been sent to France. In the second half of May, however, No. 2 H.M.U. did excellent work in clearing operational traffic.[2]

On 26 October 1939 a chief signals officer of the rank of group captain was established in France to co-ordinate Signals activities, in particular in conjunction with the Army and the French military authorities, and in general to act as deputy to the Director of Signals, Air Ministry, in communications matters in the French War Zone.[3] C.S.O.s were already appointed to the A.A.S.F. and the air component, but these were responsible only for R.A.F. communications within their separate forces. Up to the time of this appointment considerable difficulty was experienced in arranging for R.A.F. communications which did not form part of general arrangements made by the Army.

Extension of R.D.F. Chain

It was decided in March 1940 to extend the R.D.F. chain, the French authorities supplying the lines and cable for two new R.D.F. filter centres at Arras and Rheims. It was planned to set up a chain of R.D.F. stations between Calais and the Swiss border, reporting to these two centres. The air raid reporting liaison service was reorganised as a result.[4]

Experience in the operation of the A.A.S.F. squadrons up to March 1940 showed that communication by telephone was insufficient, an additional teleprinter organisation being essential. The A.A.S.F. role in operations in support of the Army called for a great deal more communications than had been used in France up to this time, and an exercise which was carried out to practise this role indicated that the bottleneck in communications was the wing headquarters. This was because all operational and intelligence reports from squadrons were telephoned to wings, where they were collated and the relative matter transmitted by teleprinter to Headquarters A.A.S.F. It was requested by the Air Officer Commanding A.A.S.F. that teleprinter circuits be installed between all squadrons and their respective wings.[5]

Because of the shortage of teleprinter operators, the possibility of meeting this requirement by means of the despatch rider service was considered; each bomber squadron had an establishment of three despatch riders and each wing one despatch rider, wings also having an Army signals section on their establishment. However, owing to the backwardness of satellites

[1] A.M. File S.2194.
[2] A.H.B./IIH2/191.
[3] A.M. File S.57902.
[4] A.M. File S.2544.
[5] A.H.B./IIH2/174.

and their lack of accommodation, all reinforcing squadrons had to go to the ten main airfields, and for these airfields a telephone link was inadequate, even if supplemented by D.R. It was thought that operations and intelligence reports of bomber squadrons might prove to be the most important source of information available for the direction of bombing operations; and it was therefore decided to try to obtain a teleprinter link between wing headquarters and each of the ten main airfields. This requirement was noted and the extra equipment was included in the new establishment, but the installation of teleprinters was not possible before the collapse.[1] Some teleprinters, however, were introduced from Headquarters B.A.F.F. to certain formations at the end of May 1940, and teleprinter traffic was passed to and from the Air Ministry.[2]

An Air Despatch Letter Service was instituted soon after the establishment of R.A.F. headquarters in France. The object of the service was to provide a rapid means of passing signals messages and despatches normally handled by the R.A.F. Signals Service which could not be passed by other methods due to congestion, and urgent official despatches and correspondence for which normal methods of despatch were unsuitable.[3]

A main shuttle service operated from the United Kingdom to a focal point in France, from which point other services were run to cater for the main R.A.F. headquarters and formations. The service operated once daily in each direction. Car and despatch rider services linked outlying formations to the terminals. All despatches were properly registed. When the A.D.L.S. was unable to operate due to bad weather, an alternative sea and road service was put into effect. Emergency D.R. services were ready to be put into operation in France by Army and R.A.F. vehicles and personnel if landlines were disrupted.[4]

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[1] A.H.B./IIH2/174.
[2] A.H.B./IIH/173.
[3] A.H.B./IIH2/204.
[4] A.H.B./IIH2/210.

CHAPTER 7

MIDDLE EAST

General Review of Communications Organisation

Signals resources in the Middle East prior to the war were meagre in the extreme. There was no modern equipment available or in use, and such signals organisations that did exist were necessarily of an improvised and primitive nature. The whole of the Middle East was still restricted to M/F working as late as 1937, and at this time there was only one specialist vehicle in the whole command. The entire signals staff at Headquarters in 1939 comprised one G.D. officer, one cypher officer, and a flight sergeant. There was no radar equipment in existence, and no radar staff.

In the course of 1939, however, combined plans were laid for the defence of Egypt and the Nile in the event of war. These plans involved the expansion and reorganisation of Middle East Command, and it was at once apparent that the existing R.A.F. communications were altogether inadequate to meet the war operational requirements involved in the plan. Under the Anglo-Egyptian Treaty of 1936, political considerations involving the permission of the Egyptian Government for all fixed services had tended to keep signals facilities to the minimum compatible with peacetime requirements. A review was therefore made of the whole question of communications facilities for the R.A.F. in Egypt, with the object of making provision for adequate landline and wireless facilities to meet all administrative and operational requirements in peace and war.

A detailed Signals plan was evolved which would meet the requirements of the plans for R.A.F. expansion. This plan involved the construction of additional landline systems, the earmarking of existing civil circuits, the construction of permanent fully protected buildings for operations rooms, the provision of R.D.F. and W/T stations, and of large quantities of technical equipment together with adequate Signals personnel to operate and maintain it. It was intended that, wherever possible, operational and administrative communications between permanent R.A.F. war stations in Egypt should be provided by landline, with alternative routes for all operational circuits, and with alternative standby wireless links. The particular needs of the R.A.F. in desert warfare were studied and mobile wireless equipment was to be provided for all mobile units and attachments. All sector headquarters were to have direct landline and W/T communication with each other, with their fighter squadrons and with their fighter group operations room. R.D.F. stations were to be connected by direct landline and W/T to the R.D.F. filter room, to the nearest sector headquarters, and to each other. Other landline and W/T circuits were to be provided for Egyptian observation posts for the co-ordination of artillery and fighter defence, an air raid warning system, Intelligence and a meteorological network. The combined plan provided for the A.O.C.-in-C. Headquarters R.A.F. Middle

East in Cairo to exercise command of air units in the Mediterranean, Iraq, Palestine, Transjordan and Aden, and traffic between these units was to be by R.A.F. W/T and by civil cable systems.[1]

Shortly before September 1939, certain squadrons in the Middle East were ordered to take up position at their advanced landing grounds in the Western Desert. Each squadron had to provide W/T facilities at its advance base to maintain a 24-hour point-to-point service with its rear base and with other squadrons in its group, and also provide W/T and R/T communications with its aircraft. New specialist W/T vehicles were to be part of the standard equipment of these squadrons, but these vehicles had not yet been delivered, and the squadron had to construct, from the equipment available, two general purpose pack sets for simplex working. The design and construction of these pack sets was left to the discretion and ingenuity of individual squadron signals personnel.

The equipment in general use in the Middle East at that time was the T.1083/R.1082. The main requirements of the design were mobility and sturdiness, together with a construction that would allow the quick setting-up of the equipment itself and the speedy erection and handling of ancillary equipment. The transmitter and receiver were mounted on thick sorbo rubber, securely held by expansion cording, clamped to the shelf of a cabinet which was bolted to the floor of a Ford lorry. Underneath the shelf were housed a generator, smoothing unit, condensers etc., with accumulators bolted to the bottom of the cabinet. A 30-ft. telescopic mast supported the aerial system, and a wide range of frequencies was available. Short-range working between vehicles in convoy was possible. In spite of adverse conditions, communication with rear bases at a range well in excess of 200 miles was maintained. Later, when the specialist vehicles, including power lorry and transmitter and receiver tenders, arrived from the United Kingdom, they replaced the improvised equipment to some extent, although mobile pack sets made up from the T.1083/R.1082 continued to be used for many purposes.[2]

Immediately on the outbreak of war in September 1939, a Signals Instruction was issued which gave the order of battle and probable location of units, with full details and diagrams of the existing wireless, tie-line, and defence landline communications.[3] Progress with the plans for the expansion of communications was slow; however. Due to the poor landline facilities between Ismailia and the Western Desert, some links in the organisation were heavily loaded, almost to saturation point, with administrative traffic. A further disadvantage was the siting of the Command W/T Station at Ismailia away from the Headquarters in Cairo, and this caused serious delays, in spite of there being two landlines and two W/T circuits between

[1] A.M. File S.48592.
[2] A.H.B./IIM/B26/1.
[3] A.H.B./IIM/A13/1D. H.Q., R.A.F., M.E., O.R.B. Signals Appendices, 1939—March 1941.

the Headquarters and Ismailia. Drastic control of traffic was necessary, and other remedies applied included the institution of an air mail service, and the provision of a despatch rider service, for which motor cycles were allotted to all units. By early 1940, only five of the specialist mobile transmitting and receiving units on order had arrived in the Command, and in many cases units moving to their war stations could still not be supplied with their specialist vehicles; communications were maintained over the comparatively short distances involved by the G.P. pack sets which had previously been installed in Ford lorries. Other important factors were a shortage of wireless equipment, particularly of T.1087's and R.1084's, and the need for re-building the Command W/T Station. By this time, however, there had been a considerable increase in the number of through lines between Cairo and Alexandria and Cairo and Ismailia, and a line had also been laid from Alexandria to Mersa Matruh. With one or two exceptions all stations in Egypt were now connected to a line telegraph and teleprinter organisation.[1] There was, however, a very serious shortage of personnel. The situation altered very little in the ensuing months, and in August 1940, communications were mostly being maintained by the use of 130 G.P. pack-sets, the majority of which were of local construction. The supply of specialist vehicles had not improved and some 35 pairs were needed. There was also a great deficiency in power vehicles. Of the specialist R/T vehicles required for the Army Co-operation squadrons, two were held but a further eight were needed. The personnel shortage remained acute.

It was fully realised that the three essentials for successful operations in open terrain such as the Western Desert were :—

(a) Adequate base communications for the internal organisation of the Command and for direct links to the Air Ministry and the subordinate Commands in Palestine, Aden, Malta, East Africa, Iraq, and Sudan.

(b) An adequate ground-to-air R/T and W/T organisation supported by wireless navigational aids.

(c) Fully mobile low-power communications for the forces operating in the field.

The implementation of these requirements was hindered principally by the shortage of equipment—a general shortage throughout the Royal Air Force and not a factor confined to the Middle East, though it was considerably aggravated in the Middle East by the priority accorded to home demands and the loss at sea of important cargoes. Every possible source of supply was therefore examined by the Chief Signals Officer of the Command.[2] A considerable amount of equipment was obtained from Australia, India and South Africa, but by far the most prolific source of efficient radio apparatus

[1] A.M. File S.4019.

[2] Group Captain W. E. G. Mann, later Air Commodore Mann. Group Captain Mann had been in the Middle East since 1936 and he remained C.S.O. until transferred to Mediterranean Air Command in April 1943.

was direct purchase from America.[1] This policy was endorsed and encouraged by the Air Ministry.

The base communications had already been provided on an adequate scale by August 1940. An automatic high-speed service was about to open between the Middle East and the Air Ministry, and for the internal organisation of the Command, direct W/T links existed from the Headquarters to the subordinate commands in Palestine, Aden, Malta, East Africa, Iraq, and the Sudan. These links were capable of handling all essential W/T traffic. Within Egypt, W/T networks were in existence and operating efficiently between Command Headquarters and the headquarters of the operational groups, with outward links down to wings and stations.

Because of the great distances involved, emphasis was placed on the importance of W/T communications, but these were supplemented in the base area by landlines. These were on a meagre scale by United Kingdom standards. Originally these landlines had been provided by Egyptian State Telegraphs, but their quality was low, and efforts were made to improve them sufficiently to allow teleprinters to operate on them. The teleprinter network connected Headquarters R.A.F. Middle East, the Inter-Command W/T Station at Ismailia, and static groups and stations in Egypt including maintenance and equipment units. After the outbreak of hostilities the responsibility for providing landline communications for the R.A.F. fell jointly on the Army and the Egyptian P. and T., but the general shortage of both cable and terminal equipment restricted installation largely to the base area of the Delta and the coastal zone towards the Western Desert.

Communications for ground-to-air working on W/T were reasonably satisfactory, but the aircraft R/T set, the T.R.9, made really effective ground control by R/T difficult and often impossible. The greatest weakness, however, lay in mobile equipment for air forces operating in the field. Advanced headquarters and landing grounds were still dependent on semi-obsolescent mobile W/T equipment housed in mechanical transport which was generally unsuitable for operations in the Desert.

An important event which took place in August 1940 was the arrival in the Western Desert of a skeleton Air Formation Signals Company.[2] Prior to the arrival of this company, all line and telephone requirements had been obtained by direct liaison between the C.S.O. of the R.A.F. group concerned and the appropriate Army C.S.O. All squadron internal telephone requirements and the laying of internal extensions had been carried out by the squadrons themselves, and R.A.F. speech channels between squadron and group headquarters were frequently shared with various Army units. Direct tie lines between squadron and group headquarters were non-existent.

[1] American equipment proved in nearly all instances superior to British. Most of it had been designed originally for use by amateur radio enthusiasts, but its performance was excellent, and although not always robust in appearance, it stood up to the rigours of mobile warfare remarkably well. (Narrator's interview with Air Commodore Mann.)

[2] A.H.B./IIM/A13/1D, 1939—March 1941.

War in the Middle East

This was the communications situation when the first Italian offensive began in September 1940. The Western Desert Force could not prevent a limited advance and the enemy was soon able to establish a line from Sidi Barrani to Sofafi.

The next commitment resulted from the outbreak of war between Italy and Greece, necessitating the despatch of certain air units to Greece. A communications organisation was established between Egypt, Crete, Athens and Ankara and the squadrons operating in Greece.[1] A W/T organisation was brought into force with Ismailia as Control Station over Athens and Heraklion; other W/T circuits included Headquarters No. 201 Group and Suda Bay, and Headquarters R.A.F. Middle East controlling Headquarters No. 202 Group and Eleusis. Aircraft guard and D/F facilities were also arranged. Further communications were provided under an outline Signals plan issued in November 1940, including two specialist vehicles with T.1087 transmitters and G.P. pack sets. Line requirements down to squadrons and units were catered for by a wing section of Air Formation Signals.

Meanwhile, in the Middle East, the situation had stabilised and a number of new operational telephone circuits were quickly established by Air Formation Signals and brought into use. By November 1940, every squadron in the Western Desert had a direct tie line to its group headquarters, and fighter squadrons had two speech channels, one direct to the group operations section and one to the P.B.X. Fullerphones were superimposed on the exchange line and every squadron worked a buzzer through to its group headquarters by this line, thus avoiding the need for an internal W/T organisation except for standby purposes. The line responsibility at this time included the following unit exchanges and their subscribers:—

4 Fighter Squadrons

5 Bomber Squadrons

1 Army Co-operation Squadron

An advanced Group Headquarters

A rear Group Headquarters

A Squadron H.Q. separated from its Flights

An Air Stores Park

A Repair and Salvage Section

A Medical Receiving Station

In addition, a line was run to and a telephone installed in each of the following:—

3 Supply and Transport Sections

3 Heavy Bomber Operational Airfields

[1] A.H.B./IIM/A13/1D, 1939—March 1941.

A Detached Fighter Flight

1 Mobile Radio Unit

1 High-speed Launch Mooring

1 Navigational Beacon

1 Special Dummy Flarepath Circuit

With certain exceptions, telephone channels were carried on permanent air line, those lying east and west of the group headquarters being on the main route along the railway, the rest being on spur routes specially built for the R.A.F. The responsibility for maintaining the main routes lay with the Corps or L. of C. Signals, but Air Formation Signals assisted them whenever breakdowns occurred in R.A.F. channels. The responsibility for other permanent air line and cable groups belonged to Air Formation Signals. A W/T communications organisation was set up in November 1940, using G.P. pack sets, to pass aircraft sighting reports from the wireless observer screen to the Air Report Centre in Alexandria.

In December 1940, the Western Desert Force went over to the offensive, and in the following month an Advanced Fighter Wing was formed for Operation 'Western Desert', point-to-point communications being provided from the limited number of specialist vehicles and pack sets available. In the same month, No. 5 Medium Heavy Mobile Unit was attached to Headquarters No. 202 Group, the headquarters of the A.O.C. Egypt, to provide a high-power wireless link from Headquarters No. 202 Group to Headquarters R.A.F. Middle East and other headquarters and formations in Egypt. This unit consisted of one transmitting vehicle, one receiving vehicle, one power trailer, one Crossley 3-ton vehicle, one 15-cwt. van, two motor cycles and one 32-seater coach. Meanwhile, in Egypt, the shortcomings of the inter-Command station at Ismailia had been appreciated and construction was approved of a new Command Transmitting Station at Helmieh, on a site to accommodate six SWB8's and six T.1087's. The receiving station remained at first at Headquarters, but a new station was later built at Helmieh. The shortage of wireless equipment, however, was still acute, and was only partly relieved by the decision to purchase American equipment. This included R.C.A. ET.4331 transmitters, a number of which had already been purchased and were in use, several types of Hallicrafter receiver, and a number of Phillips' petrol/electric charging sets. The shortage was aggravated by severe losses of British equipment in transit at sea.

The main R.A.F. wireless station used in the East African campaign was that situated at Khartoum. There was very little signals equipment available. One pair of specialist vehicles was transferred from the Middle East, also two wireless observer units, consisting of some fifteen posts each, equipped with pack sets. These W.O.U.s acted with flights as communications units, and were for a time the only communications available to the Army at advanced positions. Pack sets were also used at advanced landing grounds and at headquarters. Captured Italian wireless stations were adapted for use by British forces.[1]

General Wavell's advance in the Western Desert brought in its train further equipment demands. The military situation had undergone a marked change by March 1941, by which time a new Signals organisation had been produced which allowed for fixed permanent ground stations to be erected at Benina, El Adem, and Mersa Matruh, using the T.1087/R.1084 for point-to-point communications. Headquarters R.A.F. Cyrenaica was formed and was given No. 5 Medium Heavy Mobile Unit for point-to-point and aircraft communications.[2]

By April 1941, the operational efficiency of units and of air defence was being affected by the lack of good line communications—speech, teleprinter and telegraph. Wireless channels were not capable of handling any considerable increase in traffic, and were comparatively inefficient over short distances due to cyphering delays. Direct telephone circuits were essential between all air defence organisations and units, and a plan was introduced with the object of providing landline circuits for all possible channels of communications. There were a number of inter-group lines which, owing to difficulties of distance, under-water cabling, etc., could not be provided, and these included lines to Greece, the Sudan and further south; but the plan covered line communications between units in Egypt, Iraq and Cyrenaica. Schedules of internal air defence lines were drawn up for the various organisations in Egypt (including Headquarters No. 252 Wing; operations, administrative and provisioning lines for Headquarters R.A.F. Middle East; and Headquarters No. 202 Group); for Cyrenaica; for Palestine and Transjordan; for Greece; for the Sudan; and for East Africa. The plan absorbed one A.F.S. unit and two and a half companies. Lines in Egypt, Palestine and Transjordan, and Cyrenaica were scheduled to be completed within six months.[3]

The operational situation, however, was now undergoing a fundamental change. Forces under Rommel had entered the Mediterranean theatre in January 1941, and on 30 March the Axis Forces began to advance from El Agheila, forcing the Western Desert Force to withdraw from their recently won positions, and by 10 April they were back at the Egyptian frontier. At the same time the R.A.F. units in Greece came under increasing pressure as the German forces gained the upper hand.

Signals organisation in Greece and Crete

The R.A.F. Signals organisation in Greece continued in existence up to about 9 April 1941. Immediately prior to the withdrawal to the Athens area, all R.A.F. units were instructed to keep in touch with Headquarters

[1] Narrator's interview with Air Commodore Mann.
[2] A.H.B./IIM/A13/1D, 1939—March 1941.
[3] A.H.B./IIM/A13/1D.

B.A.F. Greece, and this they succeeded in doing, communication being established whenever units were halted. Unfortunately, a good deal of signals equipment was lost in the withdrawal, either before units left their bases, due to immobility of equipment, or on the road, due to poor surfaces and congestion. On the arrival of units in the Athens area, a new signals instruction was issued which prepared for the evacuation of units from Greece and for a gradual reduction in communications. Landlines in the Athens area and all W/T communications continued to operate satisfactorily at this stage.

The evacuation of unit personnel by their own aircraft continued from the time units arrived in the Athens area until approximately 21 April. Throughout this period scheduled communications continued to operate. On about 20 April, an R.A.F. W/T station was set up at Argos, to which place all remaining R.A.F. personnel in Greece were transferred by road, with the exception of a skeleton staff Headquarters R.A.F. Greece, which included Signals and Cypher personnel. The last stage of R.A.F. evacuation began with the closure and destruction of the main W/T station at Headquarters B.A.F. Greece on 23 April. An advanced Headquarters was formed at Argos on a mobile basis, acting as a central signals station for the three Services. Two W/T channels were operated with Headquarters R.A.F. Middle East, two to Crete and one to Force Headquarters A.N.Z.A.C. Corps. Other channels were operated to the air attachés at Athens and Ankara, plus a number of internal services and mobile pack sets. Communications operated as organised except that Argos was not able to operate continuously due to enemy action. A rear headquarters was formed at Canea in Crete, and communication maintained with the advanced headquarters. On 29 April, due to the military situation, it became impossible for communications to be maintained with personnel remaining in Greece.[1]

As the situation in Greece deteriorated, W/T equipment previously earmarked for Greece was diverted to Crete, and, while the arrival of this diverted equipment was awaited, low-power sets which had been taken over were quickly installed. By 20 April, Heraklion, Retimo, Maleme, and two radar stations were in communication with the rear headquarters formed at Canea. A medium-power transmitter for communication to Headquarters R.A.F. Middle East, and H.F. and M.F. facilities for aircraft, had already been installed at Canea. The diverted W/T equipment arrived about 21 April and was used to establish a medium power circuit for controlling aircraft.

In the course of enemy bombing attacks during the next two weeks, the W/T Station at Heraklion was hit and considerable damage was done to W/T masts and buildings, but little damage was done to wireless equipment, which was transferred to a cave, where point-to-point services were maintained, although the D.F. services had to be abandoned. The headquarters in Canea was withdrawn by 12 May and a new headquarters formed in seven

[1] A.H.B./IIM/A13/1D.

small shelters under cover of a cliff. The wireless station still functioned, however, and continuous communication was maintained with Egypt and with other units in Crete.[1] By 20 May, all security R.A.F. cyphers had been destroyed. Only Syko was held, and the submarine cable from Egypt to Crete was manned by Army Signals personnel, so that messages of a most secret nature could be passed in plain language. On 25 May, however, reasonably secure cypher was delivered to Headquarters R.A.F. Crete.

No more difficult country could be found to maintain communications when continually on the move than the mountainous terrain and the impassable roads of Crete, with the consequent necessity of manhandling Signals equipment. In spite of this, communications were maintained throughout and traffic cleared with a minimum of delay. The work of Signals personnel in Greece, too, earned high praise, particularly for the maintenance of communications by the humping of pack sets into boats and across the Peloponnese in most difficult conditions.

The C.S.O., Headquarters B.A.F. Greece made a number of recommendations following the evacuation, among which were that signals officers must be in the confidence of the controlling staffs and in possession of all facts regarding plans, movement of units and other relevant information. He considered that all units, including headquarters, should have a light wireless vehicle fitted with at least a G.P. set complete with spares and charging set capable of operating on the move. A comprehensive signals plan with alternatives should be ready to meet any emergency.

It was clear that one of the main duties of signals officers, particularly C.S.O.s, lay in anticipating requirements, senior signals staffs needing to be men capable of evaluating a broad situation, and always endeavouring to be one step ahead of stated requirements. Orderly routine planning was not always possible, and C.S.O.s had to gain the confidence of senior headquarters staff so that they were never caught out by unexpected demands.

Reorganisation in the Western Desert

With the withdrawal from Cyrenaica in April 1941, the Air Forces in the Western Desert were reorganised, and the existing arrangement of main and subsidiary airfields was superseded by a new organisation.[2] An advanced air headquarters was to be established in the Maaten Bagush area, a rear air headquarters at Burg-el-Arab, Headquarters No. 253 Wing (fighters, bombers and Army Co-operation aircraft of the Air Component) at Mersa Matruh, Headquarters No. 204 Group (striking force of bombers and fighters) at Maaten Bagush, replacing Headquarters No. 202 Group, Headquarters No. 257 Wing (heavy bombers) at Shallufa, and Headquarters No. 257 Wing (Advanced Elements) at Fuka and Wadi Natrun. Squadrons were to operate from operational landing grounds (O.L.G.s); administration and

[1] A.H.B./IIM/B26/1A. Personal account of Wg. Cdr. Hurst, Chief Signals Officer, R.A.F. Crete.
[2] A.M. File CS.9728/I.

maintenance of squadrons was to be carried out at base landing grounds (B.L.G.s). In addition, there were to be refuelling and re-arming landing grounds (R.L.G.s) in the forward area, and dispersal landing grounds (D.L.G.s). Landline communications between landing grounds were practically non-existent at this time, the sole means of communication being by W/T. A large number of landing grounds existed in all areas, the occupants were continually changing, and even if the equipment had been available to tie all landing grounds by landline to various centres to provide inter-communication, the continual change of occupants would have thrown any such scheme into confusion. W/T was therefore used and in the forward areas this had of necessity to be of a highly mobile nature. To this end, as light vehicles became available, W/T pack sets were installed in them.

A Signals Instruction was issued in April 1941 to provide wireless and landline communications for the newly organised Western Desert Air Force. W/T point-to-point communication provided normal operational and administrative channels from Air Headquarters (Advanced and Rear), to the headquarters of groups and wings, squadrons and maintenance units. Landlines provided telephone and telegraph circuits between Headquarters R.A.F. Middle East and Air Headquarters Advanced and Rear, and through supporting headquarters to all squadrons, units and landing grounds. This line organisation was additional to the existing A.M.E.S. and No. 252 Wing operational lines. As the telegraph circuits became available, W/T channels were closed or relegated to standby. Orders for the posting of signals personnel, and the use of cyphers and equipment arrangments, were included in the signals plan. No. 4 Medium Heavy Mobile W/T Unit was allotted to Advanced Air Headquarters and No. 5 to Rear Air Headquarters. Other signals equipment in use included specialist vehicles, power vehicles and pack sets.

Confirmation of the proposed establishments for the reorganised Air Forces in the Western Desert followed in the same month. The individual units established in the course of the next few months included Advanced Air Headquarters, Rear Air Headquarters, Group Headquarters, Wing Headquarters, and Bomber, Fighter and Army Co-operation Squadrons with forward and rear bases. The individual establishments ranged from the three Signals Officers, five Code and Cypher Officers, 12 N.C.O.s, and 52 airmen of Advanced Air Headquarters (with an equipment establishment of four specialist pairs, two 7 kVA. power vehicles, two vans, six motor cycles, and three 30-cwt. trucks to accommodate five duplex or ten simplex W/T pack sets) to the two Code and Cypher Officers, five N.C.O.s and ten airmen of a forward fighter squadron base (one specialist pair, one 7 kVA. power vehicle, two motor cycles).[1]

There were still, however, grave shortages of equipment. A number of major items had been lost in the evacuation of Greece and Crete, including six T.1087's, six T.77's, 14 R.1084's, three specialist pairs, four duplex pack

[1] A.M. File CS.9728/I.

sets, 25 simplex pack sets, together with three H.F. D/F stations and a quantity of power vehicles and charging sets. Replacement of these losses was urgently required. In addition, the reorganisation and expansion taking place in the Middle East, coupled with the responsibility for the new West African reinforcement route, called for large quantities of wireless equipment. Some of the outstanding requirements on 1 May 1941 included 45 T.1087's, 10 R.1084's, 20 Meadow's petrol/electric sets, 40 pairs of specialist vehicles, 40 power vehicles, 40 duplex pack sets, 10 simplex pack sets, 49 transportable H.F. D/F stations, and 35 T.1090's. The specialist vehicles were to be equipped with T.1087's/R.1084's and were urgently required.[1]

By July 1941, 14 specialist pairs had been shipped from the United Kingdom plus 16 power vehicles and 150 small petrol/electric sets. Large quantities of wireless equipment were ordered from America and Australia, including 20 R.C.A.4331's, 50 R.C.A.4332's, and some 250 Hallicrafter receivers of various types. W/T equipment was also supplied from South Africa. It was also decided that Middle East Command should produce its own specialist vehicles, given the necessary vehicles and equipment. The American Collins 18Q set was ordered in large quantities for ground mobile use, both in vehicles and in pack sets. The shortage of T.1087's remained acute.[2]

Amended establishment proposals to meet the reorganised signals facilities were produced in June 1941, but great difficulty was experienced in shipping sufficient personnel from the United Kingdom to fill these establishments and thus complete the target force proposed and approved. It became necessary to signal the priority in which personnel for the various units were to be despatched. Demands for signals personnel had to take their place behind many other priority requirements of other branches. By July 1941, the strength of signals personnel in the Middle East and Iraq was just under 5,500, of which about 2,900 were wireless operators, 830 wireless electric mechanics, 830 electricians II, 530 radar operators, and 330 radar mechanics.[3]

Line communications in Egypt remained weak, and with the additional squadrons and units being provided it became essential to expand the landline system as soon as possible. Large stocks of poles, copper wire, insulators and spindles were ordered from the G.P.O. to form a stock of equipment from which Egyptian State Telegraphs could draw to meet the communication requirements of the Services, and much of this equipment had been shipped or was awaiting shipment by July 1941. There was still a serious shortage of telephone and line equipment, however, and a quantity was obtained from American sources. The bulk of R.A.F. landline communications in Palestine and Transjordan was furnished by the Palestine Posts and Telegraphs, but this was not regarded as likely to be satisfactory if the situation in Palestine were to change, and the posting of an Air Formation

[1] A.M. File S.4834.
[2] A.M. File S.4834.
[3] A.M. File CS.9673.

Signals unit to Palestine was agreed in June 1941.[1] A maintenance group was formed in Egypt in June 1941, necessitating the further provision of line communications and standby point-to-point channels.

Air Support

The policy for communications between R.A.F. units operating with the Army and the Army formations themselves was laid down in publications such as the R.A.F. Manual of Army Co-operation.[2] Normally, an air component was allotted to an army in the field, comprising Army Co-operation, Bomber and Fighter squadrons, and the headquarters of the air component was kept in direct touch with Army headquarters by Air Formation Signals, which provided line communications from air headquarters to unit headquarters and down to but excluding squadron headquarters. Communications in squadrons were provided by R.A.F. personnel, but equipment was normally provided, installed and maintained by Royal Corps of Signals personnel. The landline facilities were backed up by point-to-point W/T, which was provided and operated by the R.A.F.

The most efficient method of communication between a detachment or column commander and an operational air base at this time was by means of a vehicle fitted with an R.A.F. W/T pack set. These were known as 'Rodex' vehicles. Rodex were employed with convoys, escorts and columns on operations in areas where contact with the enemy was expected. Where the columns were operating away from roads, the Rodex was stationed at the nearest convenient point and a W/T or other link provided between the column commander and the Rodex. The pack sets communicated direct with the group or unit headquarters providing the close support aircraft, and although the method was not regarded as ideal, a fair measure of success was achieved.

Following the 'Battle-Axe' offensive of June 1941, the whole question of air support for the Army came under review, both in the Middle East and at home.[3] In order to ensure that the maximum effect was obtained from direct air support, an Air Support Control (A.S.C.) was formed to meet, modify or reject requests for support received from various sources. The control was to be exercised by command vehicles equipped with R.A.F. Signals offices, which were to be attached to division and brigade headquarters, where they would provide channels of communication forward to advanced Army units on Army frequencies and back to R.A.F. airfields and airborne aircraft. Such vehicles would also accompany division and brigade commanders of Army mobile formations. The Air Support Control itself was to be formed from the headquarters of R.A.F. formations which might be called upon to give direct air support, plus one or more mobile advanced air headquarters, combined with an Army element. The R.A.F. element comprised the formation commander or his deputy, plus a small operational staff, together with Forward Air Support Links (F.A.S.L.s) for controlling support aircraft in the air and for liaison with reconnaissance

[1] A.H.B./IIM/A13/1D, April—December 1941.
[2] A.H.B./IIM/A13/1D, 1939—March 1941.
[3] *See* A.H.B. Monograph, 'Air Support' (A.P. 3235).

aircraft, Rear Air Support Links (R.A.S.L.s) for communicating direct to selected landing grounds, and a number of other wireless links at the selected landing grounds. The scheme was held up at first because the Army was unable to provide A.S.C.s on the basis of one to each Corps and one to the Armoured Division.

In order to test the system, a signals exercise was carried out on 11/12 July 1941, Signals equipment being assigned to Army formations, together with R.A.F. liaison officers. Nos. 1, 2, 3 and 4 R.A.F. Armoured W/T Units were formed to provide the first F.A.S.L.s. These units consisted of armoured fighting vehicles of the Marmon Herrington type plus wireless equipment and personnel to ensure that the unit was fully mobile and capable of being used in any theatre of war. It was found that R/T facilities were also required between ground and support aircraft as well as tactical reconnaissance aircraft, and the signals organisation was modified accordingly. The unit normally accompanied the commander of a division or brigade in the field. The composition of the unit was:—

(a) *Personnel*: 1 Squadron Leader G.D. to command.
1 Driver M.T.
1 Sergeant W.E.M. } trained in ground
2 Corporals W. Op. } gunnery duties.

(b) *Equipment*: 2 G.P. Pack Sets.
1 Hallicrafter S.29 R/T Receiver.
1 Petrol/Electric Charging Set.

The officers commanding also acted as R.A.F. liaison officers and advisers to the commander to whose force they were allotted on all questions of air support.[1] The scheme could not be fully developed in 1941 because of the shortage of vehicles.

Lessons of the Early Campaigns

A review of the lessons learned in the first twelve months of the Desert campaign was carried out by the Command Signals Officer in September 1941. In order to maintain satisfactory point-to-point communication between the Command and its groups, experience had shown that two channels with one-to-one working with each group were required, thus separating operational from administrative channels. A general lowering of the standard of wireless operating since the outbreak of war made this doubly necessary. However good the standard of communications themselves, the actual amount of traffic passed was dependent on the speed and accuracy of the operators at either end. A one-to-one W/T channel, under war conditions, was overloaded when traffic exceeded 8,000 groups a day, and two channels were then required. Every landline circuit required a

[1] A.H.B./IIM/A13/1D, April—December 1941.

W/T standby channel, and it was desirable for every operational speech or telegraph circuit to have a one-to-one standby if possible. For continuous communications, different frequencies for day and night working were required in Egypt and the Eastern Mediterranean generally. In the Sudan, however, good point-to-point communications were maintained over distances of up to 800 miles with low power W/T pack sets using only one frequency. For aircraft working, it was apparent that each group and wing operating independently needed an aircraft and D.F. organisation of its own. This was uneconomical in equipment and frequencies, but necessary to avoid congestion.

Mobile Signals Units

The following types of specialist vehicle were in use:

(a) Standard W/T specialist vehicles, twin channel, using transmitters T.1087 and receivers R.1084.

(b) General purpose W/T R/T vehicles of a standard type for Army Co-operation work.

(c) Brockhouse power trailers with Meadows 9 kVA petrol/electric sets.

(d) Power prime movers with Meadows 9 kVA petrol/electric sets.

Pack-set equipment was the duplex and simplex field transportable T.1083/R.1082 equipment (Kidbrooke Pattern); and universal simplex T.1083/R.1082 (Aboukir pattern).

Experience gained during the Libyan and Abyssinian campaigns showed that the standard pattern W/T and Army Co-operation specialist vehicles with T.1087 transmitters were unsuitable for operating over rough ground at the speeds necessary for mobile warfare; they were built for operation on good roads, and their overall height and length were too great. During the Greek campaign, the combination of these factors was responsible for slowing down convoys to approximately six miles an hour, and only by extreme care and in some cases manhandling were these vehicles prevented from becoming a total loss when operated on the hair-pin bends characteristic of these mountainous regions. Good roads were practically non-existent in the Western Desert, and considerable damage was caused to wireless instruments when moving over desert tracks. Experience showed that it was imperative for all W/T and power vehicles to be prime movers. In the event of a sudden quick move, there was not always a prime mover available for the towing of a trailer. W/T pack sets generally were also insufficiently mobile.

It was decided to produce a W/T vehicle containing equipment specially designed for mobility and not, as previously, normal ground station equipment. In addition, squadrons were to be supplied with highly mobile vehicles fitted with G.P. equipment on the basis of three vehicles per squadron. A number of highly mobile low power W/T vehicles had already been produced in the Middle East at No. 103 M.U.; these were Ford 3-ton vehicles containing the following equipment and fittings:—

Transmitter T.1083
Receiver R.1082 } and ancillary equipment.
Generator Type 'E'
'Chorehorse' petrol/electric set complete with charging board.
Steel chest for secret and confidential publications.
Desk for cypher officer.
Desk for traffic superintendent.
Steel cupboard for stationery, etc.
Stowage for distilled water.

The aerial was designed in such a manner that the W/T equipment could be operated while the vehicle was in motion. These locally constructed mobile units stood up to the conditions better than the U.K. vehicles. The engines were equally powerful, the Ford vehicles were half the weight of the Leyland vehicles of the U.K. pattern, and the interior stowage of the radio equipment was stouter.

Also constructed was an Army Co-operation vehicle. This again was a Ford 3-tonner, and, in addition to the equipment listed above, it contained a transmitter T.1090 and a Hallicrafter S.29 receiver. Experiments were also being made with a view to producing a suitable medium power W/T station. This was to consist of three Ford 3-ton vehicles instead of the existing two Crossleys; one vehicle would contain the Meadows power unit and switchboard, a second vehicle the transmitters and control panels suitably modified, and a third vehicle the receivers. Experience in Greece and Crete had also demonstrated the need for a highly mobile pack set which could be carried by hand and be operated for reasonable periods without charging apparatus. It was decided to manufacture a pack set using the TR9D transmitter and a Hallicrafter S.29 receiver. The transmitter was modified so that C/W as well as R/T could be used. This pack set gave a range of about 50 miles on C/W and 20-30 miles on R/T, and was used by isolated detachments for communication with adjacent Army and R.A.F. formations. The Hallicrafter S.29 was a lightweight, battery operated, high-gain commercial broadcast receiver fitted with a beat frequency oscillator for C/W reception. The set could be either battery or mains operated, and provision was made for charging the battery where a suitable mains supply was available. The S.29 receiver was also used as a battery ground set for artillery reconnaissance purposes, as it was well suited to use as an R/T receiver for ground-to-air communication.

The lessons learned in the 1941/42 winter campaigns resulted in the re-organisation of air support units, which subsequently operated as mobile signals organisations, capable of providing any information which the Army and R.A.F. commanders considered necessary to effect co-operation between the air and the ground forces.[1]

[1] A.H.B./IIM/A13/2D.

Landline Organisation

In the course of the campaign, advance parties of Air Formation Signals were sent forward to prepare lines, first in the Sollum area, then in the Tobruk area and finally in the Benghazi area. In the Sollum area it was necessary to lay a cable to nearly all units, and although the majority was Italian cable found running in the right direction, it took a great deal of work to put this cable into good order. In the Tobruk area, Air Formation Signals were primarily concerned in replacing broken parts of Italian poles. Again, in the Benghazi area, the majority of telephone channels were carried over Italian permanent routes.

A number of lessons were learnt in this first advance. The average satisfactory length of cable used for telephone pairs was found to be about 12 miles, owing to maintenance difficulties. Field cable in the desert was particularly liable to damage by vehicles, animals, etc., causing poor insulation and breakages. It was found to be a slow job to repair Italian cable as a means of putting a circuit through for the first time. It was quicker to lay a new cable and deal with the captured cable later. Much unnecessary cable was laid in some squadrons owing to the dispersal of offices without regard to the telephone system.

One of the most important factors to emerge was the extreme vulnerability of overhead telephone lines to ground strafing by fighters. German fighters made deliberate attacks on overhead telephones and many wires were damaged as a result. It had not previously been thought possible to destroy overhead telephone lines by this means.

Protection of Signals Stations

It was found in Greece and Crete that insufficient attention was paid to the protection of W/T stations. These were subjected to the first really heavy bombing and ground strafing attacks experienced in the Middle East, and those W/T stations that were not sufficiently protected from blast and splinters were quickly put out of action. It was apparent that receiving and transmitting stations must either be built underground, hidden away in buildings near airfields, or placed in specially constructed buildings sunk a few feet into the ground, sandbagged and camouflaged. It was also necessary to protect mobile wireless specialist vehicles when used with stationary or semi-stationary units, and the practice in the Western Desert became to dig a pit into which the prime mover or trailer was run. The pit was then sandbagged round the edges to the height of the vehicle, and the top of the vehicle was then covered with netting and camouflaged. This was comparatively easy in places where the ground was fairly soft, but was more difficut on rocky ground. When it was not possible to dig a pit, a thick wall of sandbags was built on three sides of the vehicle and camouflage netting spread over it to break up the shadow. Whenever possible, advantage was taken the equipment required to establish this network had been despatched from of any natural cover, even when this meant the erection of a station some miles away from an airfield.[1]

Landlines for the Defence of Egypt

A conference was held at the Air Ministry on 24 September 1941, attended by representatives from the Middle East, to discuss the provision of line communications for the air defence of Egypt.[2] The air defence of Egypt comprised a fortress defence of the Delta area, communications for which were to be entirely separate from other communications in the area and from mobile defence communications for the Western Desert and other areas. The improvement of defence communications in the Middle East, and particularly in the Nile Delta area, had been under consideration for some time, and the basic communications requirement was the minimum needed for the operation of a fighter group. This was far beyond the resources of Egyptian State Telegraphs, and proposals were therefore formulated for the construction by the Army of a landline, telephone and telegraph system, including repeater stations, voice frequency telegraph apparatus, etc.[3]

A schedule of landlines and communications facilities required for the R.A.F. was prepared, and to provide these facilities it was necessary to construct a large underground cable network. By 21 November, the bulk of factories in the United Kingdom for shipment. Great assistance was given by the G.P.O. in preparing the apparatus sent to Egypt and in giving advice in designing the scheme. The schedule of communications included approximately 100 'D' tariff private wire circuits and 16 voice frequency circuits. Mobile D.T.N. equipment was provided for Heliopolis, consisting of a power and audio van and a V.F. telegraph van, and mobile telecommunications equipment(M.T.E.) vans, consisting of switchboard, teleprinter, etc., were supplied for Ismailia and Wadi Natrun.

Owing to shortages of cable, and to changes in the military situation, the immediate plan for improving defence line communications was modified in November 1941, the plan taking shape in three phases. Phase 1 was the immediate construction of 600 miles of air line; this was completed in December 1941 and met immediate requirements. Phase 2 was the construction of the backbone of the underground trunk system consisting of single 14/40 cable running from Alexandria to Amriya to Wadi Natrun to Heliopolis to Ismailia, with spurs from Ismailia to Port Said, Ismailia to Shandur, and a tail from Heliopolis to Cairo. Phase 3 covered separate air defence and air line communications. Repeater stations were supplied by the R.A.F. at Amriya, Wadi Natrun, Heliopolis, Ismailia, Port Said, Shandur and Geneifa. The R.A.F. manned the terminals while Air Formation Signals were responsible for the planning, construction and maintenance of communication in the same way as the G.P.O. at home.[4]

[1] A.H.B./IIM/A13/1D, April—December 1941.
[2] A.H.B./IIJ1/183/5(A).
[3] A.M. File CS.9728/I.
[4] A.H.B./IIJ1/183/5(A).

Up to the end of February 1942, sufficient equipment had been despatched to the Middle East to fit out one group operations room, two wing operations rooms, six sector operations rooms (Heliopolis, Amriya, Port Said, Shandur, Wadi Natrun, Mex), and two wing filter rooms. The question of the expansion of air defence communications in Palestine, Syria, Iraq and Iran was also raised at the Air Ministry Conference of September 1941, and by February 1942, equipment had been supplied for filter rooms at Aden, Cyprus, Malta, Iraq, Palestine, and Syria.[1]

' Crusader '

Part of the preparation for the ' Crusader ' offensive which began in November 1941 included an Outline Signals Plan aimed at providing W/T, R/T and landline communications for those units which would be based in Cyrenaica and the Western Desert after the offensive had achieved its objective. At the outset of operations, W/T communications were good, except for a bad period in the early mornings. The major difficulty arose through frequencies not being always suitable for the distances involved; distances depended on the forward moves of units and were difficult to predict accurately. Frequencies were allotted which appeared satisfactory in theory for estimated distances; when they proved unreliable in practice, adjustments were made as far as possible.

The volume of traffic depended largely on the relative positions of the operational units and the various headquarters. Where ample line facilities could be provided, the telephone saved a great deal of signalling, especially to the fighter wings, and in arranging co-ordination between bombers and fighter escorts. In these circumstances an artificially low level of traffic was reached. The daily totals of W/T traffic at Advanced Air Headquarters Western Desert varied considerably during the advance, peaking to 21,000 groups and dropping to 9,000 even before more static conditions were reached.

The W/T channels provided in the Signals Plan proved ample for the traffic passed. Only when W/T conditions became unfavourable at night, or when it was impossible to open up a forward W/T station in a new position before a main party moved forward, were there any gaps or delays in signalling. The bottleneck was always cyphers, coupled with the necessity for originating many operational signals at the end of the day, just when W/T conditions were apt to deteriorate.

The old-type W/T specialist vehicles gave considerable trouble, but this had been expected. The recently constructed general purpose W/T vans were the mainstay of wireless communications, their chief fault being a lack of low-pressure sand tyres, which were in short supply. The provision of adequate power both for wireless and battery-charging was another continual source of worry. Power plants were of the high-speed petrol/electric

[1] A.M. File CS.9728/I.

type, and they failed continually under desert conditions. The Germans used a slower-running diesel/electric set of higher output, with tropical radiators and filters for sand protection, and after the advance some of these gave good service to our own forces.

In providing the R.A.F. requirements for telephone communication, Air Formation Signals worked in great harmony with the R.A.F. and gave a most expeditious service. The principle was followed of laying D.8 lines between wings and their squadrons after every forward move, and between Advanced Air Headquarters and the wings when distances permitted. Wing sections of A.F.S. were allotted to each fighter and bomber wing, while at Advanced Air Headquarters there was an operating section with line maintenance parties to maintain lines in the vicinity. Line construction sections were chiefly engaged on the main routes and were attached to Advanced Air Headquarters. Wherever possible, temporary lines were replaced by permanent and semi-permanent construction provided they were likely to form part of the rear network. 'Through' trunk facilities to the back areas were provided in conjunction with the Royal Corps of Signals. As the quality of the lines to back areas improved and new routes were built it became possible, using carrier equipment, to provide teleprinter services to Rear Air Headquarters and eventually to Headquarters R.A.F. Middle East. Where telephone lines functioned successfully it was necessary to maintain the strictest discipline over their use, otherwise there was a tendency for lines to become overloaded with administrative traffic to the detriment of operations.

In the forward areas long landlines were impracticable, it being still found that any line over twelve miles in length was difficult to maintain. Heavy transport, tanks, etc., cracked lines and desert dews caused frequent earthing, and line parties were continually employed in repairs. The bombing of road and rail communications by the enemy remained a frequent cause of damage to telephone lines and poles and often interfered seriously with their operation.

Because of the time factor in the installation of lines in the forward areas, combined with maintenance difficulties, the conviction grew that the highly fluid warfare of the Desert demanded a direct means of speech communication such as mobile R/T, using some form of directional aerial which would prevent the enemy from monitoring transmission.

Before the original Signals Plan for 'Crusader' could be fully implemented, the enemy made a recovery in the form of a successful counter-attack at El Agheila on 21 January 1942, and by February the Western Desert Forces had been pushed back as far as Gazala. Communications were, however, maintained throughout, and the organisation of a salvage party, which had a roving commission behind the front line, resulted in the collection and return to base areas of much captured enemy W/T and electrical equipment. No undamaged R.A.F. signals equipment was left in the path of the enemy advance. Nevertheless there were heavy losses due to casualties.

The first aim now became the security of lines and communications in the Delta area. The Middle East air forces, however, were being depleted due to squadrons fully equipped with specialist vehicles and signals personnel being sent to India and the Far East. In addition, quantities of aircraft, equipment and personnel had been diverted from the Middle East theatre. As a result, the Air Forces were considerably weakened. Whereas in February 1942 air superiority had been held, in the following month it was in the balance. The effect of this on communications was that the enemy were once again able to cut overhead lines by infiltration and by aircraft machine-gun fire.[1]

The equipment situation was still causing concern. Over 2,500 wireless and electrical equipments were on order from America, but with the entry of America into the war, some of the equipment had already been taken up by the United States Signal Corps. and it was not certain whether the Americans would be prepared to release the remainder. It seemed inevitable that there would be a severe shortage of W/T equipment throughout 1942, and it was expected that, in particular, reliance would have to be placed to a large extent on salvaged aircraft equipment for R/T and W/T communications in the field.

Air Formation Signals had the problems of line construction well in hand, and although they were unable to cope with line construction between units that were up to 200 miles apart, they continued to provide internal telephones and lines to nearby wing headquarters and units in spite of the rapidity of movement. There was a great improvement in Signals maintenance and in R/T communication in the Western Desert in March 1942, full advantage being taken of the lull in mobile operations to bring this about.

There was a considerable increase in the number of teleprinter links in the Middle East theatre in 1941 and early 1942, and in April 1942 it was decided to introduce standard teleprinter procedure based on that in use on the D.T.N. in the United Kingdom. The stations on the Middle East D.T.N. now included Headquarters R.A.F. Middle East, Air Headquarters Egypt, Air Headquarters Jerusalem, Air Headquarters Levant, Almaza, Aquir, Maaten Bagush, Beirut, Fayid, Haifa, Heliopolis, Helwan, Ismailia, Lydda, Shallufa, Suez Road, and headquarters groups, wings and maintenance units.[2]

Lessons of the Winter Campaigns 1941-1942

Following the review of lessons learnt in the early Desert campaigns, various measures were taken designed to benefit from these lessons and recommendations, and a review of these measures, together with further recommendations, was made following the Western Desert and Libyan campaigns of the winter of 1941-42.

[1] A.H.B./IIM/A13/2D, January-June 1942.
[2] A.M. File CS.13275.

Following the recommendation that a minimum of two one-to-one W/T channels were needed for point-to-point communication from Command to groups and wings, two operations and one administrative channel were provided. This provision proved adequate, but failures still resulted due to operators, many of whom were comparatively unskilled, being unable to keep in touch over the necessary distances on the frequencies provided with the equipment available. This problem became more acute as forward units advanced and lines of communication became extended. Delays were also caused by the slow handling of traffic in unsuitable accommodation, both at advanced locations and on the move. There was a need for frequencies to be more carefully allotted and operators on important links to be more carefully selected. There was also a need for semi-permanent medium-power linking centres, suitably located, at which types of highly efficient aerial and other aids to continuous and successful communication incompatible with mobile units could be employed. More care was needed generally in the erection of aerials. It had become apparent that accommodation must be provided in prime movers for traffic offices, cypher offices, telephone exchanges and teleprinters.

In communications with aircraft, each group or wing had been provided with an operational aircraft guard and D/F station, but many aircraft were still hampered by the continued use of the T.1083/R.1082, which was much inferior to the Bendix aircraft set and the new Marconi T.1155/R.1154 in use in some aircraft. The T.1087 had proved unsuitable for long distance working and an early replacement was needed. Fighter aircraft were finding the air-to-ground combination of the TR.9-T.1087 incapable of providing the R/T ranges required in mobile warfare; better results were obtained with the small Collins 18M, due to its greater band width. The fitting of fighter aircraft with V.H.F. equipment was urgently required. The short life of H.T. batteries in mobile warfare was a further problem.

The development of specialist vehicles to meet earlier recommendations had not been entirely successful and a restatement of the requirement was made. Vehicles must be very strong and hold the road well, must be fitted with low pressure sand tyres and must be fitted with W/T sets of a much smaller size and weight than previously. The T.1087 was still in use but was much too heavy and too large, and a compact modern transmitter delivering about 400 watts to its aerial was needed. A sensitive mains receiver was required as a replacement to the R.1084, simple to use and capable of being driven by mains or battery. Both Meadows and Ford engine powered vehicles had continually failed under normal working conditions. 7½ kVA. was no longer sufficient for the varied wireless services and greatly increased charging requirements of squadrons, and a slow running diesel set was needed with an output of 12-15 kVA., fitted with tropical radiators and adequate filters for sand protection. The Army Co-operation vehicle proved altogether unsuitable; it was much too large and insufficiently robust. The T.1083 gave good service but the R.1082 was inselective and insensitive and frequently caused failures, and a replacement was needed. New vehicles to house the Army Co-operation low power general purpose equipment were in the course of production at No. 103 M.U. in large quantities, but were not ready for the 1941/1942 winter campaign.[1]

Landlines were continually disrupted in this period by machine gun attacks by fighters, in spite of attempts to provide adequate blast and camouflage protection wherever possible. Landlines remained highly vulnerable to both bomb and machine gun attack and the policy became that where they could not be buried, duplicate lines were to be laid over geographically separated routes. Landlines were laid at least 200 yards from roads or railways and cables at 50 yards distance.

All kinds of wireless equipment used in the Desert were subjected to serious deterioration through the penetration of sand and dust. Every effort was made to make vehicles and apparatus dust-proof, but this could only be achieved by the complete exclusion of air, and exhaust fans were needed to dissipate the heat generated by transmitter valves. Dust covers were provided for all transmitters, receivers and power supplies; this protection was particularly valuable when vehicles were on the move.

There followed a period in which both sides were engaged in building up their strength for offensive purposes. During this period the construction of Signals specialist vehicles for mobile Desert warfare continued steadily. The small general purpose W/T vehicle designed to operate on the move, a mobile cypher office, Typex (Coding) vehicles, and mobile operations rooms were all turned out at No. 103 M.U. in preparation for future campaigns.

Rommel's main pre-occupation in this period was with the threat that Malta represented to his supply shipping, and the very heavy bombing of Malta which took place in April 1942 threatened to cut the island's W/T communications with the outside world. Although there was little possibility of the actual transmitting and receiving stations being damaged, control lines, co-axial feeders and aerial arrays were extremely vulnerable. It was therefore decided to operate one of the Eastern Telegraph Company's spare cables between Malta and Alexandria. Traffic for all the Services was handled, being distributed by teleprinter from the cable heads. Transmissions over this cable were considered absolutely secure, and with the combination of teleprinter links, much of the existing cypher traffic between Malta and Middle East could now be passed in plain language. The cable heads were manned by R.A.F. personnel. By employing specially selected personnel, and secure teleprinter links, it was possible for the A.O.C. No. 201 Group in Alexandria to pass a short message to the A.O.C. Malta and to receive a reply within 15 minutes.[2] Provision was also made for Service cable communications to be established between Alexandria and Haifa, and Beirut and Nicosia, should the need arise.

[1] A.H.B./IIM/A13/2D, January—June 1942.
[2] Narrator's interview with Air Commodore Mann.

The heavy bombing of Malta during this period played havoc with the internal communications system on the island, however. Several major breakdowns of mains cables and remote control and telephone lines occurred. The Signals organisation was severely strained as a result of the damage, but the essential communications channels were kept going, often under emergency conditions. All available telephone lines had to be commandeered for fighter control. Telecommunications power supplies depended largely on the use of small chore-horse charging plants and accumulators. During the critical period, alternative ground communications between fighter sector headquarters and the airfields were improvised using V.H.F. R/T aircraft sets, with satisfactory results. Energetic action was taken by Headquarters R.A.F. Middle East to supply replacement signals equipment by air, and by the end of May the situation had improved considerably, all urgent signals equipment requirements having been met and the telecommunications situation being practically normal again. Trying to maintain vital telephone links in the face of attacks of the weight Malta was receiving in April 1942, however, proved a most strenuous task. Many lines had to be relaid two and sometimes three times in the same day. But the vital communications for the control of fighters were maintained, playing their part in exacting a heavy toll from the attacking formations.

By May 1942, a number of new V.H.F. sets had been supplied and fitted in fighter aircraft and, in addition, most new aircraft now arriving in the Command were already fitted with V.H.F. This equipment had first begun to arrive in the Command in January 1942, and two months later ground mobile transmitters and receivers and mobile D/F equipment had all been tested and the fitting of aircraft equipment was under way. However, a large number of sets were still wanted for retrospective fitting as more and more areas and squadrons changed over to V.H.F. The co-ordination of the changeover to V.H.F. included the fitting of V.H.F. equipment in cruisers and flotilla leaders of the Mediterranean Fleet for fighter direction over the sea. The conversion to the much more efficient V.H.F. equipment continued well into the summer of 1942, and the increase in efficiency of operation of fighter and tactical reconnaissance aircraft so fitted was soon demonstrated by the improved co-operation achieved between the Army and the R.A.F. As an instance, on 31 May 1942, when No. 73 Squadron were airborne with orders to attack a certain position, the Army captured the point, and within fourteen minutes the squadron had been successfully redirected to another target. Such control was rarely possible using the old H.F. equipment.

Telecommunications Centre Middle East

The intention to establish a Telecommunications Centre in the Middle East on the lines of Leighton Buzzard in the United Kingdom was first put forward and agreed in principle early in November 1941, when it became apparent that the rapidly expanding Signals Section at Headquarters R.A.F.

Middle East could no longer be housed efficiently or satisfactorily in the Headquarters building.[1]

T.M.E., as the new centre was known, opened in June 1942. Fortunately the building had been planned on a generous scale, as many additional commitments arose in the months between the planning and the completion of the centre. At the same time, a Traffic Control Section was formed to analyse and collate reports on delays and irregularities in communications and to be responsible for outlining proposals based on these reports.[2]

It was thought at first that considerable economy could be effected by the building of this central communications centre for other formations in the Cairo-Heliopolis area, leaving these formations to operate an essential minimum of operational channels only; personnel thus thrown up were to be used to cover the war establishment for T.M.E. In the event, the building of T.M.E. barely kept pace with the increase of communications requirements which was a natural development of subsequent operations in the Western Desert and the occupation of North Africa. Later, in 1943, plans for special amphibious operations called for more and more communications channels and further increases resulted as operations in the Mediterranean area developed. Some increase in the administrative facilities provided by T.M.E. for subordinate formations in the Cairo-Heliopolis area was made, but the expansion of the Middle East sphere of influence was such that the responsibilities of these sub-formations were so increased that no cutting down of staff was possible. Two instances may be cited: that of Air Headquarters Egypt, which was originally responsible for the air defences and administration within the Delta area and which later, as Air Headquarters Eastern Mediterranean, controlled the fighter defences between Tripoli in Syria and Tripoli in Libya through four subordinate group headquarters, as well as administering the majority of units in Egypt and Cyrenaica; and that of Headquarters No. 216 Group, which was originally formed to control the West African and Indian reinforcement routes but whose commitments were doubled with the opening of the route across North Africa in 1943.

T.M.E. thus became the centre of the Middle East communications system and, in addition, formed an integral part of the R.A.F. overseas network. It was also responsible for the following units :—

(a) H.Q., R.A.F. Middle East Signals Centre;

(b) Teleprinter Exchange Trunk Signals Centre;

(c) Signals Production Unit;

(d) Inter-Service Cypher Production Centre;

(e) Command Secret and Confidential Publications Unit;

(f) General W/T Fitting Parties;

(g) Command Traffic Control Section.

[1] A.M. File CS.10696/I.
[2] A.H.B./IIM/A13/2D, January—June 1942.

By the middle of May 1943, the technical side of T.M.E. included a main receiving station operating 11 automatic high speed and 31 manual W/T channels, and 34 teleprinters; and two transmitting stations, located at Helmieh, the first consisting of medium and low-power transmitters, and the second housing high, medium and low-power transmitters, with a total of 60 transmitters in all. The layout of this second transmitting station comprised three separate transmitter buildings, each with its own power plant, arranged in a triangle half a mile apart. In the centre of the triangle was a workshop, standby power plant and key line distribution centre.[1]

Control of Communications Channels

All signals planning was considered from the Services point of view by the Inter-Service Wireless Sub-Committee, and by taking advantage of all military and civil channels of communication, and routeing traffic by the most rapid and efficient means, economy in equipment and an increase in the efficiency of communications was effected. Nevertheless, the Combined Signals Board was worried by the political background regarding the setting up of communications for various British and foreign organisations. It was apparent that there was insufficient control and co-ordination on an inter-Service and inter-Allied basis of communications facilities, both externally and internally, affecting the Middle East, and the action required to obtain the necessary additional control lay outside the scope of the powers of the Combined Signals Board. There was a danger that the clash of interests between the Services on the one hand and political and commercial considerations on the other would prejudice the development of the telecommunications system as a whole. This was bound to be so when so many authorities were providing communications facilities; these included the Royal Navy, the Army, the R.A.F., Cable and Wireless (and their Associated Company, the Marconi Radio Telegraphy Company of Egypt), Egyptian State Telegraphs, Palestine and Transjordan Posts and Telegraphs, Sudan Posts and Telegraphs, Iraq Posts and Telegraphs, Iranian Posts and Telegraphs, Service Telephonique of Syria, the Iraq Petroleum Company, the Anglo Iranian Oil Company, Radio Orient at Beirut, Pan American Airways, and the United States Army Air Corps.

Service requirements and political and commercial interests were in some respects conflicting. The Services welcomed the development of communications facilities to meet existing needs, to provide for future expansion, and, by establishing alternatives, to ensure against the interruption of any particular channels. They were not concerned whether the link was a paying proposition or not; they were not directly interested in political questions, and within certain security limits it was immaterial to them to whom circuits belonged or by whom they were operated. On the other hand, firms like Cable and Wireless had to safeguard their financial position and status, both currently and for the future. Commercial encroachment, under the

[1] A.M. File S.79894.

guise of meeting wartime needs, had to be resisted. Political factors also operated. The Marconi Company, being an Egyptian company, were particularly interested in their position *vis-à-vis* the Egyptian Government, while the British Ambassador was concerned that the terms of the Anglo-Egyptian Treaty should be observed.

The pre-war policy of the British Government, on the recommendation of the Imperial Communications Committee, had been to keep telecommunications in the Middle East, including some internal wireless services, in British hands. But now encroachment by American companies, and also by the French, was threatened. Many of these factors were outside the scope of the Services, who were nevertheless concerned in that the smooth running of communications facilities might be affected. In the interests of the Services, the Combined Signals Board therefore decided to set up an inter-Service and inter-Allied Sub-Committee, with the following objects:—

(a) To consider the wireless layout in the Middle East as a whole, existing and projected, and to make recommendations as to how equipment and channels should best be used to meet requirements.

(b) To examine and report on the question of local purchase of wireless equipment (there had already been a small measure of inter-Service competition).

(c) To produce information regarding the routeing of traffic to ensure that all channels of communication were used to their full capacity and that traffic was distributed in accordance with the communications situation.

The Board was only able to deal with matters directly concerning the Services, and was powerless to deal with any political, diplomatic or commercial aspects. A further measure of control and co-ordination was therefore provided by the appointment of a small advisory staff to the Minister of State.[1]

Signals in the Retreat

Towards the end of May 1942, Rommel began his attack and the Western Desert Forces were thrown on the defensive. The forces available to the A.O.C.-in-C. Middle East Command in June 1942, excluding those based on Malta, comprised three main components. There was the tactical air field striking force of the Western Desert Air Forces—fighters, fighter bombers, and light bombers; No. 205 Group's strategical force of medium bombers, supplemented by a small number of heavy bombers; and No. 201 (Naval Co-operation) Group's mixed coastal force employed on shipping strikes, convoy escort and sea reconnaissance work. There was also a small force under Air Headquarters Egypt for defensive duties. In the

[1] A.H.B./IIM/A13/2D, January—June 1942.

course of the retreat to the El Alamein line, particularly good work was done by Signals units in maintaining communications and in completing an orderly withdrawal. R.D.F. mobile stations, for instance, which passed their plots by means of W/T pack sets, continued to pass plots in many cases until the last possible moment, one station passing 744 plots in seven hours and holding its position until directly threatened by the enemy. This typified the morale of signals personnel at this time. Army/Air Co-operation collapsed during the retreat, but this was not the fault of R.A.F. communications. The system broke down under the strain and confusion of a retreat in which the Army often lost track of the whereabouts of their own units.[1]

A number of precautionary signals arrangements were made in the course of June 1942. The C.S.O. Western Desert was made responsible to the C.S.O., R.A.F. Middle East for all communications in the Western Desert, in Rear and Advanced Air Headquarters Western Desert, and at operational landing grounds, during the fluid situation that existed in this month. In consultation with the C.S.O.s of Nos. 201 and 205 Groups, and the Senior Signals Officer, Rear Air Headquarters, Western Desert, he amended and modified existing organisations as he considered necessary. Of the medium heavy mobile units, No. 4 was stationed at Maaten Bagush and was placed under the control of C.S.O. Advanced Air Headquarters Western Desert; No. 5 was moved to No. 1 Signals Centre Burg el Arab, under the control of the C.S.O. Western Desert. Four light mobile W/T units were formed, each consisting of one specialist pair or trio and two very low power vehicles, in addition to two special W/T units which had already been formed. Sufficient cypher staff were posted to each unit to maintain four continuous W/T channels. Two signals officers, each to be in charge of two light mobile and one special W/T unit, were also provided. One section of three units (two light mobile and one special) was based at Burg el Arab and the other section of three units was based at No. 2 Signals Centre Amriya. All were placed at the disposal of the C.S.O. Western Desert. A third Signals Centre was at Wadi Natrun.[2] These three signals centres were established to provide communications for the numerous administrative and maintenance units based along the Western Desert road. No. 1 was set up first at Burg el Arab, and No. 2 was intended to be at Mersa Matruh, but the battle moved eastward and it was set up at Amriya. No. 3, at Wadi Natrun, served the many units concentrated in this area in mid-1942.

As a result of the land situation, Delta Force was formed at the beginning of July 1942 to hold the western edge of the Delta, to prevent the enemy securing Alexandria, to oppose the penetration of the Delta, and to strike at the enemy's flank should the Eighth Army be forced to withdraw from the El Alamein line in the direction of Cairo. An air support unit was attached to the Delta Force to co-ordinate requests to Air Headquarters

[1] *See* A.H.B. Monograph, 'Air Support' (A.P.3235).
[2] A.H.B./IIM/A13/2D, January—June 1942.

Western Desert from G.O.C. Delta Force, and aircraft were operated from the new Force Headquarters when airborne. It was necessary to maintain communications between formations and with aircraft while maximum air support was being given to land operations and shipping.

The existing W/T organisation of all formations was maintained, and no pooling of services took place. Mobile signals equipment continued to be used, and C.S.O.s improvised low power mobile equipment by every means in their power, using any aircraft equipment available, so that fixed stations were duplicated and could continue to operate on a mobile basis at short notice. The air support unit at Delta Force Headquarters opened W/T links with Air Headquarters Western Desert and with airfields from which close support aircraft were operating. Existing W/T and R/T facilities for aircraft were left undisturbed. Air support units maintained R/T communication with close support bomber aircraft in flight on squadron R/T frequencies wherever possible. No reliance was placed on line communications: they were regarded purely as adjuncts to wireless, which in this situation was necessarily the primary method of communication.[1]

In the event of Headquarters R.A.F. Middle East being forced to move, it was to divide into three headquarters—rear at Gaza, southern at Khartoum, and main at Almaza and then Ismailia, and subsequently to join rear at Gaza. The organisation and revision of W/T and landline communications for the three headquarters were planned on 2 July 1942. The operational and administrative communications required for rear headquarters were to be provided by a mobile signals centre to be set up at Ramleh; strategic communications for rear headquarters were to be provided at Helwan W/T station. The communications required by main headquarters were to be provided by T.M.E. while the headquarters was at Almaza, and by Ismailia W/T station when the main headquarters moved to Moascar. Other units were to make way for the various moves. Details of signals equipment to be moved, such as heavy and medium heavy mobiles, specialist vehicles, and pack sets, were also listed. Responsibility for the maintenance of the various W/T channels was clearly allocated. W/T and landline channels between T.M.E.—Ismailia—Ramleh were strengthened to enable them to act as signals centres during the initial movements. Orders for the destruction of equipment, etc., on evacuation were also given.

This remained the emergency plan throughout July 1942, but early in August it was cancelled, and it was then decided that in the event of an emergency move, Headquarters R.A.F. Middle East would divide into two echelons—'Y' and 'Z'—and that Headquarters R.A.F. Middle East would at the same time provide reinforcements for Air Headquarters Egypt in the event of that headquarters moving southwards. The two echelons would be approximately equal and each would be capable of operating and administering the air forces in the Command for a short period. In the

[1] A.H.B./IIM/A13/2D, January—June 1942.

event of the evacuation of the Cairo area, 'Y' echelon was to move to a location near Ramleh and was to be prepared to operate and administer the air echelon in the Command. 'Z' echelon would remain in Cairo until ordered to leave. Communications would be provided by Ramleh Signals Centre until equipment and personnel were transferred from T.M.E. A small tactical headquarters might be required for the A.O.C.-in-C.; this was to be formed from 'Z' echelon, with communications provided by No. 5 Medium Heavy Mobile W/T Unit. A Nile river steamer was equipped as an A.O.C.-in-C.'s headquarters, complete with cypher office and signals centre. Complete W/T and landline communications for all stages of the move for both echelons were laid down.

A Signals Instruction was issued by Air Headquarters Egypt on 2 August 1942, giving full details of landline and wireless communications, W/T plotting, telling and operational sections, sector R/T and D/F fixer stations, V.H.F. organisations, etc. The regular testing, maintenance and exercising of lines were a feature of this Instruction. All operational landlines were permanently manned, and communication tests were carried out every fifteen minutes on all plotting and telling lines. W/T standby circuits were ready to open immediately in the event of landline failures. All possible precautions were thus taken to ensure against the results of landline breakdown.[1]

Signals plans at this period, in addition to the possible withdrawal from Egypt, catered for the entire reorganisation of communications in the Middle East, including the withdrawal of cypher and communications personnel and some equipment from squadrons and the centralising of communications on a wing basis in mobile areas and on a signals centre basis in static areas. It was hoped that this reorganisation would achieve better control in communications, greater flexibility and mobility, and considerable economy in personnel and equipment. However, the expansion and efficiency of communications continued to be seriously hampered by the lack of personnel and equipment. Incoming drafts were still much below standard, and new wireless operators frequently needed a two-month refresher course, partly due to the operators having been passed out at too low a speed initially and partly due to lack of practice on the long sea voyage. In view of the acute shortage of equipment, liaison visits were paid by Signals staff officers to London and Washington. Lease-Lend procedure was not working satisfactorily and it was apparent that much of the equipment ordered over a year earlier would never be delivered. Nevertheless, everything possible was obtained. Supplies of V.H.F. equipment were now arriving steadily, and four-channel transmitters and receivers and a triangle of D/F fixer stations were in operation at the Haifa, Gaza, Port Said, El Adem, Shandur, Heliopolis and Alexandria sectors. Additional equipment had also been issued to the sectors at Fayoum, Hurghada and Cyprus. One fighter group in the Western Desert was equipped com-

[1] A.H.B./IIM/A32/1(J).

plete. The aircraft equipment situation was not so satisfactory, and only three fighter wings in the Western Desert were fitted plus one day and two night fighter squadrons in the Delta. A V.H.F. R/T link was established between Headquarters R.A.F. Middle East and Air Headquarters Western Desert.

The resources of trained Signals personnel in the Middle East were further strained with the arrival of the American air forces in July 1942 without cypher staff, signals equipment or personnel. Adequate communications had to be provided for them and local R.A.F. signals officers assumed responsibility for their communications as necessary. Eventually, in return, American equipment was supplied in some quantity. The training of American wireless operators was undertaken to ease the personnel situation.

Air Formation Signals companies continued to be reinforced, and one task at this period was to cover gaps in line communications over the Sinai Desert due to base landing grounds of heavy and medium bomber squadrons moving back to Palestine, and to the arrival of the U.S.A.A.F. squadrons.

Advance from El Alamein

In October 1942, in view of the preparations being made to deliver a knock-out blow to the enemy and to establish British forces as far west as Tripoli, a Signals plan was prepared to provide the extra W/T and landline channels required to ensure adequate communications along the L. of C. and to reinforce the existing communications between Headquarters R.A.F. Middle East and Advanced and Rear Headquarters Western Desert.[1] In comparison with the previous year's inadequate equipment for 'Crusader', the Signals organisation was now on a lavish scale. All the equipment was adequately mobile. The ground W/T apparatus was modern and efficient. Aircraft control on V.H.F. was excellent and highly satisfactory ground-to-air ranges were being obtained. Two medium heavy mobile and one heavy mobile W/T unit were to be employed as mobile signals centres; one medium heavy mobile unit was later located in the Mersa Matruh area, and this was leap-frogged by a second which was located and operated at El Adem. When the military situation allowed it, a fixed signals centre with staging post facilities was to be set up at Mersa Matruh and the first medium heavy mobile unit thus released for use elsewhere. The heavy mobile unit was used later to provide communications at Benghazi. Radio aids to navigation and meteorological stations were to be provided at Mersa Matruh, El Adem and Benghazi, and R.D.F. cover was to be provided at Mersa Matruh, Daba, Sidi Barrani, Tobruk, Martuba, and Benghazi.

Three signals centres for W/T communications along the route to the forward areas were provided at the three main staging posts at Mersa Matruh, El Adem and Benghazi, using low power mobile equipment, mostly

[1] The outline Signals Plan is at Appendix No. 12.

T.1087/R.1084's and T.1083/R.1082's, with V.H.F. at the sectors. Thus the policy of centralising communications, begun with the conception of T.M.E., was carried forward into the desert, providing a solid signals backing to operations. In addition, W/T communications were provided for the air transport organisation and for sector and sub-sector control. Until the advance reached El Agheila, everything to the west of Mersa Matruh was provided on a mobile basis, while plans for works services for fixed accommodation were prepared later.

Considerable reconstruction of landlines was necessary in re-occupied areas as the advance moved westwards, and schedules of main landline services to be provided were prepared. A V.H.F. R/T link was provided from Air Headquarters Western Desert to the most westerly termination of the main pole or underground route carrying the Western Desert-to-Cairo speech channels. Standby-to-line R/T channels between Advanced and Rear Air Headquarters Western Desert and their groups and wings were also provided, though these were insecure.

The advance took place at a speed out of all proportion to the speed of landline construction and all communications initially were therefore provided by W/T. R.A.F. signals were better organised and equipped for this advance than ever before, but the personnel situation remained acute, there being a serious shortage of cypher clerks and wireless operators. However, Signals security had improved greatly, and W/T discipline on point-to-point channels reached a high standard.

During the rapid moves of the mobile headquarters of Air Headquarters Western Desert the possibility of a breakdown in normal communications was always present, and it was decided on 27 November 1942 to provide a direct operating channel between A.O.C. Advanced Air Headquarters Western Desert, A.O.A. Rear Air Headquarters Western Desert, and A.O.C.-in-C. Headquarters R.A.F. Middle East for operational communications, removing the linking arrangements at T.M.E. For this purpose, a single receiving position was set up near the operations room and went to the A.O.C.-in-C.'s office at Headquarters R.A.F. Middle East, from which a transmitter at Helmieh was keyed.

Between the battle of El Alamein and the end of 1942, traffic delays between Headquarters R.A.F. Middle East and Air Headquarters Western Desert were one of the biggest headaches. Advanced Air Headquarters had insufficient equipment to maintain all the essential operational channels during an advance which was so rapid that rear and advanced parties were separated for most of the time: the advance party moved forward, but by the time the rear party was ready to join it, the advance party had moved forward again. Consequently, for long periods all the commitments for an air headquarters had to be met from half the total amount of equipment planned. Mobile conditions made demands which not all personnel had the experience or resource to meet. The increased number of channels in use by the Army and R.A.F. in the Western Desert further emphasised the need for a more selective receiver than the R.1082. The signals organisation was not able to fall back on an efficient air-mail service to clear accumulated non-priority traffic, while Advanced Air Headquarters did not make sufficient use of 70-foot masts and good aerials. Steps were taken to improve all these matters and by January 1943 an air mail D.R. service was working well.[1]

The V.H.F. standby-to-line channel from Air Headquarters Egypt to Air Headquarters Western Desert was a failure. The speed of the advance altogether outstripped the speed of line construction, so that in a few days the gap between Advanced Air Headquarters and the L. of C. was too great to be bridged by V.H.F., even with the use of a relay station. Within limited areas, however, H.F. and V.H.F. R/T was extensively and successfully used as a standby-to-line. Both H.F. and V.H.F. R/T for communication with aircraft were used successfully, ranges of over 100 miles being common on H.F. with the Collins 18M.[2] The communications of the Army Air Support Control Unit attached to the Eighth Army were highly successful and the point-to-point communications of groups and wings were also excellent, the only major delays occurring between Advanced and Rear Air Headquarters and T.M.E. The Signals Centres at Mersa Matruh, El Adem, and Benghazi strengthened communications in addition to providing navigational aids for transport and reinforcement aircraft.

Special security measures were devised for the El Alamein battle and subsequent advance. A verification procedure for point-to-point W/T was introduced to enable any ground station to verify the authenticity of any other station. Other codes, including an air support control code, devised locally, proved successful. A new aircraft movements code came into force on 1 December 1942.[3]

The saving grace in mobile operations remained the small single-channel low power W/T station with the small lattice mast attached to the roof of the vehicle with an R.E. pole extension giving an effective height of approximately 30 feet. These stations were capable of going into action within five minutes of arrival on site. The vehicles were small and self-contained, with G.P. sets, a petrol electric generator, and wireless operators. The specialist pairs, equipped with T.1087/R.1084 and a crew of six wireless operators and two mechanics, were also used considerably, but were much slower on the route in convoy, took at least one hour to get into action, and were more of a second line of advance communications, the small G.P. vehicles filling the gap until the specialist pairs came into operation. Each pair had equipment for three W/T channels, sufficient for a wing. Much use was made of the Collins 18M, working off a power pack. This equipment was small and compact and was used for controlling fighters

[1] A.H.B./IIM/A13/3D.
[2] This was a very low power battery-operated American set.
[3] A.H.B./IIM/A13/2D, July—December 1942.

by H.F. R/T. V.H.F. pairs were also in use. All units were provided with Meadow's petrol/electric sets or an equivalent.

The landlines for the Western Desert Air Force were provided by No. 4 Air Formation Signals. This unit consisted of three composite companies, four line sections, two line maintenance sections, two operating sections, one despatch rear section, seven wing sections, one telephone maintenance section, and one light aid detachment. W/T communications maintained while static included 13 channels by Advanced Air Headquarters and eight by Rear Air Headquarters. In addition, V.H.F. R/T backed up by H.F. R/T was available as a standby in the event of landline failure. V.H.F. R/T was reliable up to distances of 25 miles, and capable of taking the place of landlines over these distances.

As the advance progressed, signals centres were installed at Mersa Matruh and El Adem. These centres were equipped with H.F. D/F, M.F. beacon and specialist pairs, and acted as linking stations along the L. of C. They were sited adjacent to good landing grounds so that their navigational facilities were of assistance to the L. of C. air route. They acted as focal points for the area in which they were situated for A.D.L.S. and D.R.L.S.

Forward Control during the advance was sited as far forward as possible, with a suitable operations table or board, and was equipped to control both V.H.F. and H.F. R/T fighters. Wherever possible, the forward control was connected by landline to the group operations room. The controller did all his controlling in the receiving vehicle, in which were situated an R.1132 for V.H.F. control, two Collins 18M for H.F. control, and one R.1082 for receiving H.F. D/F plots. Wireless units were deployed at about five miles spacing between posts, and considerable value was attached to their reports, which supplemented and often amplified the R.D.F. plots.

In spite of the much more generous supply of equipment and personnel during this campaign, traffic delays were unduly heavy. Signals traffic was high owing to the lack of faith in air mail, the sending of unnecessary signals, and the excessive number of addressees. This resulted not only in delays but in the excessive use of high priorities, which introduced further delays.[1]

By the middle of December 1942, the majority of the communications organisation laid down in the Signals plans prepared before El Alamein had been set up, and the three new signals centres were all in operation. A backbone organisation on which the mobile Western Desert Forces could move forward beyond Benghazi was therefore available. However, the majority of this communications organisation was on a mobile basis, and a change-over to a static basis was necessary. In addition, amendments to the original organisation were necessary in the light of experience, and provision had to be made to cover a forward move of the Western Desert

[1] A.H.B./IIJ1/335/2/5(B).

Forces beyond El Agheila. It was essential that all administrative communications in the static area from the Delta to Benghazi be provided as far as possible on a common user basis, so as to economise in equipment and personnel. The existing facilities were converted to a static basis, and as many as possible of the W/T channels were converted to landline, thus releasing W/T equipment for the advance towards Tripoli. Further signals sectors were planned to provide local communications at forward locations and outlets to base areas at Sirte and Misurata (later No. 7 Signals Centre was established at Sirte and No. 8 at Castel Benito).

By the end of the year, the military situation in North Africa and Tripoli had reached a stage at which it was essential that operational co-ordination between Headquarters Eastern Air Command and Headquarters Middle East be put on a firmer basis to give adequate and efficient communication.[1] The move of the Western Desert Forces into Tripoli, coupled with the advance of the Allied Forces in North-West Africa and Tunisia, had confined the ports and communications systems available to the enemy for supplying his forces to an extremely small area, and in consequence our forces in North Africa, Malta and Cyrenaica were operating coincidentally with each other. Speedy communications between all the formations was therefore essential for proper co-ordination.

There were four distinct communications requirements between North Africa, Malta and the Middle East. These were strategic channels for the co-ordination of all operations to be carried out by major formations; operational channels for immediate tactical co-ordination of operations by formations in contact with the enemy; channels of communication to give effective co-ordination of G.R. and anti-shipping operations; and communications for air transport reinforcement aircraft. Between the area of Cairo and the area of Algiers there were in existence three separate and distinct channels under different control, serving the R.A.F., Army, and U.S.A.A.F. Headquarters in the two areas. These channels were necessary because the various headquarters formations were widely dispersed and a speedy system of passing traffic between the different locations was not yet in operation. The total volume of traffic did not warrant three channels, and the re-planning of these channels on a common-user basis was the ultimate aim. Meanwhile, a new air force organisation for strategic and tactical communications between the Middle East and North Africa was introduced.

Other major communication needs concerned cable communications and reinforcement aircraft. It was essential that the task of restoring the disused cable system throughout the Mediterranean was pursued with all speed. The passage of traffic in plain language between Malta and Alexandria had allowed the operation of a 'flash' service, and a similar system was wanted elsewhere. The main breaks in the cable system were in the

[1] Operation 'Torch', the Allied landings in French North Africa, had taken place in November 1942.

area of the Bone—Malta—Tripoli triangle, and these could not be repaired while the enemy was in occupation of Tunisia, Pantelleria and Tripoli. As the capture of these locations was achieved, repair of damaged cable presented little difficulty.[1] Planning for the opening of a new reinforcement route across North Africa through Casablanca, Oran, Algiers, Tunisia, Tripoli, Sirte, etc., was in progress.[2]

Air Headquarters Egypt assumed control of Cyrenaica in December 1942, and an advance signals organisation for Cyrenaica was brought into force in the same month.[3] Landline policy was to create line switching centres at each sector, centres being established at Tobruk, Cyrene and Benghazi. The W/T organisation was split up into two parts — basic and special. The basic was a permanent network which was maintained irrespective of the provision of landlines, and was brought fully into use in the event of landline failure, though it was not regarded wholly as a standby but as a part of the normal communications system and given a reasonable load at all times. It catered for movements, intelligence, orders, liaison and R.D.F. traffic. The special W/T organisation was provided for communications to units with inadequate landlines, and was primarily used for administrative traffic.

Advance into Tripoli

In January 1943, preparations were made to give signals support to another blow at the retreating Axis forces and to establish Western Desert forces in Tripoli. The division of control of units was that Air Headquarters Egypt were responsible for sector controls on a mobile basis at Misurata and Tripoli, though it was intended that both these sectors should subsequently be handed over to Air Headquarters Egypt. Headquarters No. 216 Group were to set up staging post facilities at Marble Arch and Tripoli; signals centres on a mobile basis were to be set up at Sirte and Tripoli and sector controls for coastal defence and protection of the L. of C. to be set up at Misurata and Tripoli. Meteorological units were located near signals centres. No. 6 Signals Centre Benghazi was expanded on a static basis and all new signals centres, staging posts and sectors were also established as soon as possible on a static basis, mobile signals units being provided meanwhile.[4]

On two occasions during the advance of the Eighth Army into Tripolitania, an offensive fighter wing operated from a landing ground to which the R.A.F. had not yet gained access by road. The tactical requirement was the same on each occasion: the advance of the Eighth Army had been temporarily checked, the enemy had then been forced to give way, and had

[1] State of Cable Communications in the Mediterranean in December 1942 is shown at Appendix No. 13.
[2] A.H.B./IIM/A13/2D, July—December 1942.
[3] A.H.B./IIM/A32/1 (A-J).
[4] A.H.B./IIM/A13/3D.

found himself with no alternative but to retreat some hundred miles or so before attempting to hold a new line; in the course of this retreat, an admirable target was presented to those of our fighter bombers who could get within range, and four Kittyhawk squadrons, together with the necessary supplies, were flown to forward landing grounds immediately they were secured by our forward troops. Approximately 30 Dakotas were made available for the air lift of equipment and supplies. The signals facilities provided included R.D.F. cover for each landing ground, together with operating personnel; a small Air Formations Signals party equipped with field cable and telephones and a ten-line switchboard; and wireless communications consisting of one H.F. R/T channel for controlling aircraft and one H.F. R/T point-to-point channel to fighter group headquarters (a Collins 18M was used for both purposes), and one W/T point-to-point channel to fighter group headquarters, for which a T.1083/R.1082 pack set was used. The Signals personnel to operate the wireless communications were one N.C.O. (W.O.M.), two W/T operators and one R/T operator, and the ancillary equipment included aerial masts, accumulators, batteries, spares and a 350 W. charging plant. A cypher officer accompanied the party.

In each case the operation was carried out according to plan, and resulted in our aircraft regaining contact with the retreating enemy forces some 24 hours earlier than would have been possible in a normal move, though the advantage was considerably reduced by the time taken in clearing landing grounds of enemy mines. A number of lessons were learnt with regard to the air control of such an air lift, and on the signals side the Collins 18M proved suitable but the W/T pack set T.1083/R.1082 proved unsatisfactory at night, mainly due to the poor performance of the receiver. A replacement in the shape of a Collins 18Q or TR.1154/1155 was necessary.[1]

In February 1943, it was decided to provide communications and R.D.F. on a mobile basis for a composite fighter group headquarters, a fighter wing, and a number of airfields, as the Middle East Command's contribution to the Sicilian invasion force. The list of signals units included a fighter wing headquarters signals section, a group headquarters signals section, a mobile signals servicing unit (M.S.S.U.), four advanced landing ground signals sections (A.L.G.S.S.), four field force heaquarters signals sections (F.F.H.Q.S.S.), and some 30 mobile signals units of various types.[2]

Stabilisation of Middle East Communications

With the movement of the theatre of operations to Tunisia, landlines in the Delta area were established on a static basis. In the three years of Desert War, a large point-to-point teleprinter and line telegraph network had been built up in the Delta area, but careful planning of this network had been made difficult by the varying requirements and the fluctuating

[1] A.H.B./IIM/A13/3D.
[2] A.H.B./IIE/25.

campaigns which had resulted in frequent changes in the location and number of units within the area. The majority of units in the Delta area were located in one of three zones, Cairo, Alexandria and the Canal Zone, and a primary necessity was the provision of adequate circuits to link each of these main zones with the remaining two. This was one of the tasks carried out in 1943.[1]

In March 1943, Air Headquarters Egypt was reformed as Air Headquarters Air Defence Eastern Mediterranean, responsible for the whole air defence from the Turkish border to Tripoli. The setting up of the many sector and group headquarters required to maintain this organisation, together with the necessary communications, threw a great strain on the available resources of equipment and personnel.[2]

The channels of communication laid down in C.C.O.1 (M.E.), excluding radio aids to navigation, fell into two categories; those required by the Air Ministry to implement the world-wide communications systems of the R.A.F., and those required by Headquarters R.A.F. Middle East to maintain the essential communications organisation within the Middle East Command. The main W/T station was still situated just outside Cairo at T.M.E., exercising the function of control station on the main communication channels of the Command. Ismailia, formerly the inter-command station, had now become a component part of T.M.E.[3]

Also based at T.M.E. was a Traffic Control Section, first formed in 1942 and accorded the status of a separate section of T.M.E. in 1943. This was a permanent central control organisation where a complete record of all factors affecting the Command system was kept. Although based at T.M.E., this section came under the operational control of Headquarters R.A.F. Middle East and functioned as part of the Signals Branch.[4] The section produced a complete Signals Routeing Directory for the whole Command, which, among other things, indicated the type of cypher held by units and the channels by which signals should be routed. The section was also responsible for working out the most economical Signals organisation from a daily study of the traffic levels handled.[5]

W/T Fitting Parties

A number of W/T fitting parties were established in the Middle East, to cover such activities as the installation of high power, general purpose and D/F wireless installations, the erection of masts and the rigging of aerials and D/F calibration and training. Seven parties were in existence early in 1941,[6] but more were urgently required, some of the outstanding work

[1] A.H.B./IIM/A13/3D.
[2] A.H.B./IIM/A13/3D.
[3] A.M. File CS.13275.
[4] A.M. File CS.13275.
[5] A.H.B./IIM/A13/3D.
[6] A.H.B./IIM/A13/1D, 1939—March 1941.

being at the new main transmitting station at Helmieh. Other commitments included a total of 40 H.F. D/F stations, an underground standby transmitting station at Ismailia, transmitting, receiving and D/F stations on the West African reinforcement route, a W/T station at Nicosia, and an inter-command station at Khartoum. Three fitting parties were sent to carry out installations on the West African reinforcement route in May 1941. By early 1942, there were twelve fitting parties in existence, work being undertaken in the Levant, Abyssinia, West Africa, Cyprus, the Western Desert, Khartoum and the Sudan, East Africa, Air Headquarters Egypt, Headquarters R.A.F. Middle East, and Palestine. There was also a newly formed V.H.F. fitting party. After the formation of No. 3 Signals Depot,[1] the parties were administered by the new depot, but Headquarters R.A.F. Middle East continued to exercise technical control over all installation work.

There were five parties remaining in the Middle East Command in November 1943, the nominal strength of each being one officer and 31 other ranks. This was a useful size for large electrical constructional projects, but for most tasks the parties were sub-divided. The work consisted of electrical installations, the erection of aerial arrays, and the wiring of buildings such as operations blocks and instructional workshops. Quite apart from actual fitting, much improvisation was done, gear unobtainable locally being specially constructed. The men had a considerably higher standard of training and experience than the average.

The headquarters of the fitting parties was at Helmieh, where a base workshop was maintained; and a drawing office, which produced the blueprints and diagrams to which the parties in the field were required to work, was situated at Headquarters R.A.F. Middle East and came under the eye of the Signals Engineering Section there.[2] Work was being undertaken in Aden, East Africa, Palestine, Cyprus, and El Hagg, where the construction of a new main transmitting station was in progress. Other parties were assembled for transfer to North Africa.

The parties were based at Helmieh until May 1944, when they were transferred to various maintenance units, where they retained their identity but came under the signals radar sections of the M.U.s. Increased personnel were obtained from M.A.A.F. in November 1944 to carry out installations on Transport Command routes.[3] At this time there were 15 small fitting parties at various stations distributed from Castel Benito to Bahrein, from Sharjah to Athens. The overall strength of the parties was two officers and 80 men.

[1] This was formed in 1942 to undertake the design, development and construction of specialist signals equipment, but was later disbanded, signals squadrons being formed at maintenance units to undertake the construction and repair of signals equipment.
[2] A.H.B./IIJ1/183/5(A).
[3] A.H.B./IIM/A13/4D, November—December 1944.

Training

A Middle East Signals School was established at Ismailia in 1940, mainly with the object of making first-hand operators out of inexperienced Signals personnel arriving in the Command.[1] The enforced idleness of the long journey via the Cape was the main cause of operators being below standard. The school was not concerned with operational training. The school was bombed out towards the end of 1941 and was re-established at Helwan in March 1942.[2] During the crisis of the summer of 1942 the school was moved to Palestine, returning later to Helwan.

Wireless operators continued to arrive in the Command barely able to receive 15 words per minute and with their hand-sending appalling, and the school was expanded early in 1942 at Helwan to accommodate 400 pupils per month. At the same time a High-Speed Training Section was opened, due to a shortage of automatic operators to meet new commitments. Training in the operation and maintenance of American signals equipment was also carried out, and a technical school staffed by American volunteers was opened at Ismailia and subsequently transferred to Helwan. Special training was instituted for desert warfare. By the middle of 1942 the average number of pupils in the school had reached 800.[3]

In 1943 a scheme was introduced at No. 22 P.T.C. to provide wireless facilities, mock-ups and technical literature to crews awaiting posting to operational squadrons after O.T.U., the approximate time spent in transit being three weeks. In view of the growing deficiency in manpower, a high standard of efficiency was essential to make the most of the personnel available. At the Signals School the total number under training dropped in the course of the year to about 550.

A new establishment for the School was approved in 1943 of 950, and a fresh policy was required to fill the vacancies. A steady input was maintained of all Signals trades for conversion and refresher courses, the number of pupils in September 1944 being kept at 600. In view of the proved efficiency of the school and the need for trained personnel in the Far East, every effort was made to keep up a steady input.[4]

Middle East Pigeon Service

A decision to operate a pigeon service in the Middle East was taken in 1942, and in mid-1942 the service was going ahead on an inter-Service basis, with a member from each Service on the Middle East Pigeon Staff. Birds were trained in the Western Desert, Gaza and Beirut, and by August 1942 new lofts had been opened at Alexandria and Port Said and airmen had been trained as pigeoneers. Highly successful tests were carried out with

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[1] A.M. File CS.9673.
[2] A.H.B./IIM/A13/2D, January—June 1942.
[3] A.H.B./IIM/A13/2D, January—June 1942.
[4] A.H.B./IIM/A13/3D.

birds over the Desert and the Mediterranean. Pigeons from all lofts were made available to all Services. R.A.F. requirements included air/sea rescue, the location of and rescue operations for force-landed operational and reinforcement aircraft, and naval and army co-operation. The training of personnel was carried out at the Middle East Pigeon School at Diggla, and full equipment for each operational loft was supplied by the Army. A sample sea rescue container was sent from the United Kingdom and manufacture was arranged in the Middle East through the Army Ordnance Depot. Parachute containers were also manufactured. R.A.F. Pigeon Centres were established at Malta and Nairobi.

An unexpected and valuable use of pigeons was found by Repair and Salvage Unit personnel, who carried a pigeon with them whenever they went out into the desert searching for crashed aircraft. The pigeon was released with a message as soon as a crashed machine was located and this saved about four days in getting the salvage party together and salvaging the aircraft. It also greatly reduced the risk of equipment being looted.[1]

Following an Air Staff decision to retain the R.A.F. Component of the Middle East Pigeon Service, a revised establishment was promulgated on 24 March 1943, and lofts were established at Benghazi, Mersa Matruh and Gambut, taking over a proportion of the Army commitment in the Western Desert. Message containers, marked with a distinctive colour code to indicate the loft from which the pigeon was operating, were distributed. This was in line with practice in the United Kingdom. A notable performance was put up in this period by a young pigeon on special duties. This involved flying between points 450 miles apart, the direct route being over sea all the way; by any other route, at least 200 miles of open sea had to be covered. The pigeon chose the direct route, completed the flight successfully, and maintained an average speed of 40 miles per hour.

A limiting factor in the use of pigeons, especially in mobile warfare, was the length of time required to settle and train birds to an area. As a result of considerable experiment and trial, a system of 'Nomad' training was evolved by the Middle East Pigeon Service, and was the subject of a memorandum which was distributed to all air headquarters in the Middle East and other interested Commands. The system provided pigeons who were trained to trap to a distinctively marked portable 'retriever' cage. Regardless of the locality, 'Nomad' trained pigeons could be settled and operated in an area in a matter of hours, and they were also trapped to cages at sea.

To meet the probability of increased demands in the Western Desert, four more mobile lofts were sent to Benghazi in June 1943, and a redundant Army mobile loft was moved from Tripoli to Misurata. The Army continued to serve the Tripoli area from fixed lofts. The rescue of a crew of a Baltimore of No. 203 Squadron at this time was directly attributed to a

[1] A.H.B./IIM/A13/2D, July—December 1942.

message brought in from them by a carrier pigeon. This message gave the information that the crew had safely launched their dinghy, and gave a location about 30 miles distant from the first H.F. D/F fix. The original search based on the H.F. D/F fix was unsuccessful, but a launch was sent out in response to the message brought in by the pigeon, and it successfully located and rescued the crew.[1]

The pigeon loft at Benghazi had supplied over 1,000 pigeons to operational aircraft up to June 1943, and three wings were using pigeons by the following month, the Americans being by far the greatest users. The Pigeon Service was abandoned in the United Kingdom at this time, but it was decided to retain it in the Middle East for a further twelve months.

Reorganisation of Mobile Signals Units

By April 1943 it had become evident that the Mobile Signals Unit organisation in Middle East Command was in a confused state, and it was therefore decided to hold a conference to clarify the position. It was necessary to review the whole of the organisation in the light of the experience gained under the mobile conditions of the Western Desert campaign since El Alamein.

The problem was complicated by the fact that standard mobile signals units were being built in the United Kingdom for the European theatre and for Mediterranean Air Command, none of which were on the same pattern as those designed in the Middle East. It was therefore desirable for proposals for the re-design of Middle East equipment to be referred to a larger conference which should include representatives of the Air Ministry and Mediterranean Air Command, so that the standardisation of mobile signals units throughout the Royal Air Force could be achieved. A preliminary conference was held at Headquarters R.A.F. Middle East on 17 May 1943, when it was agreed that the existing organisation under which nine different types of mobile signals unit were allotted to the various formations in sufficient numbers to meet individual requirements was unwieldy. It was more economical, both in personnel and equipment, for separate signals sections to be formed on the establishment of those formations requiring to maintain mobile communications.

It was decided that mobile signals units in the Middle East should be abolished in their existing form, and that a signals section in accordance with the number of signals channels to be maintained should be included in the establishment of air, group and wing headquarters, and that a number of supplementary signals units, to be known as 'Advanced Landing Ground Signals Sections' and 'Field Force H.Q. Signals Sections', should be established in addition to the Main Signals Section.[2] Thus any of these formations suddenly needing extra channels for any reason, such as a squadron or other unit operating from an advanced landing ground or other

[1] A.H.B./IIM/A13/3.
[2] A.H.B./IIM/A13/3.

advanced location, would have ready-made signals units able to take over the commitment, on a temporary or semi-permanent basis.

The training of Advanced Landing Ground Signals Sections and Field Force Headquarters Signals Sections was carried out at Almaza, and most of these units moved to the North African theatre towards the end of 1942. Final training was completed in early June, and the units were held in readiness in North Africa for embarkation on Operation 'Husky'.[1]

Following the reorganization of mobile signals units in the Middle East, details of the new policy were forwarded to Mediterranean Air Command for comment and onward transmission to the Air Ministry, the ultimate aim being standardisation of mobile signals units throughout the R.A.F. Papers covering the various proposals were also forwarded to India for information. It was decided that an increased number of specialist vehicles and mobile and transportable equipment were to be manufactured in the Middle East, so as to supply the whole Mediterranean area, including North-West Africa, Palestine, Iraq, East Africa, and the Eastern Mediterranean.

Four vehicle types were now standardised in the Middle East, all being considered suitable for mobile operations in any theatre. Three of these were 3-ton chassis on which were mounted transmitting, receiving, and power equipment respectively, either for H.F. or V.H.F. The fourth type was a general purpose vehicle on a 15-cwt. chassis in which either very low power H.F. or V.H.F. or a combination of both could be fitted. The 15-cwt. vehicle could be adapted to act as a cypher or signals office. In addition to these basic types, an earlier type of V.H.F. D/F tender (Type 105) was still in use.

Production in mid-1943 was 6 trios (i.e. 18 3-ton vehicles and 20 15-cwt. vehicles) complete per month, and provisioning in hand allowed for a further 60 trios and 180 15-cwt. vehicles to be provided by March 1944. Production was however dependent upon a regular supply of equipment. By September 1943 Headquarters R.A.F. Middle East were making all the M.A.C. requirements for North Africa and Southern Europe, both 3-ton and 15-cwt.[2]

In August 1943, a Base Signals Unit was formed at Helwan to provide a location where mobile signals units could be formed, fitted and trained. In addition, the unit provided a base at which specialist signals and R.D.F. units could be accommodated while in transit. The unit had a very different function from the Base Signals Unit in the United Kingdom. A mobile signals unit was sent from B.S.U. Helwan to Tripoli later in the same month for despatch on call from the Mediterranean Air Command to provide signals facilities that might be required for an advanced command post in Sicily.

[1] A.H.B./IIM/A13/3D.
[2] A.H.B./IIJ1/183/5(A).

There were two Army air support controls operating with the Western Desert Forces in the final campaign in North Africa, Nos. 2 and 5, and they operated on a Corps basis, with one R.A.F. mobile signals component (Nos. 50 and 51) attached to each. In July 1943, the Eighth Army decided to amalgamate Nos. 2 and 5 Army Air Support Controls and operate them on an Army as distinct from a Corps basis, and the two R.A.F. signals components were likewise amalgamated and operated as No. 50/51 M.S.U.[1]

Signals Traffic following Victory in North Africa

The invasion of Sicily began on 10 July 1943, and 'minimize' procedure was introduced on the following day, all formations being instructed to restrict signalling to the minimum consistent with operational efficiency. Three days later the traffic at T.M.E. had been reduced by 34 per cent. At the same time, congestion on the high frequency bands had reached such proportions that adjacent channels could not be separated by more than 5 K/cs, and it therefore became essential that all W/T and R/T stations operate on their allotted frequencies and that any tendency to operate off frequency be immediately checked. A frequency checking service was therefore operated from T.M.E., and in its first report, which was issued at the end of July 1943, it was disclosed that 25 per cent of all frequency checks had revealed off-frequency operation. The stations at fault were informed.

A 'Fastair' system was introduced in July 1943, on the lines of similar systems completed during the advance from El Alamein, for the despatch of messages to and from certain airfields in North Africa and Malta and thence as rapidly as possible by local signals arrangements to units in the immediate vicinity of these airfields. The service was of use to a large number of formations and units in the Delta area. The signals service at this time was overloaded with low priority traffic, and the 'Fastair' service was a valuable contribution to the cutting down of signalling and did much to improve the transit times of the more urgent communications. The routine air services scheduled at 20 July 1943 were: —

(a) Cairo West—Benina—Castel Benito. Twice daily in each direction.

(b) Cairo West—El Adem—Marble Arch—Castel Benito. Daily in each direction.

(c) Cairo West—Marble Arch—Luqa. Twice daily in each direction.

(d) Cairo West—Marble Arch—Biskra—Maison Blanche. Four times weekly in each direction.

(e) Cairo—Benina—Castel Benito—Biskra—Ras-el-Ma. Daily in each direction.

The service was used to units in the immediate vicinity of staging posts, and modified services of this kind continued in use into 1944.

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[1] A.H.B./IIM/A13/3D.

A further easing of wireless channels was provided by the extended use of cables. Traffic for the Tripoli area was being passed in plain language over the Alexandria—Malta and Malta—Tripoli cables by June 1943, thus decreasing delays and relieving the load on the cyphering offices at the terminals. Transmission on this type of network was considered secure, and all traffic except 'Most Secret' could be passed on these links in plain language provided the addressees were linked to the cable terminal by a secure landline. The Malta—Bizerta cable began operating on 21 July 1943. Transmission on all these cables was satisfactory.

Manpower Reductions in the Middle East

When Operation 'Husky' was being mounted, the Middle East reduced its personnel to the barest minimum to operate its essential commitments. 'Husky' absorbed over 1,500 Middle East Signals personnel, and 'Avalanche' a further 670. Iraq, the Levant and East Africa were all combed and reduced to provide their quota. With the expulsion of Axis Forces from North Africa and the demands of operations in southern and western Europe, further large reductions were necessary. Signals establishments and strengths in the Middle East were ordered to be reduced by 17½ per cent—a reduction of about 2,000 personnel.

Three years of war on African soil had left in its wake a network of Air Force communications stretching from Somaliland to Sierra Leone and from Persia to Casablanca. The wireless stations involved numbered some 300 and the R.D.F. stations about 100, absorbing some 17,000 signals personnel. The areas covered, however, varied in operational importance, and the time had come for the paring down of facilities in areas of past importance. This could only be done by complete reorganisation on a high level as the fullest economies had already been practised. A start was made by the transfer of a large number of mobile signals units to the Mediterranean Allied Air Forces and the disbandment of others. A number of wireless units were also disbanded.[1]

The contraction of forces in the Middle East was complicated by the expansion of certain Middle East responsibilities, particularly the establishment of a number of operational training units which in turn required the provision of landlines, wireless channels, etc. Four O.T.U.s, Shandur, Ismailia, Abu Sueir and Gianaclis, were already open in September 1943, and five others were planned, plus heavy conversion and air gunnery units. These training establishments were provided with a 50-line switchboard, two outlets to the most appropriate trunk centre, at least two outlets to the most appropriate R.A.F. switchboard, and one telegraph outlet to the most appropriate R.A.F. signals centre.[2]

[1] A.H.B./VD/85/2.
[2] A.H.B./IIM/A13/3D.

Reorganisation of Air Formation Signals

Several Air Formation Signals units were moved from the Middle East to the North African theatre in the course of 1943. No. 9 A.F.S. was sent to take over all commitments and to be responsible for the area from Marble Arch to Tripoli in March 1943, so as to leave No. 4 A.F.S. free for its mobile role with the attacking air force. This meant withdrawing one company from Palestine and one from Teheran. No. 6 A.F.S., which had been responsible for Iraq, was now made responsible for Persia as well. There was now no A.F.S. unit which could be made available for the new operation unless some existing commitment was dropped. In September 1943, No. 6 A.F.S. was released by Headquarters R.A.F. Middle East, for employment in Mediterranean Air Command, and in the following month No. 8 A.F.S., although remaining in the Middle East, was earmarked as a reserve for either the Middle East or M.A.A.F. This left No. 3 A.F.S. responsible for Egypt and Cyrenaica, and No. 5 A.F.S. responsible for Palestine, Syria and Cyprus.[1]

Manpower Reductions Continue

In January 1944, the Air Ministry asked for 10,000 men from the Middle East and M.A.A.F. for the building up of the Allied Expeditionary Air Forces for operations in Western Europe. 6,000 were to be found by Middle East and 4,000 by M.A.A.F. Heavy demands were made on the signals trades, and personnel were required to sail by 1 February 1944, so that, of the Middle East quota, only personnel already in the Delta could be cleared in time. The Delta formations therefore suffered heavily until the personnel situation could be reorganised.

Hitherto the R.A.F. had worked on the basis of being an expanding force. The stage of the limit of expansion had now been reached, and the recruiting programme could do no more than replace casualties. The available resources could be redistributed as necessary but new sources could no longer be found. Thus the Air Ministry now decided the total allocation to a particular theatre, the manpower ceiling being fixed for each command. Increases in the ceiling of one command could only be met by decreases in the ceiling of another. If there was a transfer of responsibilities from one command to another, a corresponding transfer of personnel was required. It was the duty of the Air Ministry to assess the relative priorities to be accorded to competing claims. From this point on, skilled personnel could only be found by training unskilled personnel already serving; therefore a gradual increase in the proportions of skilled to unskilled men was inevitable. The resulting deficiencies were made good wherever possible in the Middle East by the use of civilian P.O.W. and non-European labour.[2]

[1] A.H.B./IIM/A13/3 and A.H.B./IIM/A13/3D. The organisation of Air Formation Signals throughout M.E. Command in February 1944 is shown at Appendix No. 14.
[2] A.H.B./VD/85/2.

Further Reorganisation of Middle East Communications

The Middle East Command was the largest in the R.A.F., covering one-tenth of the world's land surface and embracing every kind of signals activity. Its responsibilities included anti-submarine warfare in the Eastern Mediterranean and the Western Indian Ocean, air defence, the backing up of M.A.A.F., the backing up of A.C.S.E.A. in India and Ceylon for the war against Japan, training for M.A.A.F. and A.C.E.A. operations, assisting Headquarters No. 216 Group in implementing the signals plans for Transport Command, and rehabilitation in the Balkans and Dodecanese. The full efficiency of all these commitments had to be maintained, and at the same time the maximum economies had to be effected.

From the end of 1943 there was, therefore, a progressive run-down of signals facilities in the Middle East, except for air route communications for American, civil and R.A.F. aircraft. Nos. 6 and 8 Signals Centres were both disbanded and cable services took over much of their work. Other signals centres in the Middle East had already been disbanded after the end of hostilities in North Africa.

By April 1944, a considerable amount of traffic was being passed over civil submarine cable circuits in the Mediterranean, some of which were manned by Service personnel and others by specially selected civilians. These cable circuits, which were considered to be secure, and over which Service traffic of a security classification up to and including Confidential could be passed in plain language, included Alexandria to Larnaca, Alexandria to Malta, Malta to Brindisi, Malta to Bizerte, Malta to Algiers and Malta to Naples. However, as traffic congestion on Service routes cleared, and in view of the cost of using the cable services, the Air Ministry ruled in May 1944 that civilian-manned submarine cables were to be used only in emergency, and that where Service W/T channels existed, full use was to be made of them.

Middle East Standing Orders were re-promulgated in March 1944, covering all aspects of the signals war organisation. Procedure was now covered by a series of Combined Communications Board Publications which included the following: —

C.C.B.P.1—Combined Radio-Telegraph Procedure.

C.C.B.P.2—Combined Operating Signals.

C.C.B.P.3—Combined Radio Telephone (R/T) Procedure.

C.C.B.P.4—Teletypewriter(Teleprinter) Procedure.

C.C.B.P.5—Combined Visual Signalling Procedure.

C.C.B.P.6—Combined Visual Signalling Procedure (Abridged).

Not all these publications had yet been universally introduced, however

All problems relating to traffic control, routeing, etc., continued to be referred directly to the Command Traffic Control Section, still located at

T.M.E. but remaining under the direct control of Headquarters R.A.F. Middle East, to which it was responsible for the efficient functioning of the Middle East Command Signals organisation. The detailed duties of the Command Traffic Control Section were:—

(a) To examine signals traffic passed over R.A.F. channels in order to ensure that these channels were being used to the maximum advantage.

(b) To maintain a careful check of the traffic levels of all the main channels of communications and to recommend any changes in the organisation essential to maintain maximum efficiency.

(c) To issue up-to-date signals and cyphers routeing instructions to major W/T stations.

(d) To analyse and collate reports on delays and irregularities experienced over the communications system and from these analyses to issue instructions about alternative routeing, etc., to overcome such difficulties.

(e) To assist subordinate formations with traffic problems arising in their internal organisation and to suggest improvements where necessary.

Landline faults and unserviceability were dealt with by Air Formation Signals, a standard reporting procedure being laid down. Maintenance, installation and recovery of telephone equipment on static R.A.F. stations and certain mobile formations was also an A.F.S. or Royal Corps of Signals responsibility. A system of priority calls was in use. Service telegrams passed over civilian channels had to be authorised by an officer or the captain of an aircraft, and could only be passed where Service channels were not available. C.C.O.1. (M.E.) was re-issued by Headquarters R.A.F. Middle East and contained details of the communications organisation within the Middle East and such portions of the organisation of adjacent commands as affected the Middle East organisation.

The W/T organisation was now divided into six main categories:—

(a) Communications required to implement Air Ministry short and long term planning.

(b) Communications required for the conduct of operations in areas under the control of Headquarters R.A.F. Middle East and for liaison with adjacent commands.

(c) Communications required by Transport Command for reinforcements.

(d) Standard world-wide operational communications.

(e) Radio aids to navigation and rescue organisation.

(f) Internal organisation of air and independent group or wing headquarters.

Frequency Allocation

To prevent severe interference between radio stations and the fighting Services, civil administration, broadcasting services, etc., rigid control in the use of frequencies was essential. This control was exercised by inter-Service Communications Boards, located in Washington, London, and in the main areas abroad in which the Allied Services were operating. In Africa and adjacent countries, Communications Boards were established in North West Africa, West Africa, East Africa, the Middle East, Iraq and Persia, and India; and to simplify the work of these Boards, Communications Committees under their control were established in Egypt, Cyrenaica, Tripolitania, the Levant, the Sudan, and Aden. These Committees had the power to allot frequencies for use within the areas under their jurisdiction provided the frequencies were not in excess of 7.5 megacycles and the power output of the transmitter was not more than 10 watts. Each communications committee was also allotted a block of frequencies in certain bands for local allocation to channels on which transmitters of a power output rating of up to 250 W. was contemplated. Very high frequencies were allotted by the Air Ministry on a block system. Frequency control and checking and general radio interference problems were dealt with by special staffs. Monitory watches were employed to check procedure and to guard against breaches of security.[1]

Meteorological Signals Organisation

The meteorological W/T channels had been completely reorganised in May 1943, with reception at Almaza and transmission at T.M.E., so that the meteorological organisation was completely independent of normal signals administrative channels. Full details of the organisation appeared in the re-issue of C.C.O.1. (M.E.). The times at which the various broadcasts were made were laid down by the Command Meteorological Officer. Meteorological Flights and Meteorological Reporting Centres passed their information to the appropriate broadcasting unit by telephone, and where no telephone circuit was available, by the most expeditious means. The forecasting unit in each geographical area maintained continuous watch on point-to-point channels, exchanging meteorological information and broadcasting collectives at scheduled times, for the benefit of all other meteorological units within reception range. The control unit in each area maintained a continuous point-to-point channel with Almaza, exchanging meteorological information and broadcasting at scheduled times its own collectives and those of the other meteorological units in its area, primarily for reception at Almaza, but also for reception at other meteorological units too distant to receive the original broadcast. Almaza issued broadcasts at scheduled times, transmitting simultaneously on three or four allocated frequencies, in order, as far as possible, to ensure good reception at points over widely different ranges. These broadcasts consisted of collectives from Egypt and

[1] A.H.B./IIM/A13/4D.

Cyrenaica and repetitions of such other Middle East collectives as were found by experience to be necessary in order to ensure reception by the more distant stations. Urgent non-routine meteorological information was sometimes broadcast by Almaza at non-scheduled periods, the point-to-point channels, on which continuous watches were maintained, forming a medium by means of which all meteorological units could receive special instructions to listen out for non-routine broadcasts. Meteorological information was passed to operations rooms, squadrons, etc., in plain language by landline where possible. Where landline circuits were not available, the most expeditious W/T channel was employed.[1]

Middle East Inter-Service Teleprinter Network

In the interest of economy and efficiency, all teleprinter circuits in the Middle East were concentrated on five switchboards in October 1944, at G.H.Q. Middle East, T.M.E., Alexandria, Moascar, and Ramleh. These main switchboards were inter-connected by trunk circuits for the purpose of clearing traffic between subscribers connected to different switchboards; these trunk circuits also ensured flexibility in the event of breakdown. Four main signals centres were established for traffic handling purposes, at T.M.E., Air Headquarters Middle East, No. 107 M.U., and at Telecommunications Centre Levant at Ramleh.

Other Signals Responsibilities

Although the operational importance of the Middle East had declined, many responsibilities remained, including the planning of operations in adjacent areas. The Allied successes in Italy, and the imminence of the Second Front in Western Europe, brought about a favourable change in relations with Turkey, and in order to take advantage of possible developments, it was decided in May 1944 to build up the Army and Air Forces in Northern Syria. Signals and landline organisations were therefore outlined to be set up at once in the Aleppo area for controlling the Air Force formations. Again, consequent upon the withdrawal of defences from Kirkuk and Abadan, it was necessary to plan a fighter defence system which could be in operation within seven days should a threat develop, and a signals plan was therefore prepared. Another plan concerned the landing of an airborne force in Athens with a signals component, and the provision of an air support network for Army forces engaged in operations in Palestine against terrorism. In November 1944, a mobile signals unit was located at Army/Air Headquarters Jerusalem, forming in effect an air support signals unit.

Malta

Proposals had been submitted for construction of an underground central receiving station at Siggieui in Malta, about two miles from Luqa, in October 1936, together with proposals for the accommodation of all the required transmitters and a telephone exchange underground at Kalafrana,

[1] A.H.B./IIM/A13/5D, January—May 1945.

and by the outbreak of war the underground works were practically completed. The installation of a number of transmitters—SWB's, T.1087's, etc.—was made in 1940, two SWB8's having been in operation for some time in a barrack block at Kalafrana. The provision of underground cabling and telephone exchanges also went forward.[1] The main R.A.F. receiving station remained at Valletta, also underground, and of the 250 personnel on the war establishment of the inter-Command station at Malta in mid-1942, two-thirds were employed at Valletta.

The siting of wireless stations in Malta was one of peculiar difficulty, since there were several airfields, and runway approach funnels had to be avoided. However, towards the end of 1944, when representatives of the Inspectorate of Inter-Command Telecommunications visited Malta mainly with the object of investigating the position with regard to the meeting of the future requirements of both Air Headquarters Malta and Transport Command, it was apparent that a new receiving station would be needed. It was decided to build the new station above ground. The question to be decided was when the new station was to be built and what circuits were to be catered for. The site at Siggieui had two important advantages : a number of pairs of underground cable conductors existed and more could be made available, and the underground station could be used in case of hostilities. In addition, this site was a good distance from any transmitting station and within reasonable distance of Valletta, where Air Headquarters was situated, and Luqa, the Transport Command airfield. This site was therefore chosen. The new station was to house the main receivers of Air Headquarters and Transport Command.[2]

At the same time the transmitting station at Kalafrana was inspected. The main transmitting hall was underground, but a small overflow building, above ground, accommodated a few low-power transmitters, and was in the course of being extended. All the required services could be run with the transmitters already installed. Control lines were being laid to connect Luqa—Kalafrana, Air Headquarters—Kalafrana, Siggieui—Luqa, and Siggieui—Air Headquarters. The final location of Air Headquarters had still to be decided.

Gibraltar

By early 1941, Gibraltar had assumed a position of great importance in connection with long-distance operational and reinforcement aircraft, and it became necessary to provide high-power short-wave transmitters to carry out the following functions: —[3]

(a) Fixed W/T services with Malta and the United Kingdom, and with Bathurst, Freetown and Takoradi.

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[1] A.M. File S.35322.
[2] A.H.B./IIJ5/113/1/23.
[3] A.M. File S.67982.

(b) A number of aircraft channels, including G.R. operational waves, for the North Atlantic and the Western Mediterranean, and communications for aircraft on non-operational flights between the United Kingdom—Lisbon—Gibraltar—West Africa and from Bermuda to Gibraltar or Bathurst, and for aircraft on mail and delivery flights over the routes United Kingdom to Gibraltar and Malta, and from Gibraltar to Malta.

It was essential that these services be carried out on separate frequencies, but it was impossible to provide an SWB8 for each function. However, two SWB8's were provided immediately and installed in a new naval underground W/T transmitting station inside the Rock. This was a specialised operation, concentric feeders having to be used when transmitters were installed underground, and a Marconi engineer was provided in April 1941 to supervise the installation. Three T.1087's and a T.77 were installed in the naval underground station in the following month for the remaining circuits.

Early in 1943, due to the volume of traffic being handled on the existing hand channels, it became necessary to open an automatic circuit between Gibraltar and the United Kingdom. The equipment was shipped from the United Kingdom in mid-1943. In May 1943, a new transmitting station was completed at Camp Bay and an RCA E.T.4331 for the Bathurst circuit was installed there, together with four T.1190's for communications to Morocco and North Africa.[1] Signals facilities were also provided for control of G.R. aircraft in Agadir and Port Lyautey. By the end of 1943, in addition to the low-power transmitters, there were four SWB8's and three E.T.4331's in constant use at Gibraltar on the various long-distance point-to-point and long range aircraft channels.

Aden Command

Aden Command remained the responsibility of Headquarters R.A.F. Middle East. The signals facilities at Aden were divided between Telecommunications Centre Aden and the Combined Operations Room, which was completed in 1944.[2] The policy was to operate all administrative circuits from T.C.A. and all operations circuits from the Combined Operations Room. T.C.A. was housed in a reinforced concrete building on sandy desert land which made air conditioning essential. The Combined Operations Room was built on a generous scale but the accommodation for cypher and signals staff was not so lavish or comfortable. Communications at T.C.A. were generally satisfactory but reception conditions were poor at the Combined Operations Room due to an extremely high static noise level from nearby electrical plant. Strenuous efforts were made to reduce this. A teleprinter switchboard was installed in the Combined Operations Room with circuits

[1] A.M. File S.67982.
[2] A.H.B./IIM/A13/4D, July—August 1944.

from the adjacent Signals office to Khormaksar, T.C.A., the Naval Base, and Cable and Wireless Ltd. In addition, there was a tied circuit between teleprinters at T.C.A. and the Combined Operations Room.

The transmitting station at Aden was a building of the blast-proof type, solidly constructed in stone and reinforced concrete. Transmitters in use included two SWB8's, one E.T.4331, and eleven T.1087's.

Stations under the control of Aden Command included Khormaksar, Masirah Island, Salalah, Riyan, Bandar Kassim, Scuiscuiban, Socotra, Bandar Alula, Hargeisha, and Ras-el-Hadd. Both R.A.F. and American equipment was operated at Masirah, the R.A.F. equipment being mostly T.1087/R.1084 with TR.1196 for R/T control. Most of the transmitters in use at Salalah and Riyan were T.1190's. Bandar Kassim and Scuiscuiban had a mixture of T.1190's, T.1087's and T.1083's. Similar facilities were provided at Socotra, Bandar Alula, Hargeisha and Ras-el-Hadd.

Signals Facilities at Stations in the Persian Gulf

The conditions under which Signals personnel worked at Habbaniya and stations in the Persian Gulf were extremely poor. Receiving and transmitting stations were small, ill ventilated, and in many cases not even weatherproof. Even at permanent stations such as Habbaniya, Signals buildings were most crudely designed. However, under the Transport Command expansion programme of 1944, Habbaniya and stations *en route* to India were completely re-designed and the new layouts proved most efficient. The only remaining difficulty was that at Desert stations such as Habbaniya and Shaibah, local unit requirements had not been taken into consideration in the Transport Command reinforcement route planning, so that the Transport Command requirements were efficiently operated while the station proper was often forced to work under the same bad conditions as before. To overcome the difficulties of the split in the Signals responsibility for these stations between Transport Command and Air Headquarters Iraq and Persia, it was decided to place the Signals responsibility for any one station under one single authority, establishing a unit signals section responsible to the station commander for this purpose.

The signals organisation at Habbaniya was complicated by the usual problems affecting all stations shared by Transport Command with another Command, and in addition to this, the construction and layout of the inter-command W/T station was both inefficient and inadequate. The receiving station consisted of two blast-protected buildings erected in the middle of a palm-grove adjacent to one of the main routes passing through the camp. One building contained the high-speed reception channels, landline circuits, traffic office and cypher office, and the other contained the high-speed W/T transmitter. With the exception of a rhombic aerial directed on Cairo, which was erected in a small adjacent field, all the aerials were slung between 70-foot steel masts which protruded above the tops of the palm trees, thus substantially reducing their effective height. There was no other space where these aerials could be erected. In all, the receiving station was most unsatisfactory, both from a traffic handling and a W/T reception point of view. There were two transmitting buildings approximately 500 yards apart. No. 1 was a pre-war building which was satisfactorily air conditioned, but the aerial space was very limited, and it was impossible to erect rhombic aerials without very long feeder lines over main routes passing through the camp. No. 2 was a smaller building, with the advantage of having greater space around it for the erection of aerials. Transmitters in use included SWB8's for the Cairo high-speed automatic circuit, for the Moscow-Air Ministry-T.M.E. circuit, and for the meteorological broadcast circuit, together with E.T.4331's, T.1190's and T.1087's for the shorter point-to-point circuits.

At Shaibah, the Signals organisation was poor; the receiving building was small. and of the two transmitting stations, one was virtually useless. The main transmitting station, however, was regarded as large enough to house the total number of transmitters required for future commitments at Shaibah, and it was satisfactorily air conditioned. Transmitters in use included E.T.4331's for the longer distance Transport Command circuits to Karachi and Cairo West, and T.1190's and T.1087's for point-to-point and aircraft guard.

At both Habbaniya and Shaibah, a new control tower was built which was designed to house all the Transport Command air-to-ground and point-to-point channels. It was decided to accommodate in this building the receivers for all channels of communication at these stations.

New transmitting stations were built at both Bahrein and Sharjah, where the accommodation and conditions in the old stations were very bad indeed. These stations operated E.T.4331's, E.T.4332's, and the usual British point-to-point transmitters. Other stations in this Command included Jask, where the traffic consisted mostly of meteorological reports and where there was one W/T circuit linking the station with Sharjah, Masirah, Ras-el-Hadd and Muscat; and L.G.H.3, where the Signals organisation was confined to H.F. and V.H.F. airfield control and an M.F. beacon. There was telephonic communication with Habbaniya, but this was not always reliable.

East Africa

In May 1942, in view of the Japanese threat to India and Ceylon, it was decided that fighter and G.R. forces were to operate on the East African coast for the defence of naval and air bases, and that in addition long-range G.R. forces were to be based there for operations over the Indian Ocean. An order of battle was therefore drawn up and an organisation for W/T and landline communications was prepared.

The main formation was to be a wing headquarters located at Mombasa, which was to have fighter sector and G.R. operations rooms. A second fighter sector was to be located at Dar-Es-Salaam, and other stations planned included Changanwe, Tanga and Zanzibar, Lindi, MacKinnon Road, and Kalifi. At Mombasa, V.H.F., low-power, medium power and long-range point-to-point, and short and long-range G.R. aircraft guard facilities, were set up. Low power W/T was provided by the T.1083/R.1084; medium power W/T and short-range G.R. aircraft guard channels by the T.1087/R.1084 or the Collins 16EA/Hallicrafter SX.28; and long-distance point-to-point and long range aircraft guard channels by the E.T.4331 or SWB8 with R.1084 or Hallicrafter SX.28 receivers. The other stations employed T.1087/R.1084's, Collins 16EA/Hallicrafter SX.28's, and T.1083/R.1082's, with V.H.F. for fighter squadrons. A plan of signals personnel required to man these channels was produced and a line plan for fighter control and for wing operations and administrative circuits was prepared by Air Formation Signals.

Installation of W/T stations went forward in the latter part of 1942, but by the end of the year the threat to our shipping in the Indian Ocean had increased, and a corresponding increase in the air forces in East Africa was decided upon. A new outline plan was therefore produced in January 1943. An Air Headquarters East Africa was formed and located at Nairobi, with two wings, the one at Mombasa to control G.R. and fighter squadrons and a new one at Diego Suarez with responsibilities for the R.A.F. units that were to be based on the Indian Ocean Islands and in Madagascar. There were some twelve reconnaisance bases and four fighter sectors, plus a number of Fleet Air Arm bases and some training units. Additional stations to be established included Mauritius, Pamanzi, Seychelles, Tulear, Rodriguez, and Voi. Separate operational and administrative landline communications were provided, together with sector lateral communications where necessary.

In the initial stages on the mainland, W/T was the primary method of communication, but as landline facilities were developed the W/T links became the auxiliary means of communication. Between the mainland and the island bases in the Indian Ocean, W/T was the main method of communication, but full use was made of cable facilities where they existed. Meteorological communications were also provided. Standby W/T or R/T communications for R.D.F., V.H.F./D.F. and M.F./D.F. were provided by the T.1083/R1082. Some 50 per cent of the total communications had been installed by January 1943, the remainder being completed in the ensuing months. The main W/T items included some 60 T.1087's and 80 R.1084's. Signals facilities in East Africa, as in the Middle East, suffered inevitably from inertia and when the need was greatest the supply of equipment and personnel was inadequate, but a state of comparative plenty obtained when the dangers had receded.

T.M.E. Transmitting Stations

A new main transmitting station for T.M.E. was built at El Hagg, designed to accommodate four high power, 25 medium and 25 low power transmitters. By June 1944, however, proposals for the inter-command radio teleprinter network had been formulated, and it was apparent that the new transmitters could not be housed at El Hagg without building additional accommodation. Under the terms of the Anglo-Egyptian Treaty, we were bound to withdraw to the Canal Treaty Zone at the conclusion of the European War, and it was at first decided to defer the question of a new building until a new transmitting and receiving station could be erected in the Canal Zone. Later, a third transmitting station, to house transmitters for the radio teleprinter network was built at El Hagg.

By August 1944, the transmitters in use at T.M.E. included SWB8's for the Air Ministry, Accra, civil aviation, Caserta, Algiers, the Balkans, Ambala, meteorological broadcast, radio teleprinter, and Naval Intelligence broadcast circuits; E.T.4750's for Air Ministry automatic circuits; E.T.4331's for Djerba, Moscow, Habbaniya, Malta, Bari, Khartoum, Gibraltar — Birdlip, Castel Benito, Shaibah, Bahrein, meteorological broadcasts and 'Z' broadcast circuits; and E.T.4332's and Collins 16EA's for low power internal circuits and as spares.

In February 1945, although no information was yet available on the probable location of R.A.F. Headquarters in the Canal Zone or on the distribution of airfields, certain assumptions were made for planning purposes and in order to get ahead with the new communications centre. For planning purposes the circuits were assumed to be 15 inter-command channels using SWB8's and E.T.4331's, 20 internal channels using the TR.1190 or its equivalent, 5 high power relay transmitters of output 10-20 kW., plus suitable transmitters for the operational airfields. A receiving station and a signals centre were planned to cover this commitment plus about 20 internal teleprinter circuits. It was intended to select a transmitting site as soon as possible, with a receiving site near Ismailia. The trunk telephone system and teleprinter network requirements were to be considered in conjunction with the requirements of the other Services. However, when the Signals instruction for the withdrawal of units from the Nile Valley to the Canal Zone was drawn up in July 1946, it was decided that T.M.E. should remain at its existing location for the present and should continue to serve as the main command W/T station. A standby transmitting station giving certain communications in the Canal Zone was constructed at Spinney Wood, Ismailia.[1]

After extensive tests with dummy traffic, including the testing of reperforating facilities and the internal organisation at T.M.E., the radio teleprinter service opened for R.A.F. traffic on the 1 October 1945.[2]

Aircraft Reinforcement Routes

When the West African Reinforcement Route was opened in September 1940, the signals organisation along the route consisted almost entirely of civil channels. These consisted of an aircraft and D/F wave of 333 kc/s

[1] A.M. File C.25800/45.
[2] A.M. File CS.23550.

and a joint aircraft and point-to-point frequency of 6593 kc/s. These channels were standard in the Gold Coast, Nigeria and the Sudan, and were the responsibility of the government concerned. It was appreciated, however, that this organisation was altogether inadequate to meet the requirements of the flow of aircraft planned for this route, and an R.A.F. signals organisation was prepared. The final organisation was to be: —[1]

(a) One point-to-point channel between Takoradi and Khartoum.

(b) One point-to-point channel linking all staging posts between Takoradi and Abu Sueir.

(c) An additional point-to-point channel between staging posts for the sole purpose of passing meteorological and navigational messages.

(d) An H.F. aircraft channel on 4575 kc/s, with D/F at all main staging posts.

(e) D/F loops, giving bearings on 333 kc/s at subsidiary staging posts where civil M.F. D/F was not available.

In addition to R.A.F. requirements, Pan American Airways were under contract to provide an air transportation service and to supply their own communications, and they set up a chain of radio beacons and point-to-point services to this end. And as the flow of R.A.F. aircraft increased, the R.A.F. communications were correspondingly expanded. Then, with the entry of America into the war, a parallel organisation to that operated by the R.A.F. was set up by the U.S.A.T.C. Thus a route that had originally been a weak civil route was gradually transformed into a Service air route strong in communications and navigational aids.

The existing route point-to-point communications between the Sudan and Egypt were inadequate and they were drastically reorganised in January 1942, when it was also decided to make a number of alterations to the existing strategic point-to-point channels between Headquarters R.A.F. Middle East and East and West Africa. The reorganisation entailed the use of a number of additional SWB8's on long-distance point-to-point channels, additional T.1087's on the medium channels, and a network of short-range point-to-point channels within the Sudan using T.1083's.

The vital factors in the expansion plans were the availability of equipment, manpower and material, and in order to co-ordinate these matters from the communications aspect as soon as possible, it was decided in May 1942 as an interim measure to form an Inter-Allied Sub-Committee of the Combined Signals Board. But since the true function of the Combined Signals Board was to co-ordinate communications between the three British Services, it was later decided to set up a Cairo Inter-Allied Communications Committee to co-ordinate the effort and resources of the Allies. The supreme authorities on inter-Allied communications matters were the

[1] *See* R.A.F. Signals History, Volume III: 'Aircraft Radio', for details of the D/F organisation.

Washington Communications Board and the London Communications Committee, and the channel of approach was to one or other of these bodies as appropriate. On all major matters of communications policy, London, Washington and Cairo were in complete agreement.

The flow of reinforcement aircraft from the United Kingdom and the U.S.A. to the Middle East and India continued to increase, and No. 216 Group was formed as a ferry group in May 1942, and expanded in the course of the year, to cope with the task of concentrating ferry and transport operations under a single authority. The group was responsible for the operation, administration and communications of all reinforcement routes through the Middle East, the signals organisation and the provision of local landline communications for all these routes coming under its control. The group headquarters was established in Cairo, with wings in Cairo, West Africa, Khartoum, and Habbaniya. The group worked in liaison with the ferry group in England (No. 44) and Ferry Command in Montreal. On the formation of Transport Command in 1943 it became a part of that command.

In September 1941 it was decided that aircraft being erected at Port Sudan were to be ferried to No. 108 M.U. and Hurghada via Atbara and Wadi Halfa, and new staging posts with point-to-point and aircraft services were established at Port Sudan, Atbara, No. 108 M.U., Summit, Wadi Halfa and Hurghada. T.1087/R.1084's were provided for the wireless services. A main base was also established at Asmara for R.A.F. and civil aircraft services operating in East Africa and between Aden and Egypt, with point-to-point, aircraft and meteorological communications. An SWB8 was put into Service on the main aircraft frequency. A reinforcement route between Iraq and Egypt was also established in the summer of 1941, with full point-to-point, D/F and radio beacon facilities. Main staging posts for this route were established at Shaibah, Habbaniya, Aqir, and Abu Sueir, where T.1087/R.1084's were installed. Refuelling posts on this route used mobile pack sets. This route was later extended to India via Basrah, Bahrein, Sharjah, Jiwani, Karachi.[1] Habbaniya, Sharjah and A.H.Q. India acted as control stations, staging posts being established at other stations.

A southern route to India and the Far East, known as the South Arabian route, was decided upon in February 1941, and in order to provide bases for air operations over the Arabian Sea and staging posts for short range aircraft traversing the route, a number of airfields were developed between Aden and Karachi. Point-to-point, aircraft guard, and navigational facilities were provided at Riyan, Salalah, Masira, and Jiwani, where the route joined the northern route. Low-power facilities were provided initially, from Middle East resources, using duplex and simplex T.1083/R.1082 pack-sets, medium-power facilities being provided later on a permanent basis with T.1087/R.1084's and T.77's. However, it was some time before the agreed facilities could be provided, and a serious shortage of equipment on this

[1] A.H.B./IIM/A13/1D, April—December 1941.

route persisted. At one station on the route the equipment in use in 1942 consisted of a T.21/Tf pack-set, a T.19B, and a short-wave Type 'A'.

With the defeat of the Axis forces in the Western Desert and in North Africa a new reinforcement route was opened across North Africa. The first staging posts to be established were at Mersa Matruh and El Adem in December 1942, followed by Benghazi. The signals channels were found partly with equipment issued by Headquarters R.A.F. Middle East and partly through the signals centres at Mersa Matruh, Tobruk and Benghazi, the staging posts being linked to their respective signals centres by landline. Signals equipment provided included T.1090's for permanent installations and T.1154/R.1084 and G.P. pack-sets for less permanent installations. Further staging posts were formed at Marble Arch and Castel Benito in February 1943, first by mobile signals units and later with static facilities provided by W/T fitting parties. The permanent equipment provided included T.1190/R.1197B's for point-to-point and R.C.A. E.T.4331's for long-range aircraft guard. In March 1943 the establishment of staging posts was decided upon at Ras El Ma (Fez), Tafaraoui, and Biskra, the idea being to provide the minimum essential communications first and permanent facilities later. Administrative traffic was routed over North-West African internal channels. The essential communications were set up by the use of transportable equipment provided by No. 216 Group (T.1154/R.1082 and T.1083/R.1082 transportables), provisioning action being taken for permanent equipment by Headquarters R.A.F. Middle East. D/F facilities were provided by N.A.A.F. switchboards and field telephones were provided by the use of pack-ups, and local Air Formation Signals units provided camp extensions and outlets to the main trunk system, connecting up with the existing North-West African teleprinter network.

A route in use throughout the war was the civil route from the Cape to Cairo, where the W/T organisation was such that, along the Middle East portion of the route, either the air/ground frequency was used for point-to-point traffic, or alternatively messages were passed over R.A.F. operational or administrative channels when and where they existed. This procedure was not satisfactory, and at an informal meeting between the Director of Signals, Union Defence Force, and the C.S.O., R.A.F., Middle East, on 30 August 1944, which was held specially to discuss the signals organisation required on the Cape-Cairo air transport route, it was agreed that an inter-staging post point-to-point channel should be set up throughout the route.

Further Manpower Reductions

In December 1944, the Air Ministry instructed Middle East Command to carry out a ruthless examination of all unit establishments with the object of determining whether their retention at this stage of the war was justified. The Air Ministry objective was to cut the R.A.F. and Middle East by a total of 15,000 men. The Signals aspect of this reduction was studied and proposals were prepared. These included the reduction of several sector operations rooms and mobile A.M.E. stations to a 'Number only' basis, the reduction of all static A.M.E. stations to a 'care and maintenance' basis, the closure of all V.H.F. D/F fixer services at Air Headquarters Eastern Mediterranean except the V.H.F. homers at Abu Sueir, Benina, Derna, Gamil, and Tocra, the closure of R.A.F. Stations at Berka, Tocra, Mersa Matruh and Gambut, the abandonment of all R.A.F. stations and communications in Syria north of a line Damascus — Beirut (with the exception of a small maintenance party at Aleppo), a greater centralisation of radar work, the reorganisation of the Command commmunications system, the closure of a number of stations in East Africa, the disbandment of British Radar Control, Turkey, reductions at the O.T.U.s and the Middle East Signals School, the closure of H.F. D/F and V.H.F. D/F fixer services in Cyprus, and the reduction of the number of Middle East Command M.A.A.F. circuits to one. Concurrently, Air Formations Signals in the Middle East was completely reorganised, providing for the retention of the Chief Signals Officer and staff, the provision of liaison officers at Eastern Mediterranean, the Levant and Egypt, and the retention of a small nucleus for internal security and special commitments. The responsibilities of Nos. 3 and 5 Air Formation Signals were taken over by Area or L. of C. Signals on 10 February 1945. These responsibilities covered Cyrenaica, Egypt and the Levant. The reason for the transfer of responsibility was that Air Formation Signals was designed to operate with the R.A.F. on a mobile or semi-mobile basis, whereas the R.A.F. formations in these areas had become static.[1]

[1] A.H.B./IIM/A13/5D, January—May 1946.

CHAPTER 8

NORTH AFRICA AND THE MEDITERRANEAN

Operation 'torch' was mounted on 8 November 1942. The basic aim was to create a situation which would enable the Allies to seize and occupy the French North African province and Tunisia, and to control the sea communications between Gibraltar and Tunis. The role of the Royal Air Force was to :—

(a) Provide air cover and support for the naval and land forces engaged in the initial assault upon Algiers from such time as advanced landing grounds were secured.

(b) Protect the base of Algiers and lines of communication against air attack, and, in conjunction with the naval forces, against attacks by submarines and surface raiders.

(c) Provide air co-operation and support for land operations subsequent to the assault phase.

(d) Provide an offensive air striking force for strategic bombing.

In view of the possibility that the French might offer resistance, it was decided to equip the Royal Air Force units engaged on the assumption that all civil landline communications would be out of action, and that the only method of communication would be by W/T until such time as the Army re-established the trunk routes.

The initial signals planning for Operation 'Torch' was carried out by the Combined Signals Board of Allied Forces Headquarters at Norfolk House, the R.A.F. Chief Signals Officers appointed for the operation together with staff being posted to Norfolk House and being members of the Board. A member of the staff of D.G. of S. assisted the Board with R.A.F. matters, and all the facilities available to D.G. of S. were at the disposal of the R.A.F. planning staff. Headquarters Combined Operations were available to advise on signals planning in the assault. The control of signals planning through a Combined Signals Board proved on the whole to be satisfactory and was generally considered to be the best method. The Board, however, was not fully representative at first, and this led to delays in the outline signals plan, as a result of which the training of units in their operational role was not begun soon enough.[1] Close liaison between the R.A.F. members of the Combined Signals Board, D. G. of S. and Headquarters Combined Operations was the ideal; but this was not always achieved in the planning of 'Torch', due primarily to the rigid security regulations laid down, which resulted in the R.A.F. Signals Officer on the staff of Headquarters Combined Operations not being able to hold frank discussions on relevant matters with the planning staff at Norfolk House.

[1] A.H.B./IIJ15/49.

Similar security restrictions hampered the initial planning for the employment of the headquarters ship.

An Advanced Signals Party was sent to Gibraltar on 23 September to set up ground equipment, which arrived three weeks later, for point-to-point communications between Gibraltar and Headquarters Ship Eastern Task Force, the R.A.F. Headquarters ashore at Algiers and the Centre and Western Task Forces. The R.A.F. provided all the equipment at Gibraltar for these links, those to the two Task Forces being operated by American personnel. The equipment comprised six T.1190's, one SWB8, and seven R.1084's, housed in tenders, the T.1190's being mounted in pairs with one Meadows' petrol/electric set. Nearly all this equipment was unserviceable when unpacked, the faults revealing that thorough servicing and testing had not been carried out before packing.[1] Although considerable difficulty was experienced in siting the extra equipment at Gibraltar, it was set up and ready to work by D minus 1. Communication with the headquarters ship was opened satisfactorily.

Owing to the lack of accommodation at Gibraltar, the Combined Signals Centre could not be established as planned, except for teleprinter services. The position was aggravated by the inexperience of individual signals officers, the different methods employed by each Service, the general unfamiliarity with the equipment provided, and the time that the more senior controlling officers were forced to devote to technical matters at the expense of the broader organisation of message handling. During the early phases of the operation, the A.O.C. was established at Gibraltar, and all communications between the theatre of operations and the United Kingdom were routed through channels already existing at Gibraltar. The intention was, first, to establish point-to-point communications between Gibraltar and Algiers, together with W/T and R/T control of aircraft in the Algiers area during the assault phase, and, secondly, to build up and maintain a point-to-point and air-to-ground communications system, together with an R.D.F. coastal chain supplemented by a W/T inland reporting system.

The landings required the despatch of a large number of R.A.F. and U.S.A.A.F. aircraft, responsibility for the despatch of which was delegated to No. 44 Group. Because of the number of agencies involved, communications were an important factor; and special point-to-point facilities, an air-to-ground organisation, and landline communications between departure airfields, forward posts, and No. 44 Group, were provided. Between 6 November and the end of the year, nearly 1,000 aircraft were despatched, with very few losses.[2]

Communications in the assault phase were concentrated in a headquarters ship which had no conflicting fighting role, and the advantages of this arrangement proved themselves.[3] The immediate aim of R.A.F. signals

[1] A.H.B./IIJ15/44/2.
[2] A.H.B. Narrative 'The North African Campaign, November 1942—May 1943'.
[3] A.H.B./IIJ15/49.

in the assault landings was to provide facilities for the control of aircraft in the Algiers area. The following services were to be provided :—

(a) W/T and R/T communication between the headquarters ship and the landing beach, and W/T between the beach and Gibraltar.

(b) V.H.F. R/T facilities at the airfields at Maison Blanche and Blida.

(c) Two radar light warning sets to broadcast plots by W/T for reception at the airfields and elsewhere as required.

(d) A skeleton field telephone service between the temporary operations rooms at the two airfields and the dispersal points.

The signals units which were to provide the above services were two field force headquarters signals section (F.F.H.Q.S.S.), each consisting of two officers and 27 other ranks, with four vehicles; two advanced landing ground signals sections (A.L.G.S.S.), each consisting of one officer, 21 other ranks, and three vehicles; and two light warning sets with radar personnel. The F.F.H.Q.S.S. consisted of a T.1087 or T.1190, three pack-sets and a V.H.F. set, and the A.L.G.S.S. consisted of three pack-sets, a V.H.F. set and a V.H.F. homer. The light warning radar stations communicated by means of pack-sets. These units, together with two servicing commandos and two A.A. flights, were to form the advanced party of Nos. 322 and 323 Wings, and they sailed with the assault convoy. The role of this advanced party was to operate five fighter squadrons from Maison Blanche until the arrival of the main body of personnel.

These units were to land on 'Charlie' beach, the most easterly of the three main beaches selected for the landing at Algiers. The first units to commence operations would be No. 2 Field Force Headquarters and one of the light warning sets. These two units were to proceed sufficiently far inland to be clear of the beach, and they were then to establish an Advanced Wing Headquarters, at which W/T or V.H.F. R/T would be established with the headquarters ship on pack sets, and with Gibraltar on a T.1087. The light warning set was to prepare to broadcast radar plots as soon as possible on the radar wave. Meanwhile, the four remaining units (i.e. No. 1 F.F.H.Q.S.S., Nos. 1 and 2 A.L.G.S.S.s and the second light warning set) were to drive clear of the beach and shelter or disperse until the road to Maison Blanche was reported clear by the Army, when the two A.L.G.S.S.s and the light warning set were to proceed to the airfield. On arrival, No. 1 A.L.G.S.S. was to establish a temporary operations room and to open communication with the headquarters ship and with No. 2 F.F.H.Q. and the first light warning set (L.W.S), using a W/T pack-set. No. 2 A.L.G.S.S. was to open W/T point-to-point communication with No. 34 Division. The second light warning set was to be established adjacent to the temporary operations room, pass plots in by telephone, and also broadcast plots by W/T on the radar wave. Telephone lines between the temporary operations room and the dispersal points were to be provided from the equipment held by the A.L.G.S.S.s.

When signals facilities were satisfactory at Maison Blanche it was planned that No. 2 F.F.H.Q.S.S. would move from the landing site to the operations room at Maison Blanche until relieved by the arrival of a wing signals section with the main party. While the signals units were being erected it was expected that R.A.F. fighter aircraft would arrive, and No. 1 A.L.G.S.S. was to be prepared to control and home them on V.H.F.[1] No. 1 F.F.H.Q.S.S. was to be prepared to move to Blida airfield on receiving instructions.

Unfortunately, when the assault took place on 8 November 1942, the sea conditions for 'Charlie' beach were too rough to land the R.A.F. equipment as planned. Many landing crafts were wrecked, and this prevented the landing of W/T vehicles, with a consequent breakdown of communications. Neither point-to-point W/T stations nor radar light warning stations could be landed. The only communication between the beach and the command ship, which was lying off the main beaches west of Algiers and out of visual signalling touch with 'Charlie' beach, was a small Army set. Communication between Gibraltar and Algiers was conducted entirely through the headquarters ship, as was the early warning of the approach of enemy aircraft and fighter control. To improve communications, a Walrus was flown to Maison Blanche and was used as a W/T station until late on the 9th.

The immediate objectives in the drive towards Tunis were the airfields at Djidjelli and Bone.[2] The forces detailed for the occupation of Djidjelli included an advanced landing ground signals section, and for Bone, a detachment of a field force headquarters signals section.

Follow-up Convoys in 'Torch'

The first follow-up convoy was planned to arrive at Algiers on D plus 4. The signals units included in this convoy were two Air Headquarters Signals Sections, two Wing Signals Sections, a Wireless Observer Unit (W.O.U.), a Mobile Signals Servicing Unit (M.S.S.U.), two Ground Controlled Interception (G.C.I.) units and one L.W.S. Unit.[3] The air headquarters signals sections were to take over the functions of No. 2 Field Force Headquarters Signals Section, which was then to move east to strengthen No. 2 A.L.G.S.S. or to Blida to strengthen No. 1 F.F.H.Q.S.S., according to the situation. The air headquarters signals sections were to be set up in Algiers to provide the major communications services for the Air Headquarters. No. 322 Wing Signals Section was to take over the functions of No. 1 A.L.G.S.S. at Maison Blanche,[4] and No. 323 Wing Signals Section was to operate under the

[1] A.H.B./IIM/A36/1-1A.
[2] *See* A.H.B. Narrative 'The North African Campaign: November 1942-May 1943'.
[3] A.H.B./IIJ15/11.
[4] Because of delays in unloading equipment brought by follow-up convoys, No. 1 A.L.G.S.S. was not relieved until mid-December 1942, when it returned to Algiers for rest and refit, having operated continuously and most tenaciously in the front line, in the course of which it sustained six fatal casualties and the loss of all its equipment due to enemy action. (A.H.B./IIJ15/44/4.)

Advanced Element of No. 323 Wing, superseding No. 2 A.L.G.S.S. One of the G.C.I. units and the wireless observer unit were to provide a warning system for Algiers. The other two radar units were to provide cover for the advanced forces.

The second follow-up convoy was planned to arrive on or about D plus 14, disembarking a light bomber and a G.R. wing signals section, an M.S.S.U., and Headquarters No. 242 Group Signals Section at Algiers; two radar units at Phillipeville; and a wireless observer unit, a fighter wing signals section, and two more radar units at Bone. At this stage development of the final R.A.F. communications would begin. The third follow-up convoy was to arrive on or about D plus 28, disembarking an M.S.S.U. and a heavy mobile W/T unit at Algiers; an M.S.S.U., a fighter wing signals section, and two radar units at Phillipeville; and three radar units at Bone. The heavy mobile unit was to be sited in Algiers to maintain communications with the United Kingdom.

The total R.A.F. signals units involved in 'Torch' were two A.L.G.S.S.s and two F.F.H.Q.S.S.s, two W.O.U.s, some twenty G.C.I.s and M.R.U.s, ten L.W.U.s, two A.A.S.C.s, and a heavy automatic W/T unit. In addition, each of four mobile wings had an M.S.S.U., with an establishment of 6 officers and 130 O.R.s. The total number of R.A.F. signals personnel involved was well over 2,000.[1]

As the result of the difficulties in landing already mentioned, no communication between headquarters ship and the R.A.F. landing party was available through R.A.F. channels until D plus 2. There was thus a delay of two and a half days in fully establishing the R.A.F. communications for the assault stage, due to failure to land vehicles and equipment and, to some extent, to the unsuitability of the signals equipment. The bulk of R.A.F. traffic for Algiers was therefore routed via headquarters ship until D plus 3.

Difficulties in the Development of Communications

Four main factors affected the development of R.A.F. communications in North Africa. These were the rapid advance and taking over of airfields; the establishment of sections of the air staff in three different localities; delays and disorganisation in unloading ships; and the non-flexibility of the unit establishment arrangements for signals sections.

Equipment and personnel to deal with the rapid advance and capture of airfields was provided, and the packing and shipping of equipment was generally satisfactory. But the conditions of unloading at the docks were chaotic, and loading of cargoes had been unsystematic, signals equipment being invariably the bottom cargo. Equipment was unloaded arbitrarily over a large dock area and dispersed to various dumps in Algiers, and the C.S.O. had to arrange his own parties to search the dock area and dumps in order

[1] *See* A.H.B. Narrative 'The North African Campaign: November 1942-May 1943'.

to collect his signals equipment together. It was over a week before many signals personnel were able to find their vehicles, and when they found them they could not drive them away because they had no petrol. Having solved this problem, they found that there was no acid in the batteries, and they could not trace the acid. When they found the acid they discovered that the batteries were new and required an initial charge. The obvious lesson was that the staff of signals units should always accompany their vehicles in the same ship, petrol tanks should be full and batteries topped up with acid and fully charged.[1] This lesson was applied later in the Sicilian campaign.

Spares provisioning generally met requirements but nearly all items of signals equipment with the exception of the Marconi T.1154/R.1155 required extensive servicing before they could be put into operation. The nature of the faults was such that simple tests would have revealed them before despatch. The short notice of the operation may have accounted for the absence of testing. Once serviced, the reliability of equipment was good.

The scale of transport was altogether inadequate and mobile units were forced to operate under field conditions less domestic equipment and with only the lightest scale of spares; full sets of spares were sent forward later as space became available in road convoys. The signals staff was almost completely immobilised for the first 14 days by lack of transport, and the siting of radar stations was held up for the same reason.

Communications were provided by splitting up the small signals sections which had already been landed, and the consequent delays were due to congestion and not to the technical failure of equipment. As a result of the unloading delays, the entire campaign was run on the assault equipment until D plus 10, when the first few No. 323 Wing items were unloaded. Thereafter, the Air Headquarters Signals Section and Nos. 322 and 323 Wing Signals Sections provided a skeleton network to the limit of their resources, Air Headquarters clearing some 16,000 groups daily. The equipment in the second follow-up convoy remained unloaded, and from D plus 12 to D plus 28 the air forces in North Africa operated on the equipment provided for the assault and first follow-up convoy.[2]

The Meadows petrol/electric charging sets, for which no spares were available, failed to stand the strain of long running. This failure had already caused great inconvenience in the Middle East campaigns, but the lesson had not been applied to the new campaign. It was well known in the Middle East, from bitter experience, that the Meadows set would not stand up to heavy work, yet this was the power supply provided for 'Torch'. The

[1] Narrator's interview with Air Commodore Mann.

[2] In addition to the R.A.F. commitments, R.A.F. signals units provided equipment and communications for the U.S. Air Forces at Youks-les-Bains, who arrived with no signals equipment.

failure of these sets was a particularly serious handicap, as local power supplies were not available.

Replacement by diesel was needed, and 12 sets were urgently requested, together with towing vehicles, which were needed because of the transport shortage and the distances involved, satellite airfields being up to 100 miles from Wing Headquarters. The G.P. pack-set receiver was inadequate under local conditions and proved difficult for inexperienced men to operate. The need was for a really transportable pack-set, but twenty-four R.1084 receivers were urgently requested as a stop-gap. The V.H.F. position was sound but the distribution of crystals was almost impossible, as squadrons were moved to operate irrespective of their parent wings. Fortunately, the distance between airfields was so great that the entire force could operate efficiently on one frequency without interference.

All personnel suffered in efficiency from the short time that had been available for training and the absence of a proper formation and training scheme for mobile field units. The standard of field training was low, knowledge of practical aerial construction being particularly lacking. Few personnel had any conception of the effect of nearby mountains or corrugated iron structures on the efficiency of low power sets working over long distances, and they showed little enterprise or drive when unable to establish W/T contact. Operators had not learnt the art of searching for the required signals, and were apt to give in too easily if the station they were calling did not reply strongly at once. Their basic training was sound, but lacked attention to the difficulties of mobile warfare. There was a lack of competent N.C.O.s, and of initiative in junior officers, due to the easy conditions under which they had worked previously. The signals personnel engaged in the operation were mostly accustomed to a routine and static life in the United Kingdom, and it was some time before the team work, initiative and ingenuity demanded of mobile operations were developed.[1]

The inflexibility of the unit establishment system as applied to signals sections was responsible for further delays in the development of communications. It was difficult to operate satisfactorily on a wing basis when wings were continually moving, not necessarily with their own squadrons.[2] Signals personnel and equipment were established as part of unit establishments, but after experience in 'Torch' it was contended that all signals units for operations in the field should be on a self-contained mobile establishment, the total requirement forming a signals component under a headquarters in the base area. The signals establishments generally were cut too fine, and while they gave an initial saving, resulted in inefficiency under operational conditions.[3] The difficulties were not altogether unanticipated but the time available for the mounting of 'Torch' was too short to allow the setting up of separate mobile and self-contained signals units on a separate signals component basis.

[1] A.H.B./IIJ15/33/9.
[2] A.H.B./IIJ15/44/4.
[3] A.H.B./IIJ15/33/9.

The priority of landing signals units needed to be clearly laid down in the operational plan; any tendency to advance the priority of fighting troops at the expense of signals units resulted in the essential framework of communications not being established, making the commander unable to secure control at the outset of the operation.[1]

The misuse of priority markings of messages by staff officers and unit commanders was widespread and persistent in the early stages of 'Torch'. The effect was to reduce the level of all traffic to that of virtually no priority at all. Having reduced the value of priority markings in this manner, originators then aggravated the situation by enquiring into delays and originating further signals to expedite replies. The remedy was for orders to be issued at an early stage giving the priorities to be accorded to all types of signals messages.

The whole of the Algerian posts, telegraphs and telephone (P.T.T.) systems was taken over intact, but the facilities this system offered were meagre and the equipment old-fashioned and badly maintained. The lines themselves were generally good, and ran underground as far as Constantine; forward of Constantine and all along the coast they were above ground. In the period immediately following the assault, the First Army developed the main arteries, but as the Army advanced, Nos. 1 and 2 Air Formation Signals took over and developed the lines required for R.A.F. purposes. The allotment of lines was controlled first by the Army L. of C. and later by First Army. Control in the base areas was later assumed by Allied Force Headquarters (A.F.H.Q.). The procedure was for Air Formation Signals to indent on either Allied Force Headquarters or First Army for the P.T.T. and trunk lines, and this arrangement worked satisfactorily. Within a very short time, a sound working landline and teleprinter organisation had been installed by Air Formation Signals and the Royal Corps of Signals.

Co-operation with the Army on landline and signals matters was excellent, and Air Formation Signals did excellent work at all stations, their duties being to provide the line and despatch rider communications required by the R.A.F. They were responsible for manning and operating such communications down to wing level, though under some conditions certain telegraph channels were manned by R.A.F. operators. In some cases an A.F.S. unit was allotted on a functional basis to an R.A.F. formation, in others it was allotted to an area. The former method was the more usual during active operations, as it permitted the unit to travel with the R.A.F. formation to which it was allotted; the latter method was more practicable and economical in areas where conditions were stabilised and there were no active operations.[2]

During the assault stage, and throughout the period when combat was necessary to hold an area, radio plus organisational telephone and tele-

[1] A.H.B./IIJ15/49.
[2] A.H.B./IIJ1/238/4/41.

graph facilities was used. The majority of the telephone and telegraph facilities available consisted of tactical switchboards and field wire lines, with the addition of commercial facilities in areas dominated by Allied forces. Later, an A.F.H.Q. line network was established by using existing commercial facilities and by adding circuits to the existing pole line. Development necessitated the provision of an extensive line network requiring considerable construction and the provision and installation of a large amount of terminal equipment.[1]

Although a much larger number of long distance circuits was provided for the sole use of the R.A.F. than had been anticipated before the operation, it was generally impossible to provide more than one line between stations. Consequently lines provided for operational use had to be made available for the passing of essential administrative traffic when the operational staff were able to release the lines.[2]

Experience in Operation 'Torch' showed that the amount of signals traffic imposed on the headquarters became excessive unless strictly controlled. Such control, to be effective, needed to be exercised not only at the superior Force Headquarters but also at any other headquarters responsible for passing traffic. During the assault phase, many long encyphered messages were received which had only a minor bearing on the critical operations in progress. The only solution appeared to be to establish at each higher headquarters an agency of the general staff with full knowledge of the operations in progress, charged with the responsibility for determining which messages should be accorded priority considering the facilities available. Priorities also needed to be agreed between the demands of press and propaganda agencies and operational needs.

Unlike reserves of other personnel and equipment, signals reserves needed to be greatest when the tactical success was greatest, because it was then that movement of headquarters was most accelerated and demands for signals services most urgent. When the tactical success anticipated in 'Torch' was accomplished, the amount of signals personnel and equipment was inadequate to cope satisfactorily with the rapid movement of headquarters.[3]

Frequency allocation for all Forces in the entire operation was made by the British and U.S. radio officers of the Chief Signals Officer's staff. Requirements as to the number of channels and sets of each arm of the Service were obtained together with data on power, antenna and frequency range, all transmitters being classified according to their power; the frequency, power and location of all principal and useful enemy fixed stations was determined from Intelligence reports; the best ionospheric predictions for the latitude of the operation and the time of the assault were obtained; locations of principal ports likely to be used and the probable location of

[1] A.H.B./IIA1/25/3/12.
[2] A.H.B./IIJ15/44/16.
[3] A.H.B./ID/7/238.

A.F.H.Q. were obtained so that the approximate location of high power fixed stations could be determined. Channels were allocated on the principle of a frequency separation of not less than 10 kc/s. Frequency allocation zones were laid out geographically so that duplication of channels could be safely accomplished; it was recognised that because of the large demands for frequencies in the 2—8 megacycle band, all channels in this band would have to be duplicated, some many times over. This method was considered superior to a 5 kc/s separation between channels, which was regarded as impossible to maintain under field conditions. Two officers, one British and one American, handled the entire co-ordination of frequencies in 'Torch', allocating and revoking frequencies as required without the delay inevitable where reference was made to frequency boards or committees.[1] Due to the proposed frequencies for point-to-point stations in North Africa not having been co-ordinated with the W/T Board, London, however, interference was caused to a number of British fixed stations of long standing.[2]

W/T Organisation

After the landings in French North Africa, a telecommunications centre, known as Telecommunications North Africa (T.N.A.), was set up in Algiers on a stop-gap establishment of 100, and became of comparable importance to T.M.E. The W/T organisation was at first controlled by Eastern Air Command (E.A.C.), which consisted of an Air Headquarters, Headquarters No. 242 Group, and six wings. By 23 November E.A.C. Algiers was operating W/T channels to the Air Ministry, Gibraltar, Maison Blanche, Blida, No. 380 Wireless Unit, and the Headquarters Ship; Bone; and the First Army Command Post at Jemmappes. Also operating or planned was a circuit to Air Headquarters Western Desert, the addition of Malta to the Algiers-Gibraltar circuit, and circuits from Bone to the First Army Command Post, Souk el Arba, Djidjelli and Phillipeville.[3]

A number of changes were made to the organisation towards the end of November, so that by 2 December the North African W/T organisation connected Algiers to Birdlip; Advanced Air Headquarters Western Desert, Malta, Air Headquarters No. 235 Wing, and Headquarters No. 201 Group; Gibraltar, Malta, Bone, and First Army Command Post; a separate channel to First Army Command Post; and a local circuit embracing Maison Blanche, Blida, and all units in the Algiers area. The Bone channels were unchanged; these channels were being operated on G.P. pack-sets due to losses through enemy action. Other facilities included R/T control at air-

[1] A.H.B./ID7/238.
[2] A.H.B./IIJ15/49.
[3] The greater part of the R.A.F. fighter strength, which totalled six squadrons, was concentrated near Souk el Arba by mid-December: there was one squadron at Djidjelli, one at Phillipeville and three at Bone. The four Bisley Bomber squadrons were concentrated at Canrobert, and were largely employed on tactical reconnaissance for the Army. The procedure was for the aircraft to fly from Canrobert to the landing ground at Souk el Arba and to proceed from there on their various tasks, often heavily escorted by the Spitfires.

fields, a delivery flight frequency at Maison Blanche, a bomber aircraft frequency at Blida, M.F. D/F at Maison Blanche, and a naval help wave at Maison Blanche and Djidjelli, Phillipeville and Bone. Further channels were to be opened on receipt of equipment, but development of communications was still handicapped by the slowness of unloading at docks. Nos. 322 and 323 Wing Signal Sections were providing this skeleton network to the limit of their resources, and in spite of difficulties were giving a satisfactory service, as evidenced by the clearance of an average of over 16,000 groups daily by Air Headquarters Eastern Air Command. Cypher traffic was the bottle-neck, Typex machines being scarce and deliveries well under establishment.[1]

The location of signals sections at 2 December was that Eastern Air Command was at Maison Carree just east of Algiers. No. 1 F.F.H.Q.S.S. was at Blida, No. 2 with the R.A.F. Component of the First Army Command Post at Ain Seymour. No. 1 A.L.G.S.S. was at Souk el Arba, No. 2 at Djidjelli. No. 323 Wing Signals Section was at Maison Blanche, and No. 322 was at Bone, and was also serving Phillipeville. No. 87 Wireless Observer Unit was sited to give reports in an arc up to 60 miles east to south-east of Algiers. No. 301 M.S.S.U. was near Maison Blanche. No signals equipment had yet been unloaded from the second follow-up convoy. All airfields were served by landlines to local R.D.F. stations, observer units, dispersal areas, internal offices, and outlets to their nearest Army and local P.T.T. Exchange. By 11 December, all airfields were connected to a teleprinter system, linking E.A.C. to Maison Blanche, Blida, Djidjelli, Phillipeville, Setif and Bone. GCI/COL stations were sited at Algiers, Djidjelli, Bone and Phillipeville; light warning sets were sited at Algiers, Phillipeville and Bone. All were in telephone communication with their local airfield.[2] Headquarters No. 242 Group signals section was still in Algiers, pending a decision on its forward location.

Existing under-water cables were brought into use as quickly as possible and the Algiers—Gibraltar cable was working on 26 November. Soon afterwards it was broken by a ship dragging anchor at Algiers but repairs were completed within a few days. By the end of the month the Oran—Tangiers —Gibraltar cable was working, and it had been established that the Gibraltar—Casablanca cable was repairable.

The shortage of receivers persisted. The Eastern Air Command W/T Station at Algiers had ten transmitters and only six receivers, due to the loss of two in transit at sea and the mislaying of two in transit by air. On 15 December, the Air Ministry agreed to send six R.1188's by air. At this time Headquarters No. 242 Group signals section was moving forward, and alterations were planned to the W/T organisation to relieve the existing overload at Eastern Air Command when Headquarters No. 242 Group was sited.

[1] A.M. File CS.17524.
[2] A.H.B./IIJ15/44/4.

By December 1942, the military situation in North Africa and Tripolitania had reached the stage where adequate and efficient communications for operational co-ordination between Headquarters Eastern Air Command and Headquarters R.A.F. Middle East were an urgent requirement.[1] The move of the Western Desert Forces into Tripolitania had provided bases from which heavy bomber effort could be concentrated on the enemy's ports, and this, together with the efforts of the Allied Forces in North Africa and Tunisia, had confined the enemy's supply and communication lines to an extremely small area. In consequence, forces based in North Africa, Malta and Cyrenaica were operating virtually together. Speedy communication between all formations concerned was therefore essential in order that the proper degree of co-ordination and efficiency could be attained.

Inter-Command Requirements

There were four distinct communications requirements between North Africa, Malta and the Middle East :

(a) Channels of communication which allowed strategic co-ordination of all operations by the main formations. These were the channels by means of which long-term operations were planned and co-ordinated.

(b) Operational channels of communication which provided facilities necessary for the immediate tactical co-ordination of the operations being carried out by those formations in contact with the enemy, namely Advanced Air Headquarters Western Desert, Air Headquarters Malta, and Headquarters No. 242 Group (the main supply formation of Headquarters Eastern Air Command, responsible for operating the Air Forces working in conjunction with the armies in Tunisia).

(c) Channels of communication which allowed the effective co-ordination of all operations of a general reconnaissance nature, including shipping strikes.

(d) Communications which met the requirements of air transport and reinforcement aircraft.[2]

The point-to-point organisation was stabilised in January 1943 as follows :—

(a) A.M. 14 Algiers—Birdlip. This was a high-speed automatic channel operated by No. 11 Heavy Mobile Unit. A peak load of 35,000 groups per day was reached in April 1943.

(b) Algiers—Malta—Advanced Air Headquarters Western Desert and Headquarters No. 242 Group.

[1] The channels of communication between H.Q. Eastern Air Command and H.Q., R.A.F., Middle East, in December 1942 are shown at Appendix No. 15.
[2] A.H.B./IIJ1/335/2/6.

(c) Algiers—Gibraltar. Later, Malta, El Adem and Castel Benito joined this channel for aircraft movements traffic.

(d) Cairo (T.M.E.), Algiers.

(e) Algiers, Malta, First Army Command Post.

(f) Algiers, Headquarters No. 242 Group, Advanced Air Headquarters E.A.C.

(g) Algiers, Advanced Air Headquarters E.A.C.

(h) Command Guard : linking Algiers, Djidjelli, Setif, Phillipeville, Blida and Maison Blanche.

(i) Headquarters No. 242 Group to Advanced Headquarters No. 242 Group.

(j) Headquarters No. 242 Group, Souk el Arba, Bone.

(k) Headquarters No. 242 Group, Youks les Bains, Canrobert, Setif.

(l) Command and meteorological broadcast channels.[1]

In order to operate a ferry control unit (F.C.U.) at Marrakesh, some 100 miles south of Casablanca, a number of point-to-point circuits were set up in January 1943. A point-to-point circuit linked Headquarters No. 44 Group in the United Kingdom (through Birdlip) to an R.A.F./U.S.A.T.C. Unit at Marrakesh. The R.A.F. provided the equipment and personnel at Birdlip, and U.S.A.T.C. provided equipment at Marrakesh, where personnel were provided jointly. The circuit controlled U.S.A.T.C. aircraft routed via the South Atlantic to and from the United Kingdom, U.S.A.T.C. reinforcement aircraft routed via the South Atlantic to the United Kingdom and French North Africa, any R.A.F. Ferry Command aircraft using this route, and B.O.A.C. aircraft flying from the United Kingdom to West Africa. The Birdlip - Marrakesh circuit was provided for passing all messages between O.A.C. Gloucester and F.C.U. Marrakesh. Other circuits and facilities included a point-to-point channel Marrakesh, Casablanca, Gibraltar, primarily for the passing of aircraft movement signals; and aircraft watches at Marrakesh and Casablanca. The reception of meteorological broadcasts at Marrakesh was also arranged.[2]

Plans for a reinforcement route spanning North Africa were laid in March 1943. The route was to traverse Africa via Ras el Ma, Tafaraoui, Biskra, Castel Benito, Marble Arch, Benina, El Adem, Mersa Matruh, and LG.224, with ferry controls at Ras el Ma, Castel Benito, and LG.224. Signals requirements for the route as visualised in March 1943 were point-to-point from Ras el Ma to the United Kingdom, Bathhurst, Bermuda, Gibraltar, Casablanca, Marrakesh, Tafaraoui, Biskra, Castel Benito, and T.M.E.: Castel Benito to Gibraltar, Malta, LG.224, and Marble Arch; Marble Arch to El Adem and Benina; El Adem to Mersa Matruh and Mersa Matruh to LG.224. Short range air transit watch with D/F, V.H.F. R/T control and homing

[1] A.M. File CS.17524.
[2] A.M. File CS.18000.

channels, M.F. beacon and local airfield control was to be established at staging posts, plus long-range air transit watch at the three ferry control units. Equipment requirements were stated at the same time. SWB8's were required for the long-range channels from Ras el Ma and to the United Kingdom, Bathhurst, Bermuda and T.M.E. E.T.4331's were required at Castel Benito and Ras el Ma for the inter-connecting point-to-point channel and for long-range aircraft guard. The remainder of the point-to-point transmitter equipment was T.1190. V.H.F. equipment was required for the whole route.

Formation of Mediterranean Air Command

In February 1943, it was decided to form in North Africa a Headquarters Mediterranean Air Command (M.A.C.), which was to comprise the North West African Air Forces (N.A.A.F.), Middle East Air Command, and Malta Air Command, with Headquarters at Allied Forces Headquarters (A.F.H.Q.) North Africa.[1] This Headquarters needed first-class communications to adjacent commands, and the aim was to provide automatic W/T channels and subsidiary hand-speed W/T channels. Two heavy mobile automatic W/T stations (Nos. 12 and 13) and a mobile signals unit Type 'A' were to be provided. The co-ordination, assembly and despatch of all equipment and M.T. was undertaken by the Air Ministry and Headquarters No. 26 Group, who had formed, trained and equipped all units required by the end of March 1943.[2]

An assessment was made of the requirements for main point-to-point channels in April 1943. A total of 68 transmitters was required in N.A.A.F., T.N.A., and the Air Command Post, half of which were to be supplied and manned by the Americans, with the R.A.F. supplying and manning the remainder, plus equipment and personnel for five static sectors, three G.R. units, one coastal group and 12 associated airfields between Algiers and Gabes. This was in addition to the equipment and personnel requirement for the reinforcement route. For the main channels M.A.C. required, over and above what was already in the command, two heavy mobile units, four twin channel low power mobile units, two medium power static automatic units, two medium power hand static units, seven low power hand static units, and four twin channel mobile units. For the L. of C. coastal defence areas the approximate needs (apart from M.F. and H.F. aids to navigation) were ten twin V.H.F. transmitters and receivers, 25 V.H.F. D/F fixing and homing stations, 132 low power static sets and 93 very low power W/T—R/T sets for standby-to-line. To economise in wireless operators, it was intended to use R/T standby-to-line wherever possible, but transmission conditions in Tunisia were difficult and something more powerful than the G.P. pack-set was needed. The American B.C.191 transmitter with rectifier and H.R.O. receiver was suggested as being the ideal, and the possibility of

[1] A.H.B./IIM/A45/1JE.
[2] A.H.B./IIG/25.

supplying such a pack-up in quantity for adoption as the standard equipment for standby-to-line on all essential circuits in M.A.C. was investigated. The personnel requirement for these commitments amounted to 500 wireless operators, 120 automatic operators and 100 personnel of the wireless electrical trades. As many personnel as possible were drawn from the command itself and from the Middle East.

Mobile equipment was in short supply, and the policy ruling was that settled areas were allotted fixed installations, thus releasing mobiles for areas where fighting was actually in progress.[1] The Air Ministry had already sent a quantity of mobile units of various kinds, including V.H.F. and diesel power trailers, and in April 1943 it was decided to reinforce M.A.C. by the despatch of signals and radar units, in preparation for further amphibious operations. These reinforcements included an F.F.H.Q.S.S., four A.L.G.S.S.s, an M.O.R.U., an M.A.R.U., and various types of M.S.U. These units, which were assembled at Chigwell, were given field and operational training prior to despatch, which began in June 1943.[2]

At the beginning of May, a considerable amount of equipment was ready to be despatched from the United Kingdom, including four static SWB8's, various diesel/electric sets for standby power for the static signals services, 7 Type 105 V.H.F. D/F vehicles, 15 twin-channel T.1190 vehicles and 15 twin-channel H.F. receiving vehicles, 90 transmitters T.1190 and 90 receivers AR.77, together with 100 masts and aerial gear. Nos. 12 and 13 Heavy Mobile Units were on their way to the Command and No. 14 was being transferred, without personnel, from the Middle East. Much of the equipment, however, was still awaiting shipment at the end of June.[3]

Operation 'Husky'

Consideration of a site for a combined headquarters to control an amphibious assault on Sicily was begun in February 1943. The primary difficulty was the length of time that would be required to establish naval communications in the Tunisian area, whereas such communications already existed at Malta, which therefore seemed the obvious choice. In all amphibious operations there was a period during which the Navy had complete control of the land and naval forces, when complete dependence was placed on naval communications. For this reason, nothing less than perfection in naval communications could be accepted. Unless a considerable delay was accepted in the mounting of the assault it was possible to provide these communications at Malta only. Against this, Malta could not possibly be considered as a practical general headquarters: the major air forces and the higher direction of air operations would be located in North Africa, and reinforcing ground formations would come from that area.[4] The main operational headquarters was therefore established in the Tunis area.

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[1] A.M. File CS.18000.
[2] A.H.B./IIE/25.
[3] A.M. File CS.18000.
[4] A.H.B./ID7/203(P).

The code name of 'Husky' was given to the operation. Two important factors which affected the mounting of the operation from the signals point of view were:—[1]

(a) That the responsibility for equipping the air forces engaged was divided between Headquarters Northwest African Air Forces in Constantine and Headquarters R.A.F. Middle East in Cairo.

(b) That the interval planned to elapse between the conquest of Tunisia and the assault on Sicily was to be as brief as possible, but that during this period the islands of Pantelleria and Lampedusa were to be reduced.

Supreme command of all air forces was exercised by the Air Commander-in-Chief from the joint Mediterranean Air Command and Northwest African Air Forces command post located at La Marsa. Command of the air forces acting in direct support of the Seventh U.S. and Eighth British Armies was vested in the A.O.C., Northwest African Tactical Air Force (N.A.T.A.F.). A command post for this purpose was set up at La Marsa in conjunction with 15th Army Group (in command of the two armies engaged).

Under the command of the Tactical Air Force were :—

(a) The Desert Air Force, composed of British and South African Fighter Wings, and U.S. Fighter Groups, to be equipped and maintained by Middle East and embarked from the Delta and Tripoli.

(b) The XII Air Support Command (A.S.C.), composed of U.S. Fighter Groups to be equipped by Northwest African Air Forces and embarked from Oran.

(c) The Tactical Bomber Force (T.B.F.), composed of U.S., British and South African Bomber Groups and Wings from both Middle East and Northwest African sources.

During the planning stages of the operation the Air Commander-in-Chief and his Headquarters were situated in Algiers; thus the initial policy planning was carried out from there. At the same time, in view of the divided responsibility for supply, for training and for movements, two independent detailed planning staffs were set up in Cairo and Mostaganem (near Oran). This wide geographical separation between the planning staffs concerned led to great difficulty in the production of the signals plan, which had of necessity to be most closely co-ordinated.[2]

The necessity for limiting the time which should elapse between the conclusion of the Tunisian campaign and the assault on Sicily led to the greater part of the planning being carried out by the planning staffs without direct reference to the requirements of the Signals staffs of the tactical units to be

[1] A.H.B./IIJ1/311/1/7.
[2] A.H.B./IIJ1/311/1/7.

involved. While this step caused considerable comment at the time, it was not considered that this factor had any ill effect on the final plan for the following reasons : —

(a) Any signals plan must conform to the requirements of the air staff plan, and would thus have the same broad outline no matter by what experienced signals planning staff it was conceived.

(b) The planning staffs concerned had at their disposal full details of recent signals experience in the Western Desert and Northwest Africa.

(c) Main strategic channels of communication, frequencies and call-signs, which required a large part of the attention of any signals planning staff, did not require the attention of the executives.

The need, however, for the employment of XII Air Support Command and Tactical Bomber Force units in the operations for the reduction of Pantelleria, rendered it extremely difficult to equip and mount these forces in time for 'Husky'.

The Air Command Post, La Marsa

On 21 May 1943, a signals plan was drawn up to provide W/T and land-line communications for a Mediterranean Air Command Post at La Marsa, near Tunis. Located at the Air Command Post were the Air Commander-in-Chief and the Commanding General Northwest African Air Force, with an operations staff and liaison officers from Malta, the Middle East and the Ninth Air Force U.S.A.A.F. Headquarters N.A.A.F., N.A.T.A.F., Northwest African Coastal Air Force (N.A.C.A.F.) and Troop Carrier Command came directly under the Air Command Post for operations. Headquarters T.A.F., Strategical Air Force and Coastal Air Force were located in close proximity to the Air Command Post. Headquarters No. 242 Group was at Bizerta and the Troop Carrier Command at Kairouan. An air signals office was set up adjacent to the Air Command Post, comprising a teleprinter room, operations telephone exchange, cypher office and traffic office. The wireless communications established included two high speed automatic channels, one to the Air Ministry and one to Headquarters R.A.F. Middle East, and low power hand speed circuits to Malta, Gibraltar, Advanced Headquarters Mediterranean Allied Air Forces (M.A.A.F.), and T.N.A., with a number of reserve channels. Wireless equipment was provided by Nos. 12 and 13 Heavy Bomber Mobile Units and by a Type 'A' (8-channel) mobile signals unit. These circuits were in addition to the existing duplex circuits between the United Kingdom—Algiers and United Kingdom—Constantine. Communication between the receiving site and the air signals office was by teleprinter. Teleprinter and speech lines to supporting formations were included in the plan. Teleprinter lines connected the air signals office to the Air Command Post W/T station (two lines); to Headquarters No. 242 Group Bizerta; to the cable head Tunis (two channels); Strategical Air Force, Medjezel-Bab (two channels); to Advanced Headquarters N.A.A.F. Constantine (two channels); and to T.N.A. Algiers (two channels). Speech lines connected the Air Command Post to Headquarters No. 242 Group Bizerta, the Tactical Bomber Force in the Souk el Arba area, the Strategical Air Force, Advanced Headquarters N.A.A.F., T.N.A. and Troop Carrier Command Kairouan. Frequencies for the W/T channels were allotted by Headquarters N.A.A.F., and the provision of line circuits was carried out by Air Formation Signals.[1] The landline situation in western Tunisia was better than had been anticipated, and the co-ordination of all R.A.F. landlines was going forward and the construction of routes was proceeding. The entire plan for the fighter defence of Tunisia, for instance, was nearly completed.[2]

Submarine Cables

In February 1943, there were three submarine cables working between Malta and Alexandria and one between Malta and Tripoli. There were two further Malta—Alexandria cables, but these were broken. No cables were working from Malta westward. There had been five cables between Gibraltar and Malta and two between Bone and Malta, but all were cut in the Sicilian Channel. One of the Gibraltar—Malta cables had already been partly diverted to provide the Gibraltar—Algiers cable. The repair of the other cables was considered to be feasible, and also it was considered possible to divert certain enemy cables, depending on the capacity of cable ships, of which there were two at Gibraltar and two at Port Said.

In April 1943, it was decided that three of the Gibraltar—Malta cables should remain, leaving one already diverted to Algiers and another diverted to Bizerta. The Italian Nabuel—Igalo cable was to be diverted into Malta with an overland extension from Nabuel to Tunis: a link was to be provided from the Tunis cable office to La Marsa. This project was planned well in advance, but delay in providing equipment and personnel and in reconstructing the overland portion of the route prevented the circuit being in use by D-Day. It came into operation later. Another Italian cable was later diverted to provide a connection between Syracuse—Malta. Two Malta—Sicily cables were to be reinstated, and two Bone—Malta cables were diverted to join Bizerta to Malta. Suggestions to divert further Gibraltar—Malta cables were resisted in view of the importance of these cables for through traffic to India and the Far East.[3]

By mid-June 1943, Headquarters Force 141, the North African component of the 'Husky' assault force, was about to become operational, and signals communications in North Africa in support of the air forces gradually became more and more extended. As force 141 moved into Tunisia it moved away from the Allied Force Headquarters at Algiers. The requirements of Force 343, the American Component, also had to be met. In spite of the

[1] A.M. File CS. 18000 and A.H.B./IIM/A45/156.
[2] A.H.B./IIJ1/238/4/41.
[3] A.H.B./IIJ5/8.

efforts made it was impossible to provide all the circuits required by these forces, or for the various other formations concerned, which included the British and U.S. navies and six operational air headquarters. For Headquarters Force 141 and the R.A.F. alone it was necessary to bury 84 pairs of wire out of Tunis in addition to overhead provision.

The landline plan in North Africa provided for the linking of major formations in north-west Africa with their Advanced Headquarters and with the Air Command Post. The plan was drawn up at the beginning of June, but it was found impossible to realise it except to a very small degree. Even the lines that it was possible to provide were most unreliable. Destruction on all routes in eastern Tunisia had been severe, and the work of restoration and reconstruction proved a formidable task.[1]

As Force 141 would be almost completely dependent on wireless in the early stages, with the inevitable use of cypher, serious operational delays caused by the blocking of circuits could only be avoided by rigid adherence to orders. On 19 June Headquarters M.A.C. reported that the vast number of signals which were being despatched had completely overloaded the headquarters facilities and precipitated a situation which was causing serious delays in signals traffic. A careful analysis of W/T traffic showed that the degrees of priority were badly degraded, 75 per cent of all traffic carrying some degree of priority, and 'Emergency' being the only degree of precedence which was at all effective. 'Immediate' messages could be regarded as 'Routine', while all others had the equivalent of 'Deferred'. On 8 July, thirty-six hours before the operation, the A.O.C. directed that full signals traffic control was to be enforced and the number of signals and the use of priorities reduced to that essential for current operations.[2]

The key wireless stations in the Mediterranean were T.N.A. at Algiers, the Air Command Post W/T Station at La Marsa, Malta W/T station, and T.M.E. It was calculated that any one of these stations might be called upon to bear the heaviest load of traffic at different periods of the operation and, therefore, each would require to have ample reserve channels. No major additions were required at T.N.A. or T.M.E., as both these centres already operated channels to main formations, but at Malta equipment and personnel were provided for 12 channels additional to the normal complement of 25. At La Marsa, the two heavy mobiles and the Type 'A' M.S.U. giving eight low-power channels proved inadequate, and the station was augmented by two American mobile transmitters and additional operators and cypher staff.

In designing the linking of formations in the main strategic communications plan the governing factor was the chain of command, but of high importance were the lateral links, and these were determined by careful examination of the inter-dependence of formations at various phases of the

[1] A.H.B./IIJ5/8.
[2] A.H.B./IIJ5/86/88.

operation. The fundamental layout of the W/T network was not influenced by the landline plan, though it was taken into consideration in deciding the number of channels to be provided on any given section of the network. The principle of considering lines and W/T channels as supplementary to each other and not as alternatives proved its worth during the operation. The plan involved a total of 65 wireless channels embracing 20 formations; one-to-one links were provided in all cases except when it was an operational need to have more than two elements on one channel.

Traffic Handling

Some indication of the intensity of signalling as the operation progressed is indicated by the figures of traffic handling at the Air Command Post. On D minus 1 (9 July) the total traffic was 65,000 groups, of which 21,000 were cypher and 16,000 teleprinter. There was an increase on D-Day, but not a violent one as 'Minimize', a general request to all stations to reduce traffic to the absolute minimum necessary for operations, had been put into force from the Command Post on the previous day. From D-Day, traffic rose steadily to a peak figure of 120,000 groups on D plus 20. Teleprinter traffic did not reach 30,000 groups until D plus 8 and averaged this figure until D plus 20 when it reached 50,000 groups, due to the highly unsatisfactory line situation. Air Ministry traffic averaged 30,000 groups daily, but Middle East traffic was lighter at less than 14,000 groups daily up to D plus 4. Between the Air Command Post and Malta, traffic rose to 9,000 groups per day on D minus 3 and to 12,000 a day on D plus 3; thereafter it dropped to an average of 4,000. Two point-to-point channels and one flash channel were operated between the Air Command Post and Malta; the flash circuit was reserved for Air C.-in-C. and his Deputy and the A.O.C. Malta, and provided the most rapid communication possible in cypher. Traffic on this channel did not exceed 300 groups per day and messages of 30 to 50 groups each were passed from originator to addressee in less than 30 minutes.

Generally speaking, the main strategic channels worked successfully and according to plan, the introduction of 'Minimize' preventing congestion in the early stages of the operation. The delays which occurred were mostly due to the inadequacies of equipment and staff in signals traffic offices; at the Air Command Post, in spite of the most careful attention to layout, the traffic office was the limiting factor in message handling. Of particular value during the operation were the intercept channels provided for listening to the main tactical wireless channels, as an additional means of providing the Air Commander with information on local situations and as a means of anticipating the needs for signals reinforcements.[1]

Control of Aircraft in 'Husky'

At the outset the Spitfire squadrons of the Desert Air Force were located in Malta, and came under the command of A.O.C. Malta. The remaining

[1] A.H.B./IIJ5/8.

squadrons were held in Tripoli until such time as they could be brought forward. The Spitfire Wing of XII A.S.C. was located on Gozo under the command of A.O.C. Malta, one group of P.40's was located on Pantelleria, and the remaining groups on the Cape Bon peninsula under the command of C.G., XII A.S.C. The whole of the Tactical Bomber Force was located in Tunisia.

In view of the difficulty of providing telephone lines from La Marsa, through Tunis, to Rear Headquarters XII A.S.C. at Korba and Headquarters T.B.F. at Nabeul, it was decided to set up the Headquarters T.A.F. operations room at Hammamet, and the main W/T Station was also located there. All signals to and from the Command Post at La Marsa had therefore to be passed to and from Hammamet on two teleprinter plus speech lines provided between the two elements of the headquarters. This imposed a delay on all signals, and gave rise to difficulties in distribution.[1]

Communications for the control of bombers, troop carriers, and coastal aircraft, were mostly on standard lines; but the arrangements for the control of fighters during the assault and in the days immediately following were more experimental. Communications in the first stage of the assault were provided by British headquarters ships, which were responsible for the forward direction of fighters. The standard R.A.F. communications of these ships were :—[2]

4 T.1131/R.1132 1 TR.1143	}	for V.H.F. R/T communication with fighters, for listening to tactical reconnaissance reports, and for V.H.F. R/T communication between controllers at headquarters ships and the Controller Malta.
1 T.1190/R.1084	—	for H.F. R/T communications between controllers headquarters ships and the Controller at Malta.
1 T.1179/R.1084	—	for R/T communication with fighters fitted with H.F. only (this channel was not in fact used).
1 T.1190/R.1084	—	for W/T point-to-point working to Malta, for fighter patrol programmes, aircraft movements, Sitreps etc.

Other facilities provided were two common-user W/T base waves to Malta, receivers for listening to the Malta and ships' radar broadcasts and the assault air warning broadcast, and in one case a listening watch for meteorological broadcasts.

[1] A.H.B./IIJ1/311/1/7.
[2] A.H.B./IIM/A37/1A.

Communications ashore in the early stages were provided by the Field Force Headquarters Signals Sections and Advanced Landing Ground Signals Sections. The United Kingdom conception of a Field Force Headquarters Signals Section, as used in 'Torch', was an assault section of some 25 men with one T.1190/R.1084 and a number of pack-sets. The Middle East version, which was used in Operation 'Husky', was on a heavier scale, with 43 men, 7 specialist vehicles and 2 pack-sets for use in emergency. The function of these units was to act as a signals centre for their area pending the arrival of wing signals sections, which was scheduled to take place on D plus 3. They had channels to Malta, their associated A.L.G.S.S. and adjacent F.F.H.Q.S.S., and were planned to have lines to the local R.A.F. embarkation units, and to beach signals stations.[1]

The landing of these units was carried out satisfactorily but it soon became apparent that sites should have been pre-selected, as all good W/T sites in the vicinity of the beach were found to have been booked already by the Army. The technical equipment proved ideal, the Collins 18Q enabling quick communication to be established while higher power T.1190's were being set up. The two H.F. W/T pack-sets were insufficient and it was agreed that four were required, together with a second 3-ton vehicle for personal and domestic kit, food etc. It was also found that each R.A.F. beach brick embarkation unit needed its own signals section, owing to the distance at which it might have to operate from the nearest F.F.H.Q.S.S. These R.A.F. embarkation unit signals sections needed communications to base, to adjacent embarkation units, and to the principal R.A.F. units they were supplying—usually the local wing. They also required to be in direct communication with the main beach signals station.

It thus became clear that the ideal Middle East R.A.F. assault signals section was the embarkation unit or beach brick signals section, a specialist unit trained for combined operations. Behind this unit, who also landed on D-Day, would come the 'A' party of the unit signals section, who, when the area had been cleared, would proceed inland to their airfield or advanced landing ground and establish communications on the airfield, local flying control, R/T to aircraft, and external channels, to embarkation unit signals, to base, to the local sector and laterals to other wings.

In the Sicilian operation, A.L.G. Signals Sections were used to provide the communications required by forward fighter controls as well as local communications at an airfield. The United Kingdom establishment of six pack-sets, a V.H.F. homer, and 25 men was increased in the Middle East to five specialist vehicles including a V.H.F. homer, five pack-sets, and 44 men. The V.H.F. equipment used was the aircraft set, which proved unable to stand up to the continuous working, and replacement by ground equipment was desirable for the future.[2]

[1] A.H.B./IIM/A37/1A.
[2] A.H.B./IIM/A37/1A.

At approximately D plus 3, group and wing signals sections were landed in Sicily to take over responsibility for W/T communications from the A.L.G. and F.F.H.Q.S.S.s. W/T communications were not good in the early days in Sicily, partly due to the terrain, partly due to frequency difficulties, and partly to lack of a Mobile Signals Servicing Unit (M.S.S.U.), which was not scheduled to land until D plus 14. Landlines were provided by Air Formation Signals, except that R.A.F. signals units carried varying quantities of telephone cable. The Air Formation Signals units met with a number of difficulties, and although lessons were learned which it was thought would improve line communications in subsequent operations of a similar nature, it was obviously unwise to rely on line communications in the early stages of a combined operation.[1]

It had been originally intended to use the new combined W/T procedure on all channels, but it proved impossible to distribute the books and train all the personnel in time, and the procedure was only used within the U.S.A.A.F. and for inter-Service communication. Normal R.A.F. W/T procedure was used within the R.A.F. The new combined R/T procedure was used by all Services. The frequency planning of all three Services was delayed owing to difficulties in making up the composition of the frequency board. In order that the majority of the commitments of the Allied Air Force could be met, the existing frequencies were re-distributed, although it was still necessary for some units to share frequencies. A number of primary frequencies proved unsatisfactory, but little could be done to improve matters as there were no spare frequencies available. Fortunately the main strategic plan turned out to be an accurate prediction of the requirement and few changes were necessary. The necessity for the appointment of an R.A.F. officer with experience of frequency work to the Combined Signals Board during the planning stages of an operation was apparent.

It was originally intendel to move Advanced Headquarters, T.A.F. into Sicily to commence operations on 27 July. Rear Headquarters W.T. Station at Hammamet was closed and divided into two parties. Party 'A', consisting of 8 channels, was due to arrive in Sicily in time to open watch on 27 July, and Party 'B', consisting of 12 channels, was due to arrive four days later. Due, however, to difficulties in shipping, it soon became evident that it would not be possible to fulfil this programme. At mid-day on 25 July, the Air Staff being anxious to proceed to Sicily at the earliest possible moment, instructions were given for an attempt to be made to fly into the island a skeleton W.T. Station.

Owing to the fact that all the Headquarters W/T equipment was packed for shipment (Party 'A' was by this time embarked), three G.P. pack-sets were obtained from No. 303 M.S.S.U. In addition one SCR.188, which had been originally issued to a radar station, but which had been exchanged by T.A.F. for a G.P. pack-set, was obtained. A party of 30 officers and men

[1] A.H.B./IIM/A37/1A.

from Party 'B', equipped with tentage, rations for ten days, full kit and arms, was assembled at Hammamet landing ground at 0800 hours 26 July, and was emplaned in four DC-3 aircraft of No. 216 Group together with the W/T equipment mentioned above. This party was flown to Cassibile, arriving at about 1200 hours. Transport was borrowed from the A.D.R.U., and by 1800 hours the personnel and equipment were on site. Work was immediately started and by midnight good contact had been established with La Marsa on the SCR.188. During the next few hours contact with Malta, Desert Air Force (D.A.F.) and XII A.S.C. was made.

It was not possible, however, to advise the air staff to proceed to Sicily owing to the fact that while good communications were established with La Marsa on the SCR.188, and with Malta on a G.P. pack-set, it was not possible to maintain any degree of reliability on the two G.P. pack-sets working to D.A.F. and XII A.S.C. (Both these places, however, could be worked on the SCR.188.)

This move was an excellent example of the possibilities of flying forward a small W.T. Station, capable of maintaining itself for ten days, at very short notice.[1] It was also an example of how effort and initiative could be entirely wasted owing to failure to provide suitable equipment. A replacement for the R.A.F. G.P. pack-set was urgently required, and this fact was proved time and time again throughout the Northwest African campaign.

Party 'A' eventually arrived on 29 July, and opened watch on the evening of 30 July. Party 'B' arrived on 5 August, and by the evening of the 6th the Advanced Headquarters W.T. Station was complete.

Landlines in Sicily were placed under the control of No. 242 Group A.F.S., under C.S.O., N.A.C.A.F.[2] The state of the lines in Sicily was extremely bad. Advanced T.A.F. was in communication with Advanced D.A.F. at Lentini and with T.B.F. at Comiso. Advanced D.A.F. and T.B.F. were also linked by landline. It had not been possible, however, to establish any contact with XII A.S.C. on the north coast of Sicily.

The Landings in Italy

Signals planning for various possible seaborne assaults on Italy began at Algiers at the end of June 1943, and in the next two months plans were drawn up for no less than five major amphibious operations. These included such projects as the invasion of Sardinia, a direct assault into the town of Naples (assuming the sudden collapse of Italy), and invasions of the toe and heel of Italy. The planning for 'Avalanche', a seaborne assault at Salerno, was begun on 4 August. At this time it had not been decided whether 'Avalanche' or 'Buttress' (a seaborne assault on the toe of Italy) would be mounted, and consequently, planning for both operations was carried

[1] A.H.B./IIJ1/311/1/7.
[2] A.H.B./IIJ1/238/4/41.

out simultaneously and arrangements were made to load the convoys to sail from North Africa for either operation. On 17 August, planning for Operation 'Buttress' was dropped and all signals planning concentrated on mounting 'Avalanche' by 9 September. After a conference at Algiers on 22/23 August, attended by representatives of all branches of XII Air Support Command and N.A.T.A.F., the detailed planning for 'Avalanche' was taken over by XII Air Support Command as previously arranged.

In 'Avalanche', unlike 'Husky', the Allied air forces engaged were all under the operational command of Northwest African Air Forces. Consequently, the higher command network of main W/T and line communications was neither so extensive nor so complex for the second operation. Both XII Air Support Command and the Desert Air Force were simultaneously engaged in the offence in Italy and the weight of communications was from Headquarters N.A.T.A.F. downwards. The higher direction of the air forces was exercised from the Air Command Post at La Marsa, and the fundamental communications requirement, apart from the standing Command channels, was good links by which hour to hour information could be fed to the Command Post from naval and military as well as air force sources.[1]

The importance of sound intelligence links had been apparent in the invasion of Sicily, and during 'Avalanche' the Air Command Post was linked by W/T to XII Air Support Command Advanced Headquarters, which was set up first in the headquarters ship and subsequently ashore. The Air Command Post was also linked by W/T and cable to Headquarters N.A.T.A.F., and by W/T and teleprinter to the Headquarters of both the C.-in-C. Mediterranean and the 15th Army Group at Bizerta. These intelligence links to the Air Command Post proved very satisfactory, and were a vital factor in enabling an early decision to be made to use the strategic air force in direct support of the ground forces when the enemy thrust to the beachhead threatened the success of the operation. This decision was the critical one of the whole operation.

The heaviest volume of traffic was experienced at Headquarters N.A.T.A.F., where the cypher office handled nearly 50,000 groups on D plus 2. 'Minimize' procedure was introduced on D plus 4 as a precautionary measure. There were some delays in traffic from XII A.S.C. to the Air Command Post due to incorrect routeing.

An error which might have had the most serious consequences occurred in the arrangement for passing messages to the headquarters ship after she sailed. The ship maintained W/T silence but kept a listening watch on one of her channels with N.A.T.A.F. N.A.T.A.F. received no reply to their calls and as a result decided not to pass traffic. Fortunately, there were no changes in plan and timing after the headquarters ship sailed.

[1] A.H.B./IIJ5/8.

The headquarters ship, the U.S.S. *Ancon,* sailed from Algiers on 6 September. The convoys for the assault sailed from Oran, Bizerta and Tripoli, joining into one force north of Palermo on D minus 1. The convoy was spotted by the enemy on the morning of D minus 1 and when attacked, wireless silence was broken to allow *Ancon* to take over control of night fighters. The assault took place in Salerno Bay at 0300 hours on 9 September. Wireless silence was broken on all channels and *Ancon* resumed her full function as the main fighter directing ship and advanced headquarters of the XII Air Support Command. All air force W/T channels on board *Ancon* were successfully established by D plus 1, but operating speed was severely restricted by heavy interference between channels, 45 channels being in operation in all. Fortunately, the traffic level was not high, about 9,000 groups per day, and although operating was slow, traffic did not accumulate and there were no serious delays. On D plus 5, three squadrons of Spitfires and a group of P.40's were established on landing strips near the coast, and this was increased in the next two days to two Spitfire wings (each less one squadron), one P.40 group, one A.36 group, and half an R.A.F. Tac/R squadron and half a U.S.A.A.F. observer squadron. Communications at the landing strips were provided by the 'A' parties of R.A.F. wings, and by group signals sections in the case of U.S.A.A.F. units.[1]

The Control of Fighters

The control of fighters was exercised from *Ancon,* where there were two operations rooms, one of which acted as a fighter operations room housing the operations board and a filter board, the other being a mains operations room for the directing staffs. Information for the filter table was obtained from the ship's radar, from other ships fitted with radar and from the seaborne G.C.I.s, the first of these sources being by far the most fruitful. Close liaison was effected between *Ancon* and the other two headquarters ships, using V.H.F. R/T and H.F. R/T. Liaison with Sicily through a mobile operations reporting unit on the island was a failure, the range being excessive for the operation of H.F. R/T.

The major faults in the organisation were the establishment of both operations rooms on the headquarters ship, which resulted in congestion, controllers being besieged for information instead of use being made of the main operations room. The remedy was for the control of fighters to be exercised from a separate ship to that used as a headquarters ship, so that fighter controllers and headquarters staff were separated, and this was done in subsequent amphibious operations. Secondly, the standby fighter director ship, which had all the facilities necessary for the control of fighters, received insufficient radar information, so that it would have been difficult for this ship to have taken control in emergency.

The control of fighters on shore was exercised by the 64th Fighter Wing U.S.A.A.F. This unit landed with all low power signals equipment for the

[1] A.H.B./IIJ5/8.

control of fighters with the exception of a V.H.F. D/F fixer lay-out. Good communications to aircraft were established from the outset, vindicating the policy of establishing a full fighter control organisation at once without first putting in a nucleus organisation employing very low power equipment. New methods which were developed in the unloading of vehicles on the beaches proved that all normal signals vehicles could be landed in good weather over any beach suitable for an assault. The 64th Fighter Wing was connected by landlines to the landing strips, G.C.I.s, and to Headquarters XII A.S.C.; but these lines continually failed and resort had to be made to the standby W/T channels, which had been provided in every case.

The arrangements for passing information of aircraft movements were unsatisfactory. It was proposed during the planning stage that a broadcast for this purpose should be operated by the Strategical Air Force and the Tactical Bomber Force, but neither of these broadcasts was put into operation, and as a result fighter directing ships received no information on the movements of friendly aircraft in their area. The need for some form of broadcast to fighter directing ships and to fighter control when established ashore was apparent. Up to D plus 7, very few movement signals were received by the 64th Fighter Wing, and those that did arrive were mostly too late to be of use. They had been passed over normal channels, addressed to the XII A.S.C., where they were de-cyphered and re-transmitted.

No. 7 Army Air Support Control (A.A.S.C.) accompanied the XII A.S.C., requests for support being received on Army tentacles from X Corps and British Divisions and on air support party links in the case of VI Corps and American Divisions. These requests were then co-ordinated with Headquarters Fifth Army and submitted to XII A.S.C. The speed and accuracy of communications on these links was good; normal channels were used for passing back instructions for air support to air force formations. Signals passed on the normal channels were subject to delay, however, and better results might have been obtained had No. 7 A.A.S.C.'s rear links been employed.

The tactical reconnaissance broadcast from Sicily failed completely in the early stages of the operation; portions of R/T from this broadcast were received by the *Ancon* but they were too mutilated to be of any value, and no W/T broadcast was heard. Tac/R reports had to be passed over the normal channels and they suffered a delay of about four hours. More use might have been made by pilots of V.H.F. R/T during flight, by means of which much valuable information might have been made available in the early stages. As soon as tactical reconnaissance and observer flights began to operate from the mainland, broadcasts were set up at the appropriate landing strips and the system functioned smoothly. Spotting for the artillery was carried out successfully by Spitfires, using V.H.F. R/T.

The landline situation throughout the beachhead was extremely difficult, and there were few lines which did not suffer from almost continuous breakdown, due to the fact that the advance was slower than had been anticipated and that the unloading of units was nevertheless continued, resulting in severe congestion of all forms of transport in a very restricted area. Almost all line failures were caused by motor transport and track vehicles. The situation might have been improved if more care had been taken with the initial laying of lines. In almost every case, lines were run out in a hurry, and subsequently required continual attention and in some cases had to be almost entirely re-laid. Better communication would have been obtained if more care had been taken over road crossings and the carrying of lines over tracks. Fortunately the communications required were covered by the W/T standby network. Once again, it was shown that no reliance could be placed on landlines in the early stages of an amphibious operation and that a comprehensive wireless organisation was essential.[1]

Signals Organisation Aboard the H.Q. Ship

The signals organisation on board *Ancon* was good. Runners were dispensed with almost entirely and their places taken by pneumatic tubes for the distribution of action copies of messages and an extensive teleprinter system for information copies. In various points in the ship, including the main operations room, remotely controlled teleprinters were installed with a device to enable an image of the message being printed to be thrown on to an illuminated screen. This screen could accommodate some 25 lines of about 15 words each, which could easily be read from one side of the operations room to the other. Three such screens were installed in the main operations room, one for the use of each Service. This dispensed with a vast amount of paper work and enabled messages for information to be passed rapidly throughout the ship without the hindrance of a large number of runners.

A combined message centre was in operation on board. This system worked extremely well and the few difficulties caused by the different ways of handling messages were soon resolved. Considerable space was allotted to the main wireless reception room, the distance between the benches on which the sets were mounted being 13 feet. It was found that this use of space was amply justified by the freedom of movement gained.

Once units were established on shore, good communications depended as much on good organisation as on any technical factor. Clear instructions on the moves of units enabled advance parties to site W/T stations and avoid long breaks in communications. No essential signals vehicles were lost in the operation, but there was a noticeable lack of reserve W/T and R/T pack-sets. A number of Army Type 22 sets had been obtained for this purpose by Headquarters M.A.A.F., but due to a planning failure they never reached the units requiring them. Four of the units coming from North Africa (three R.A.F. beach brick signals sections and an A.L.G.

[1] A.H.B./IIJ5/8.

signals section) received no briefing whatsoever. As a result they were inoperative for some days.

It was found that when the signals staff of the Services concerned assembled on board the *Ancon* there were still a number of outstanding points to be settled. Even after the most comprehensive planning, this was always liable to occur and the only remedy seemed to be for staffs to assemble at least two days before sailing to allow time for any last minute difficulties to be settled. This was particularly important when the voyage was short.

Once again the air force frequency allocation was made too late. There was no time to make a thorough check of all frequencies allotted, and it was discovered when the signals staffs assembled on board that there were two clashes in inter-Service frequency allocation. Altogether the *Ancon* had 45 wireless channels in operation, and the resultant interference was appalling. No air force channels were actually rendered inoperative but the operating speed was greatly reduced. Fortunately, traffic was not high and no serious delays resulted. There was severe inflation of priorities on all channels, as in ' Husky ', and the enforcement of the correct use of priorities by the checking of individual cases of misuse was the only solution.

Formation of Mediterranean Allied Air Forces

After the invasion of Sicily, it was at first planned that the Mediterranean Air Command Post at La Marsa should move into Sicily and that Headquarters N.A.A.F. should remain at La Marsa. It was subsequently decided to retain the Air Command Post at La Marsa, and to form a new Headquarters Mediterranean Allied Air Force, to be a joint R.A.F./U.S.A.A.F. policy headquarters, with a full R.A.F. operational and administrative and executive staff. An air commodore was appointed as Chief Signals Officer with a deputy C.S.O. from the U.S.A.A.F., and a group captain telecommunications and a group captain radar, with U.S.A.A.F. counterparts. The establishment of the R.A.F. Signals staff was roughly equivalent to that of Headquarters R.A.F. Middle East in 1942. The majority of the U.S. executive communications staff were on the strength of the Twelfth Air Force.[1] The Air Command Post was amalgamated with Headquarters N.A.A.F. and, from December 1943, was known as Advanced Headquarters M.A.A.F. La Marsa.[2] The former Mediterranean Air Command became Rear Headquarters M.A.A.F. Algiers.

Headquarters M.A.A.F. exercised operational and administrative command through Headquarters Tactical and Coastal Air Forces and R.A.F. Middle East, but only operational command through Strategical Air Force. The administrative command of the R.A.F. part of the Strategical Air Force

[1] A.M. File CS.18000.
[2] A.M. File CS.21409.

was direct to Headquarters No. 205 Group. R.A.F. maintenance was controlled through three maintenance groups located in North Africa, Italy and the Middle East. The Air Force planning, maintenance and supply staffs were located with the Rear Liaison Section of Headquarters M.A.A.F. Algiers alongside Allied Force Headquarters.

A preliminary examination of communications commitments indicated that a signals station for the headquarters at La Marsa would be required to operate 30 command channels and four or five high-speed channels. Small communication centres were needed at Algiers and Tunis.[1] Most of the signals equipment and personnel were found from M.A.C. and N.A.A.F. sources. The Air Command Post was not to be set up in Italy at once but to remain for the present at La Marsa.

The main headquarters and formations to be served in the Algiers area were Allied Force Headquarters, Rear Headquarters M.A.A.F., Headquarters No. 217 (Coastal) Group, and Headquarters No. 218 (Maintenance) Group; and in November 1943 it was decided to centralise the administrative communications in the Algiers area by forming No. 10 Signals Centre, and to determine the basic teleprinter and W/T requirements for units in the Algiers area. The former T.N.A. was therefore expanded to become a teleprinter switching centre and a main W/T station, to which all headquarters and maintenance units in the Algiers area were connected. Standby W/T communications were provided where necessary, and main trunk W/T or teleprinter outlets were provided from No. 10 Signals Centre to the United Kingdom, T.M.E., Malta, Naples, Bari, Tunis, and to British and U.S. Army switchboards. The teleprinter links connected No. 10 Signals Centre to all local headquarters, wings and units, Maison Blanche, Blida and Tunis. Air Formation Signals installed a teleprinter switching centre and made arrangements for the installation of the teleprinter links. Over 40 units in the Algiers area were served by the newly formed No. 10 Signals Centre. At the same time, since it was the ultimate plan to move the Air Command Post, Advanced Headquarters M.A.A.F. and Headquarters Mediterranean Allied Tactical Air Forces (M.A.T.A.F.) into Italy, and since R.A.F. communications in the Tunis area were centralised to Advanced Headquarters M.A.A.F., it was decided to form No. 9 Signals-Centre at Tunis to provide administrative communications for the units in the Tunis area. Teleprinter links were installed to units in the area and to No. 10 Signals Centre Algiers.[2] W/T communications were set up to the Air Command Post when it moved to Caserta, to No. 8 Signals Centre Tripoli, and to Algiers.

The establishment of the signals section of Headquarters M.A.A.F. Algiers was designed to deal with average daily cypher traffic of some 27,000 groups, and up to the middle of January 1944, the average traffic handled was about 23,000 groups a day and thus well within its capacity.

[1] A.M. File CS.18000.
[2] A.H.B./IIJ1/145/106(B).

Short periods of peak traffic up to 29,000 groups occurred, but they were infrequent and of short duration and no accumulation of delayed traffic resulted. About the middle of January, however, traffic began to rise, averaging 28,000 groups with peak days of up to 33,000. This imposed considerable strain on the signals section, who nevertheless managed to keep traffic under control. There was a further slight increase in February. As Headquarters M.A.A.F. was split into three parts, the cypher personnel situation was already strained, and there was no means of obtaining additional cypher personnel. Thus a situation was reached at which the saturation of cypher staffs was threatened.

The situation was especially difficult before the move of Advanced Headquarters M.A.A.F. to Caserta, during the period when the headquarters was virtually split into three. Until this move took place, strenuous efforts had to be made to curtail signalling, to ensure that all possible traffic was passed by letter, postagram or microgram, and that full use was made of a special daily air courier service which linked Headquarters M.A.A.F. Algiers to La Marsa and Caserta.[1]

Plans for an assault at Anzio were laid early in January 1944, and a command post was set up at Caserta from which the Air Commander-in-Chief directed the operation. A communication centre, maintaining a high-speed and a hand-speed W/T link with Advanced Headquarters M.A.A.F. La Marsa, and teleprinter links with Twelfth Air Force and 15th Army Group, was already in existence at Caserta, together with receivers, transmitters and personnel capable of opening up a further 12 hand-speed W/T channels. A flash W/T channel, direct W/T links, and direct teleprinter and telephone circuits, were provided from Caserta to units and formations engaged in the operation.

As Corsica increased in operational importance units were transferred to the island from Italy and from North Africa, and it was decided at the end of January to provide a signals centre in Corsica for the handling of communications during and after the build up. No. 14 Signals Centre was therefore set up in Bastia on a semi-static basis. The centre accepted traffic for units on their initial arrival, or as a permanent traffic handling agency, and was sited to provide an alternative outlet for operational channels. It provided local very low power channels to units that could not be served with landlines and relayed their traffic to distant headquarters. The facilities provided at Bastia included low power channels to Air Command Post Caserta, Advanced Headquarters M.A.A.F., and No. 10 Signals Centre, with spare low power and very low power channels, and teleprinter channels to local units where practicable.

Move from La Marsa to Caserta

In February it was decided to move M.A.A.F. Headquarters direct from La Marsa to Caserta. Thus Caserta ceased to be available as a relay station

[1] A.H.B./IIM/A36/2BB.

and became the home of Unit Signals, M.A.A.F. Headquarters. There thus arose the need for a signals centre at Naples to provide administrative communications for the R.A.F. units in the area. No. 12 Signals Centre was therefore established there, to provide teleprinter communication to Headquarters M.A.A.F. Caserta, No. 11 Signals Centre Bari, and maintenance units and staging posts in the Naples area. W/T communication was established with No. 10 Signals Centre Algiers and No. 14 Signals Centre Corsica, with a W/T standby-to-line channel to No. 11 Signals Centre Bari, which was the first of the signals centres to be established in Italy. It had been decided to set up this centre in November 1943, in anticipation of the move into south-east Italy of a number of maintenance units comprising No. 214 Group. This group was made responsible for the maintenance and supply of R.A.F. units in Italy. A large quantity of administrative traffic for units in south-east Italy was already being routed via Headquarters M.A.T.A.F. at Bari, and the Bari signals centre was set up to handle this traffic. Hand-speed W/T communications were opened up with No. 10 Signals Centre Algiers, T.M.E., No. 8 Signals Centre Tripoli, Headquarters M.A.T.A.F. when it moved to Caserta, and Advanced Headquarters M.A.A.F. when it was established at Caserta. Teleprinter channels were established to Caserta, the Headquarters of Nos. 205, 214 and 242 Groups, and other major units in the Bari area.[1]

Headquarters M.A.A.F. La Marsa joined up with Headquarters M.A.A.F. Caserta over a period of four days commencing 24 March 1944. All W/T channels operating from Headquarters M.A.A.F. La Marsa were closed or re-routed to Headquarters M.A.A.F. Caserta or No. 9 Signals Centre; teleprinter circuits were closed or re-routed to No. 9 Signals Centre. The equipment and personnel released from La Marsa were employed to augment the facilities at Caserta and to strengthen No. 9 Signals Centre to enable it to handle the additional communications during the transit period and later. A high-speed automatic channel was opened between Caserta and No. 10 Signals Centre Algiers. In April a W/T 'flash' channel between the Deputy Air Commander-in-Chief at Algiers and Caserta was set up using a simplex hand-speed channel. All signals traffic at each terminal was handled under special supervision, and clerks and runners were provided for typing and delivery of messages direct.

Owing to the large area under the control of M.A.A.F., the responsibility for the operation and administration of signals centres was delegated to lower formations on a geographical basis. Headquarters No. 214 Group were responsible for signals centres in Italy and Headquarters No. 218 Group for those in North Africa and Corsica. Signals centres were set up on the authority of the Air Signals Officer-in-Chief (A.S.O.-in-C.) Headquarters M.A.A.F., after consultation with the telecommunications section and the Chief Air Formation Signals Officer (C.A.F.S.O.). The opening of additional channels and circuits was decided and authorised only by Head-

[1] A.H.B./IIJ1/145/106(B).

quarters M.A.A.F. Telecommunications Section, Headquarters M.A.A.F. was responsible for deciding the W/T equipment, call-signs, frequencies and routeing instructions necessary. Air Formation Signals M.A.A.F. provided the telephone and teleprinter switchboards and circuits, and was responsible for staffing all switchboards, teleprinters, D.R.L.S. etc. The R.A.F. provided personnel for manning traffic offices, W/T channels, maintenance etc., and certain D.R.L.S.

By June a number of non-operational units not normally provided with their own signals facilities began to move into the Rome area. A W/T detachment established a W/T channel to No. 12 Signals Centre Naples, and a site was selected for use as a static signals centre, accessible for landline communications and capable of good wireless communications. Until landlines were available W/T communication was provided to Headquarters M.A.T.A.F., Headquarters D.A.F., and No. 11 Signals Centre, in addition to No. 12. The unit operated first as a mobile signals centre and later became static as No. 13 Signals Centre, with teleprinter facilities to local R.A.F. units.

Landlines in Italy

The system of obtaining air force lines in Italy was for application to be made to the C.S.O., 15th Army Group via C.A.F.S.O. at Bari or C.S.O. L. of C., in respect of all trunk line requirements. The control of all lines used by all branches of the Services in Italy was exercised through these headquarters, who allotted certain lines to each lower formation as far as possible, in accordance with their individual needs, having due regard to the overall requirements along any particular route.[1] The authorities entitled to demand circuits were C.S.O. A.F.S., M.A.T.A.F. on behalf of all M.A.T.A.F. units, O.C. No. 2 A.F.S. for the Mediterranean Allied Coastal Air Forces (M.A.C.A.F.), and Os.C. Nos. 6 and 7 A.F.S. for R.A.F. units other than those in M.A.T.A.F. or M.A.C.A.F. M.A.C.A.F. controlled radar units, filter and operations rooms, and information centres, for the air defence of southern Italy, except in the forward area, where control was exercised by M.A.T.A.F. The division of responsibility for the provision of communications facilities was closely defined on 27 December 1943. M.A.T.A.F. was responsible for the provision of landlines and standby W/T to enable information on the movements of enemy and unidentified aircraft to be passed without delay to the nearest R.A.F. sector or U.S. fighter wing under the control of M.A.C.A.F. M.A.C.A.F. was responsible for the provision, installation and operation of communications equipment in R.A.F. sector and U.S. fighter wings adjacent to the area under the control of M.A.T.A.F., to enable these sectors or wings to exchange information on plots and aircraft movements with M.A.T.A.F.'s air warning centres. The A.O.C. M.A.T.A.F. was responsible for the expansion of landlines by reason

[1] A.H.B./IIJ1/238/4/44.

of the forward movement of M.A.T.A.F. units, keeping M.A.C.A.F. informed accordingly.[1]

It was necessary for one officer at Headquarters M.A.C.A.F., or his deputy in the field, to be responsible for the co-ordination and planning of M.A.C.A.F. landline requirements and for approaching C.A.F.S.O. or the appropriate C.S.O. On 25 January 1944, an instruction was issued to clarify these responsibilities. C.S.O. A.F.S. M.A.C.A.F. was made responsible for the drawing up and co-ordination of all Coastal Air Force landline requirements in Italy. Having drawn up the plan, made application for the lines, and seen that the air force requirements were met as fully as the overall landline position allowed, he delegated to C.S.O. XII Fighter Command responsibility for the implementation of the American portion of the plan. In order to relieve C.S.O. A.F.S. M.A.C.A.F. of having to centralise the entire control of Italy from Headquarters M.A.C.A.F., the O.C. No. 2 A.F.S. on the spot normally acted as his deputy and was responsible for implementing line plans and for all negotiations with C.A.F.S.O. and the C.S.O.s.[2]

Headquarters M.A.T.A.F., together with Headquarters 15th Army Group, moved from Bari to Caserta in mid-January 1944. The W/T of both headquarters remained for the time being at Bari, W/T traffic being passed to and fro by teleprinter. A six-channel voice frequency telegraph system was established between Bari and Caserta,[3] of which three channels were allotted to M.A.T.A.F.

Operational formations continued to provide their own communications, but the signals centres provided a complete organisation to handle all maintenance group and unit traffic, air movements administrative traffic, and traffic for the numerous smaller units that formed part of the active theatre. This traffic reached a formidable volume, but through the signals centre organisation it by-passed the traffic offices of the major headquarters, leaving them free for their own higher level administrative and operational traffic. Every effort was made to tie the units and centres together by teleprinter, to reduce W/T traffic and cypher work.[4] Signals centres were not regarded as static, either in location or content; they expanded or contracted according to the number of units in their district, and, as in the case of the North African signals centres, were closed permanently when the units they served moved on to more forward areas. Nos. 1 to 8 Signals Centres had all been closed by the end of 1943. The equipment installed at the signals centres at Tunis, Algiers, and in Italy included SWB8's on automatic circuits, with T.1190's and R.1084's on most other circuits.[5]

In June 1944, it was decided to move Headquarters M.A.C.A.F. to Italy, where it functioned as a policy headquarters and maintained a watching

[1] A.H.B./IIJ1/116/84(B).
[2] A.H.B./IIJ1/238/4/44.
[3] A.H.B./IIJ1/145/106(B).
[4] A.M. File CS.17524.
[5] A.M. File CS.18000/II.

brief on day-to-day aircraft operations. To administer units and to control aircraft operations in North Africa, Headquarters No. 210 Group was formed at Algiers. W/T communications were provided in both instances. For Headquarters No. 210 Group, the equipment already on site at the former Headquarters M.A.C.A.F. transmitting and receiving stations was earmarked for use by the new group. All channels were worked by the T.1190/R.1084 except the convoy escort wave, for which an SWB8 was used. Personnel were recruited from within the command. M.A.C.A.F. communications were provided with similar equipment, an SWB8 and seven T.1190/R.1084's being used to meet the commitment of operational administrative channels to superior and equivalent command headquarters and to group headquarters. Personnel were transferred from the existing M.A.C.A.F. headquarters station.[1]

Introduction of Airgram Service

The congestion on signals channels throughout M.A.A.F. increased in 1944 and became an acute problem. Although repeated requests were made to units to reduce the number of signals, these had little effect and the volume of traffic showed no decrease. The result of the congestion was to slow down the time taken in the transmission of messages, to such an extent that by June 1944 the average time taken between Caserta and Algiers for non-priority messages was 21 hours.

In the same month an Air Ministry Order (A.M.O.) was issued drawing attention to the necessity for avoiding the unnecessary use of signals and ordering that all messages be scrutinised before being handed in to signals offices.[2] The A.M.O. gave a list of examples of correspondence which, in the United Kingdom, must not be sent by signals channels. The difficulty in M.A.A.F. was that mails services had been erratic and no quick or reliable alternative to the use of signals facilities had existed. This situation, however, was so improved by the end of June 1944 that transmission times for mails along the principal routes compared well with those of normal signals. The time had arrived when most of the correspondence banned from signals channels at home could be similarly banned in M.A.A.F. and sent by air mail. A new type of message was introduced known as the 'Airgram'. This was similar in all respects to a signal, was handled through signals registries, but was despatched by courier aircraft and treated as urgent air mail. Times of receipt and despatch were recorded on the airgram form so that delays could be checked and investigated. The service was inaugurated on 7 July 1944, and all branches of M.A.A.F. Headquarters, and all formations and units in the command, were urged to make the greatest possible use of the service. Delivery of airgrams was effected by despatch rider or other faster means direct to the addressee signals section where practicable, or otherwise through the nearest air mail centre, a number of which were quickly set up. The air mail centre registered and

[1] A.H.B./IIM/A45/1JE.
[2] A.M.O. A.520 of 8 June 1944.

despatched the airgram by the first available aircraft or the fastest road service where applicable, to the air mail centre serving the addressee.[1]

Operations in the Balkans

A number of communications facilities were arranged in June 1944 in readiness for the possibility of special operations in the Balkans. The occupation of a number of airfield strips up to a possible total of seven was contemplated and messages were required to be passed from any of the strips to any other strip, to Headquarters M.A.A.F., and Headquarters No. 334 Wing. One corporal wireless operator and one A.C. wireless operator mechanic were established for each airfield strip. The equipment to be used consisted of an Army 'B' set for W/T point-to-point and the TR.1143 for V.H.F. R/T flying control, with a 500 W. Onan petrol/electric set for charging purposes. Headquarters M.A.A.F. Signals Centre, No. 11 Signals Centre, Bari, and Headquarters No. 334 Wing were each required to make available a suitable transmitter and receiver to form a network with the airfield strips, Headquarters M.A.A.F. Signals Centre remaining on the net only until a new Headquarters Balkan Air Force (B.A.F.) was in a position to assume operational control. Communications for an Italian Air Force Component of the Balkan Air Force were also arranged.

Meteorological Signals Organisation

In February 1944 it was decided to transfer the central R.A.F. Meteorological Service from its existing location at La Marsa to Bari, where it was in close proximity to the U.S.A.A.F. weather centre. At La Marsa the regular broadcast of meteorological information was carried out by sharing the equipment and frequencies employed by M.A.A.F. for the Command broadcast; but with the transfer of Advanced Headquarters M.A.A.F. to Caserta and the meteorological service to Bari, independent broadcasting facilities for the meteorological service were required. An SWB8 transmitter and T.1190 with automatic keying devices were made available for the sole use of the meteorological service and installed at No. 11 Signals Centre Bari.

The meteorological signals organisation in Italy was that M.A.T.A.F. supplied to Bari and the Air Ministry a consolidated picture of observations recorded throughout the T.A.F. area, including D.A.F., and also supplied its own units with information and forecasts regarding weather conditions in the operational area. These broadcasts were also received by D.A.F., Eighth Army, Twelfth Air Force and Fifth Army. In many cases, American units took these broadcasts in addition to their own. The meteorological section at T.A.F. operated two broadcast frequencies, two continuous reception channels, and a network to four mobile meteorological detachments. The point-to-point network received recordings and observations from the field units and passed to them general information relevant to the areas on

[1] A.M. File CS.21409.

which they were reporting. Much of this traffic was passed by telephone, but W/T facilities were maintained in view of the mobility of the force.

A meteorological unit was also operating at H.Q. D.A.F. This did not broadcast the general picture to its units since it was already covered by T.A.F., but the unit prepared charts and made forecasts specifically for the needs of D.A.F. operations. They were passed by telephone to operations staffs at headquarters and to mobile operations room units. D.A.F. also controlled a point-to-point network with four meteorological observation units, from which it collected information. It then passed a consolidated picture to T.A.F.

The W/T network for the meteorological organisation thus connected T.A.F. to four field units plus the unit at D.A.F., and connected the unit at D.A.F. to four other detachments. A third continuous reception channel was provided in the winter of 1944, so that information from Malta which had previously been passed via Bari could be received direct from Malta.

Signals Equipment

Every effort was made to ensure that the limited amount of W/T communications equipment available was disposed of and employed to the best advantage, and from October 1944 the issue from base maintenance units of R.A.F. signals equipment and specialist vehicles was controlled by the Air Signals Officer-in-Chief.[1] A special procedure was laid down for the obtaining of initial and replacement issues of signals equipment and vehicles in M.A.C.A.F., D.A.F., B.A.F., Nos. 202, 205 and 214 Groups (responsible for all units in Italy), and No. 218 Group (which was responsible for all units in North Africa, Malta, Sardinia, Corsica and Sicily). The supply of signals vehicles was limited, and it was not always possible to provide vehicles to the scale published in establishments. When vehicles could not be provided, every effort was made to provide equivalent equipment in the form of transportable or static stations.

Signals vehicles continued to be used extensively by operational units in Italy. Some of these vehicles came from the United Kingdom but a large number were built in the Middle East especially for the Mediterranean theatre. The types in use included low power and very low power H.F., V.H.F., V.H.F. D/F, telephone, teleprinter and typex vehicles, petrol/electric and diesel/electric generators, and signals offices. Bad roads resulted in considerable damage to equipment, and an M.S.S.U. was provided in Italy and attended to running repairs, No. 4 Base Signals Unit providing the necessary maintenance backing in North Africa.

Operation 'Dragoon'

Towards the end of 1943, it was decided that an operation should be launched from the Mediterranean theatre against southern Europe, intended

[1] A.H.B./IIM/A36/22.

primarily as a diversion for 'Overlord'. This operation was given the code-name 'Anvil', which was later changed to 'Dragoon'. In the preliminary stages of planning there were three alternatives under consideration—an assault in the Toulon area followed by either an overland or amphibious assault in the Sete area, a direct assault in the Sete area, and an unopposed landing (assuming the collapse of the enemy) in the Toulon—Marseilles area.[1]

The signals planning staff consisted of a Group Captain R.A.F. (Signals) and a Colonel U.S. (Signal Corps), with a Squadron Leader (Telecommunications), and a Squadron Leader (Radar), and a Major (Air Formation Signals). The staff moved from La Marsa to Algiers in December 1943, and on 8 July 1944 moved again to Caserta in order to be alongside the Allied Force Headquarters and other major formations. This meant that the Air Force planning staffs were remote from their executive staffs—a disadvantage which was outweighed by the advantage of proximity to the other main headquarters, and which was largely overcome by frequent liaison visits. By the second week in June it was decided that final plans for Anvil would be produced and that the operation would consist of an amphibious assault mounted from North Africa, Corsica, Sicily and Italy against southern France east of Toulon with the object of seizing a suitable port as a base and subsequently advancing towards Lyons and Vichy or westward to the Atlantic coast as determined by developments. The ultimate object was to join up with Allied Forces in northern France. The final outline signals plan was completed on 23 June. Early in July it was decided that the operation was to be mounted in the middle of August. The production of detailed signals instructions and co-ordination with other services on detailed aspects of the operation was now undertaken in conjunction with M.A.T.A.F., M.A.C.A.F. and XII T.A.C.

Preparatory moves in connection with the operation, some of which were complementary to air support operations on the Italian mainland, involved a large scale transfer of air forces to Corsica and Sardinia. These moves entailed the construction of some 15 airfields, and the planning of extensive landline and W/T communications. An existing submarine cable between Corsica and Sardinia provided one speech and telegraph circuit for the air forces on the island, but this was inadequate and an additional four-pair cable was laid between the islands in January 1944.

Outline planning in connection with the landline requirements in Corsica and Sardinia was carried out by M.A.A.F. in conjunction with Allied Force Headquarters, but detailed circuit and construction planning were undertaken by M.A.T.A.F. and M.A.C.A.F. The complete programme to meet the requirements of the air forces, both in their support role for current Italian operations and for their ultimate role in support of Operation 'Dragoon', was completed by 11 April 1944. This included all landline communications

[1] A.H.B./IIJ1/90/34.

for airfield control, fighter control, air defence, and control of offensive operations. Some 2,500 miles of line were laid in Corsica alone.[1]

An estimate of the air forces frequency requirements was made in February 1944. These requirements were in excess of existing allocations and 63 additional frequencies were allocated to enable them to be met. Since air forces operating in support of 'Dragoon' would ultimately be in juxtaposition to those of the Allied Expeditionary Air Force (A.E.A.F.), co-ordination between Headquarters M.A.A.F. and Headquarters A.E.A.F. was necessary, and representatives of A.F.H.Q. and Headquarters M.A.A.F. visited the United Kingdom for conferences with Headquarters A.E.A.F. When it was decided to move A.F.H.Q., C.-in-C. Mediterranean, and Headquarters M.A.C.A.F. to the Naples area before the operation was mounted, readjustments to these frequencies were necessary and were agreed at an inter-Service meeting in Naples on 15 July 1944.

Acting on previous experience gained in amphibious operations in the theatre, it was agreed that separate fighter director ships would be used for the operation. Two such ships were available in the Mediterranean and a third was provided from the United Kingdom.[2]

All questions of landline supply and construction prior to D-Day were cleared through Signals Plans M.A.A.F. From D-Day to D plus 30 the air force responsibility was undertaken by the Communications Officer XII T.A.C., and from D plus 30 onwards by the C.S.O. M.A.T.A.F. Cables out of southern France were known to exist from Toulon to Ajaccio, Cap d'Antibes to St. Florent, and also from Marseilles to Algiers and Oran. The location of breaks in the cables was known but both from security reasons and considerations of the safety of cable ships it was not possible to repair these breaks before the operation. Work on the repair of cables was begun on high priority after D-Day. The St. Florent—Cap d'Antibes cable was restored soon after D plus 6, but the Toulon termination of the Ajaccio—Toulon cable was so damaged that repairs were not attempted. One cable from Marseilles to Algiers was restored soon after Marseilles was captured and, later, the two Marseilles—Oran cables.

There was no substantial change in main strategic communications for this operation. The H.F. links from Headquarters M.A.T.A.F. to the H.Q. ship were tested by listening on a receiver installed in an M.T.B. which ran in under cover of darkness to within half a mile of the coast of southern France carrying an R.A.F. W/T crew. Messages intended for Advanced Headquarters afloat from M.A.T.A.F., No. 87 Fighter Wing and XII T.A.C. (Rear) were transmitted to XII T.A.C. (Rear) with routeing instructions to pass to the other headquarters concerned. This system persisted until XII T.A.C. (Advanced) intimated that it was ready to take messages direct after the lifting of wireless silence. This gave operators two opportunities

[1] A.H.B./IIJ1/90/34.

[2] A list of the communications on board each type of ship is at Appendix No. 16.

to intercept messages and prove reception on more than one channel. The system worked well, and during the time XII T.A.C. was afloat up to the time of the lifting of radio silence, a total of approximately 40 hours, some 10,000 groups were intercepted.[1]

After the lifting of radio silence, channels on board the H.Q. ship opened according to schedule, and were in general highly satisfactory. A certain amount of mutual interference was inevitable with the large number of transmitting and receiving arrays which were crammed together on board, but tests made beforehand helped to reduce this. The total traffic handled by H.Q. Ship on D-Day after breaking W/T silence was over 75,000 groups, and on D plus 1 and D plus 2 the totals were 102,000 and 93.000 respectively.

Headquarters XII T.A.C. (Advanced) was opened ashore on D plus 4. Prior to that time radio sets had been installed ashore, had joined the net being worked by the H.Q. Ship, and were standing by to take over. An innovation was the institution of a radio teletype link between Headquarters M.A.A.F. and Corsica, using three channels in all. Traffic averaged about 20,000 groups a day, very much less than the capacity of the system. The channel between Headquarters M.A.A.F. and Headquarters M.A.T.A.F. worked extremely well and provided excellent traffic handling results, both in speed and volume.

Landline construction personnel and equipment were unloaded according to schedule, and by D plus 4, communications for Headquarters XII T.A.C., fighter sector groups, and airfields had been constructed. The existing open wire system was generally in good condition, but inadequate, and construction work was started promptly, although progress in some areas was slow due to their being heavily mined. Existing pole routes provided the quickest means for establishing open wire lines.

The first move of XII T.A.C. Command Post was the only one in which it was possible to maintain a solid landline network. Subsequent moves were too rapid for landline communications to be built by the personnel available. Trunk routes providing circuits for the air forces as well as the Army were the responsibility of Seventh Army, but Army signals personnel were able to provide only minimum Army requirements and none for the Air Force. Air Force units were called upon to provide more than was anticipated, as the main axis visualised in the landline plan was not followed by the Seventh Army, and consequently airfield sites were well removed from the main Army axis, entailing the construction of long spurs from main trunk routes. Widespread destruction of lines in the Rhone valley made line communications impossible in that area, and entailed the setting up of duplicate Command Posts for Air Force units, with V.H.F. radio teletype links joining the two Command Posts. Thereafter a slowing down of the advance enabled landline communications to be established. The phasing of signals supplies was based on the expected progress of the advance. Actually this was much

[1] A.H.B./IIJ1/90/34.

more rapid than was anticipated, resulting in less destruction to pole lines, and a surplus of some types of material and a shortage of others.

The draft Signals Plan for 'Dragoon' was produced more than three months before the operation was actually launched, and the outstanding lesson learnt from the signals planning aspect was the immense advantage of starting the planning early, even when there was no final firm decision to mount the operation. The benefits derived from a plan prepared, co-ordinated as far as possible with the other Services, and issued, even in draft form, to lower formations in ample time for co-ordination and current consultation to be undertaken at their level, greatly outweighed considerations of time wasted on plans that were not in the end put into practice. Comparatively small planning staffs were involved, and there was enough routine planning work to justify the staffs continuing in being so long as there remained a possibility of the launching of further amphibious operations.[1]

The operation showed that signals personnel embarked in H.Q. and fighter director ships should be established on a generous scale, and that where standby channels were catered for, extra personnel to man these channels must be included in the establishment, even though they might not be called upon to operate. In the initial stages of an assault, both afloat and ashore, communications were of necessity entirely by radio; training in wireless operating was therefore required to be maintained at a high level, even in static periods when good landline communications existed.

Withdrawal of Air Formation Signals from North Africa

It was decided to withdraw Air Formation Signals personnel from North Africa entirely in mid-February 1945. L. of C. (Army Signals) were to undertake most of the maintenance work, but a number of gaps had to be filled by the R.A.F. L. of C. Signals were to undertake teleprinter maintenance at R.A.F. units in the Algiers area and to operate existing scheduled despatch rider services in the same district. Line maintenance was also taken over by the L. of C.

Teleprinters existing at R.A.F. units in North Africa at this time numbered 16, installed at No. 10 Signals Centre Algiers (4), with one each at Headquarters Nos. 210 and 218 Groups, No. 284 Wing, Setif, B.P.O., Bone, Blida, Maison Blanche (2), (one at the maintenance unit and one for the staging post), No. 351 M.U., El Aouina and Biskra. All these teleprinters were in the Algiers district except those at Setif, Bone, El Aouina and Biskra. It was decided to install Fullerphones instead of teleprinters at Bone and Setif; this, with a standby-to-line W/T link which was already established, provided adequate facilities for the existing traffic levels. Teleprinters were already manned by R.A.F. personnel. No switchboards were entirely manned by A.F.S. personnel, but the main exchange at Headquarters

[1] A.H.B./IIJ1/90/34.

M.A.A.F. was partly manned by them, and it was decided to move the exchange board to No. 10 Signals Centre, establishing additional R.A.F. personnel for its operation.

The responsibilities for regional flying control previously assumed by No. 210 Group were transferred to No. 10 Signals Centre in February 1945. The commitment consisted of a W/T channel to Gibraltar, two aircraft safety flash channels, one air/sea rescue channel and one convoy control channel.[1]

A.H.B./IIM/A36/32.

CHAPTER 9

SIGNALS COMMUNICATIONS IN THE FAR EAST

Singapore and Malaya

Communications in the Far East at the outbreak of war were of a rudimentary nature and consisted principally of the inter-command W/T stations situated at Singapore and Ambala and the civil telephone systems provided by the Malayan and Indian Governments. In Singapore, however, proposals for the provision of underground telephone cables for the defence services had been under consideration from 1934.

In April 1937, the Air Ministry decided, in conjunction with the War Office, to install in Singapore a teleprinter voice-frequency system similar to that planned for the United Kingdom. The suggested establishment was two teleprinter units complete at the Headquarters Signals Office in Singapore and one unit at the airfield at Seletar. One teleprinter unit was also to be installed at both Tengah and Sembawang when these airfields were completed. Telephone facilities for these two stations were also to be provided. Provisioning action for the supply of seven teleprinters and associated equipment was taken at the Air Ministry in August 1937.[1]

By the middle of 1940, all three stations on Singapore Island—Seletar, Tengah and Sembawang—were operating aircraft and standby point-to-point services, using T.1087/R.1084's. Seletar was also operating long-range short-wave inter-command circuits using T.26 transmitters. Further stations were under consideration at Kuantan, Alor Star, Kluang and Kallang. At Kuala Lumpur, which was scheduled to be an engine repair depot and equipment holding unit, it was proposed that signals facilities should be provided mainly by civil and Army channels (the Army had a teleprinter circuit to Singapore).[2] Air Headquarters Far East were also investigating the possibility of the provision of an extended teleprinter organisation by Posts and Telegraphs Malaya, although it was expected that R.A.F. teleprinters would have to be used. Only the seven teleprinters provisioned in 1937 were held in the command, and these were all fully employed. A W/T standby system for the teleprinter network was proposed. Other new stations scheduled at this time included Kota Bharu, Mergui and Kuching (Borneo). By February 1941 the R.A.F. stations in operation in Far East Command were Seletar, Tengah, Alor Star, Kota Bharu, China Bay in Ceylon, and Kuching in Borneo. The total equipment in use in the command included eighteen T.1087's and twenty-three R.1084's, plus the long-range equipment at Seletar.

[1] A.M. File S.27495/I and II.

[2] Civil stations were in existence or planned at Alor Star, Kuala Lumpur, Penang, Batu Pahat, Kluang and Kota Bharu in Malaya, plus a number in Burma and Borneo.

Shortage of Equipment and Personnel

There was a serious shortage of wireless equipment and signals personnel, to which the C.-in-C. Far East drew the Chief of the Air Staff's attention in December 1940. For many months there was only one officer on the Air Headquarters signals staff, and throughout the five-year period 1937 - 1942 there were seldom more than two. Apart from radar specialists, only three signals officers arrived in the Command in this period, and two of these were replacements. One officer arrived to supervise the installation of SWB8's, but there were no fitting parties (except those locally formed) and little specialist advice from the Air Ministry.[1]

In March 1941, it was decided that the next draft to the Far East should include 55 wireless operators and four wireless mechanics. The general shortage in the trade of wireless mechanic severely limited the number that could be sent. Further provisioning was requested in April 1941, the following equipment being urgently required: —

45 T.1087/R.1084's in Malaya, plus ancillary W/T equipment;

40 T.1087/R.1084's for Burma;

15 T.1087/R.1084's for Borneo.

Personnel were also required in large numbers for all these commitments.[2] At this time there was good liaison between the British, Dutch and Australian forces, and subsequent to a visit to Singapore by the Director of Signals, R.A.A.F., and a return visit to Melbourne by the C.S.O., Air Headquarters Far East, the R.A.A.F. undertook to provide 12 signals officers, about a hundred airmen signallers, 50 transmitters and 40 receivers, to the R.A.F. in Malaya. By September 1941, six of the signals officers and some of the receivers had arrived.

W/T Communication Requirements

The total number of airfields originally planned for Malaya was 12 permanent, 9 concentration, and 5 satellites. Since it was desirable that squadrons should be as mobile as possible, the intention was to provide fixed ground facilities at all these airfields, so that the mobile ground equipment could be reduced to a minimum. The actual W/T communication requirements were: —[3]

(a) *Air Headquarters Far East.* Fixed services to the United Kingdom; Melbourne and Wellington; group headquarters in Malaya and Burma; Colombo, Mombasa and Durban; Manila; Borneo; Batavia; and India. Aircraft services for inter-command flights, long range operational Indian Ocean flights, long range operational flights over the China Sea, and operational flights in Malaya. A local point-to-point organisation. H.F. and M.F. D/F services.

[1] Narrator's interview with Group Captain T. F. Moloney (Retd.).
[2] A.M. File CS.9685.
[3] A.M. File CS.10556.

(b) *Group Headquarters Malaya.* Fixed services to Air Headquarters Far East and to the group stations. Aircraft services to include a group operational wave, and channels for inter-command and cross-country flights.

(c) *Point-to-point services.* These were required to and from all airfields in Malaya, with suitable W/T facilities for squadrons likely to operate from these areas.

The stations already open in May 1941 were Alor Star, Butterworth, Kota Bharu, Kallang, Tengah, Seletar and Sembawang in Malaya; Mingaladon in Burma; China Bay, Kogalla and Ratmalana in Ceylon; and Kai Tak in Hong Kong. A number of other stations, mostly in Burma, were sufficiently advanced to enable units to operate from them, but the actual opening of these stations depended on the arrival of reinforcements and the operational movements of existing squadrons. Siting of the new stations, specially the D/F stations, was almost a major operation in many cases, involving one or two days' journey by sea, then a march of two miles or more through the jungle or through shoulder-high *lalang,* followed by perhaps another mile through flooded *padi* fields, the whole journey being made at a temperature of just under 100°F. and in high humidity. Sometimes when the site was eventually reached it was found to be unsuitable.[1] The personnel situation at this time was clearly stated by Air Headquarters Far East. Strength was well below existing establishments, being 182 wireless operators against an establishment of 252, 64 wireless electrical mechanics against an establishment of 133, and so on. This did not take into account future requirements. A list of communications channels required for the stations for Far East Command was compiled in June 1941. There were to be some 20 stations in all in North and South Malaya, all requiring teleprinter and W/T point-to-point channels.

By June 1941, the total number of squadrons in the Far East was three bomber, one general purpose, one fighter bomber, two torpedo bomber, three G.R. land-plane and one G.R. flying boat squadron. Four fighter squadrons were also forming, all of which were to be equipped with Buffalo aircraft. The locations of these squadrons were Alor Star (Blenheims), Mingaladon (Blenheims), Seletar (Vildebeest torpedo bombers), Singapore (flying boats); Kota Bharu (Hudsons), Tengah (Blenheims), China Bay (Vildebeest, one flight only), Kluang and Sungei Patani (Buffalos), Kallang (Blenheim fighter-bombers) and Sembawang (Hudsons and Wirraways). A considerable expansion of these forces was intended, and new stations were planned for this purpose. The whole air defence of Malaya was in the course of being strengthened by the construction of these new airfields, and it became apparent that R.D.F. cover, for which there was a scheme in hand which included only Singapore and Penang, would have to be greatly extended.

[1] Narrator's interview with Group Captain Moloney.

Communications for R.D.F.

Detailed consideration of R.D.F. facilities for Malaya began in 1941, when an officer was sent out from the United Kingdom to supervise the first installations. Skeleton communications requirements were in operation by August 1941, by which time requirements for R.D.F. cover in the Far East were estimated on the following basis:—[1]

(a) *Malaya*

(i) A main air defence operations room covering the Malay Peninsular, together with a southern area filter room, at Katong. A standby southern area filter room at Kallang. A southern sector fighter control at Tebrau, with a standby at Kallang.

(ii) A group air defence operations room covering North Malaya, together with a northern area filter room, at Kuala Lumpur. A northern sector fighter control at Sungei Patani or Machang, with a standby at Sungei Bakap.

(b) *Burma*

A main air defence operations room embracing a sector control and filter room at Rangoon. Standby sector controls at Mingaladon and Namsang Toungoo.

The main air defence operations room at Katong was scheduled to have two telephone lines and one teleprinter link to the sector operations rooms at Tebrau and Kallang, with three telephone lines and one teleprinter link to the northern air defence operations room at Kuala Lumpur. Numerous local liaison circuits were required in Singapore. The group air defence operations room at Kuala Lumpur was scheduled to have two telephone lines and one teleprinter link to Sungei Patani and Machang, and local telephone links from Sungei Patani to the standby at Sungei Bakap. Local telephone links were required from Kota Bharu to Machang. Numerous local liaison circuits were required in Kuala Lumpur. No R.D.F. facilities were so far envisaged for Ceylon, Hong Kong or Borneo.

The proposed R.D.F. filter room at Katong for Southern Malaya was scheduled to have telephone links to ten A.M.E. stations, each with an alternative route to the operations rooms. The proposed R.D.F. filter room at Kuala Lumpur for Northern Malaya was scheduled to have five telephone links to A.M.E. stations, again with an alternative route to the operations rooms. Duplex working on V.H.F. R/T with scramblers was to duplicate the telephone system throughout, standby W/T being considered impracticable for this purpose. One telephone link with an alternative route as standby was to join the filter rooms at Katong and Kuala Lumpur.

Where several A.M.E. stations existed in the same area, all were to report down the same trunk line, with local filtering; between such A.M.E.

[1] A.M. File CS.9685.

stations there would be one telephone link with an alternative standby route. Later there might also be a standby V.H.F. R/T link. The filter A.M.E. station was to have one parallel teller telephone link, with an alternative standby route to the local standby fighter sector control. Again, there was to be a standby V.H.F. R/T link. The general V.H.F. R/T requirements were in the course of compilation, Australia being regarded as a possible source of supply. The air observer centres at Kuala Lumpur and Singapore were to report direct to their local air defence operations room.

Development of this radar organisation needed to be closely allied to that of the signals and fighter organisations; but it was apparent that there would be considerable delay before the radar organisation could become operationally useful. Communications by landline were difficult to obtain, and when obtained the lines were bad. W/T and R/T links for point-to-point operation were not yet available, and the difficult climatic conditions imposed limitations on the type of set that could be used. Ground-to-air communications did not compare with existing home standards, no V.H.F. R/T being made available. In spite of strong representations by the C.-in-C., the Buffalo fighters were fitted with T.R.11's, which limited the distance over which they could be controlled to about 20 miles.

Filter rooms were to be in the same buildings as operations rooms, but sites for these buildings had not yet been chosen. Filter room personnel were not available, and could not be obtained unless they were specifically posted to the command for radar duties. It was hoped that some personnel might be provided from Australia. The Army agreed to accept responsibility for the installation and maintenance of internal telephone equipment in the filter and fighter operations rooms and observer centres on Singapore Island, and for the provision of equipment for installation by Malayan Posts and Telegraphs for those up country. The main sector and operations rooms were not expected to be ready until 1942.

In November 1941, the Army submitted their landline scheme for Malaya to the War Office. The scheme embraced the minimum R.A.F. requirements for fighter, radar, air observer, bomber, G.R. and trunk systems. However, it was anticipated that there would be a delay of at least 18 months before the necessary equipment could be obtained for the completion of these circuits.

Some progress was made in August and September 1941, but on a very small scale. A temporary filter room was in use at Kallang up to the end of September, and was then moved to the permanent site at Katong. The installation of plotting lines for the first four A.M.E. stations was well advanced, and during fighter exercises information from two of these stations was successfully filtered. However, general lack of progress with the laying of landlines, coupled with the unreliability of those that existed, indicated that telecommunications would be the major limiting factor in the expansion of R.D.F. cover.

The Air Ministry had informed Air Headquarters Far East that no V.H.F. R/T equipment would be available for shipment before June 1942; but in an endeavour to ease the telecommunications problem, an officer commanding one of the A.M.E. stations devised a complete standby reporting system using locally produced V.H.F. equipment, which provided duplex telephony using voice scrambler equipment between the filter rooms at Katong and Kuala Lumpur and their respective stations. These sets were of simple design, and links were installed between transmitting and receiving centres which were established in the Cathay building in Singapore, and all existing A.M.E. stations. The transmitters and receivers were constructed by a group of radio mechanics, using locally obtained components, and quotations for production were sought from local manufacturers. Wherever these links were installed, communications never failed right up to the time of the withdrawal or demolition of the stations concerned.

Provision of W/T Equipment

The provision of equipment to meet the W/T and R/T requirements under the outline signals plan for Malaya was studied at the Air Ministry in November 1941. It was estimated that, excluding Singapore Island, there was a requirement in Malaya for fifty-one T.1087/R.1084 installations and five mobile ground stations using similar equipment. In Burma the requirement was estimated at 23 permanent T.1087/R.1084 installations. Stations where a fighter fixer service was to be operated (such as Tebrau and Sungei Patani, and Mingaladon in Burma) required D.F.G.12 installations for H.F. D/F. In the course of 1941, some sixty-three T.1087's and seventy-eight R.1084's had already been despatched to the Far East, but the point-to-point organisation was still held up through non-delivery. At the suggestion of Air Headquarters Far East, financial sanction was given for the purchase of transmitters and receivers in Australia to speed installation.[1]

Air Headquarters Far East considered that the Air Ministry had underestimated their W/T requirements. The estimate would only be correct if adequate landlines were available, but this was not the case. And even when the new landlines scheme for Malaya was installed, it was considered that adequate W/T channels must be available as a standby and to augment the landline system. It was therefore thought that two W/T channels per station were essential. The Air Ministry had been anxious to keep the provision of mobile installations to a minimum, but Air Headquarters Far East considered that their use was necessary and would in fact save a total of 10 transmitters and receivers.

On 14 November 1941, Air Headquarters Far East submitted a new equipment plan. For Malaya, excluding Singapore Island, the plan suggested that each squadron should have one mobile installation; there were 17 squadrons,

[1] A.M. File CS.9685. *See* R.A.F. Signals History, Volume IV: 'Radar in Raid Reporting'.

and as each mobile unit consisted of two T.1087/R.1084's, a total of 34 sets of each was involved; one of each set was wanted for nine permanent stations; 11 more sets were wanted for coastal reconnaissance, cross country and inter-command flight channels and for three fighter homing stations and the H.F. D/F network; one set of each was wanted for five stations which on concentration were to have one squadron each: seven of each were wanted for the operation of ZZ facilities at selected stations: two mobiles were wanted for Dutch squadrons, and eight mobile units for satellite stations. These satellite stations were also to act as standby stations; but a further five mobile units were added to the plan for wastage, making a total of 96 T.1087/R.1084's wanted for Malaya, exclusive of Singapore.

In Burma, the Far East plan required seven combined sets at the group headquarters, one mobile unit at each of the four squadrons, one combined installation at each of three permanent stations and three concentration stations, three at fighter homing stations, four for the H.F. D/F network, eight for ZZ, four mobiles for satellite stations and cross country flights, and one mobile for wastage—a total of 46 combined installations. Air Headquarters Far East asked for early agreement to these proposals, and also asked whether the equipment would be provided from United Kingdom sources or whether they could approach Australia; they pointed out that lower power sets than the T.1087 would be suitable for some requirements, such as point-to-point and ZZ, and that a suitable type of 100W transmitter was being manufactured in Australia. The installations for ZZ facilities were specially asked for on the basis of the personal experience in Mayala of the C.-in-C. Far East and the A.O.C.; Ford lorries were available in Malaya to house these units.

Because the number of mobile units asked for could not be supplied except over a long period, and because of the severe limitations on shipping space, the Air Ministry were forced to reject this plan. Since Air Headquarters Far East agreed that the Air Ministry plan would be satisfactory if an efficient landline system was available, Air Ministry now proposed to provide two point-to-point channels at all stations, plus the transmitters requested for fixer stations and ZZ. This made a total for Malaya of 80 T.1087's. The adjusted requirement for Burma was 25, for Singapore Island 20, and for Borneo 6, making a grand total of 131 sets. Of these, as already recorded, 63 had already been despatched. Air Headquarters Far East had stated that Australian sets would meet the point-to-point and ZZ requirements, which totalled 56 sets; the purchase of 30 Australian sets had already been authorised, and authority was now given for thirty 100W transmitters and associated receivers to be ordered from Australia, provided 18 months' spares were available. This covered the point-to-point and ZZ requirement and left a few spare sets. A further twelve T.1087 transmitters were needed to make up the grand total of 131 and these were to be supplied from the United Kingdom. The mobile units to be supplied totalled five for Malaya and nine for Burma. The total H.F. D/F requirement for Malaya, Singapore and Burma was 23 sets, of which 8 had already been shipped. The remainder were to be despatched from the United Kingdom in December and January. Other outstanding requirements at this time included four SWB8's and twelve power trailers.

The actual situation in Malaya was that, of the 63 T.1087's and 78 R.1084's already shipped, only 34 transmitters and 46 receivers had been unpacked by mid-November. However, it was impossible to state what equipment had arrived because a vast number of cases were as yet unpacked. Air Headquarters Far East asked for packing case numbers and the names of ships by which the balance of equipment had been despatched.[1] These details were eventually supplied by the Air Ministry, though they took some time to produce, underlining the need for marking cases with recognisable code numbers and sending shipping details on despatch.

When the outline signals plan for the Far East was known, establishment action was requested for personnel to man the communications equipment detailed. The operators for inter-station point-to-point working were established on station establishments. Sufficient wireless operators were established on squadron establishments to operate aircraft channels. Operators for mobile equipment were established on the group headquarters in Malaya to form a Signals Pool. But the general shortage of personnel continued, strengths being generally much below establishments, and the signals staff took what action they could to improve the situation locally, building mobile equipment, enlisting the help of a Posts and Telegraphs engineer, constructing an amplifying system for the unsatisfactory island cable, and obtaining all possible assistance in personnel and equipment from Australia.

Five filter officers arrived in the Far East in September 1941, and undertook some training of existing filter room personnel. But when the Japanese war began, signals officers in India and the Far East had mostly been in the theatre for a considerable time, and they were inevitably out of touch to some extent with the latest developments in the United Kingdom. In addition, there were far too few officers to deal with the many problems that arose under war conditions. The Air Ministry decided in December 1941 to stiffen the two commands by sending out some of the best signals officers in the United Kingdom. The men chosen included one wing commander, one squadron leader and two flight lieutenants from Fighter Command, a squadron leader from Leighton Buzzard, and the Deputy C.S.O. Bomber Command. The posts were established quickly so that the men could be flown out without delay. Such action, however, could only bear fruit over a period; it was unrealistic to suppose that the infusion of new blood at this stage could have any considerable immediate consequence, especially with the continued shortages of equipment.

[1] A.M. File CS.9685.

Communications in Singapore

The services which it was proposed to operate from Singapore itself were:—

(a) a high-speed automatic service to the Air Ministry;

(b) an inter-command channel;

(c) a point-to-point channel to Trincomalee, Mombasa and Durban;

(d) a point-to-point channel to Melbourne and Wellington;

(e) a point-to-point channel to Rangoon, Hong Kong and Borneo;

(f) a general reconnaissance channel covering the China Sea;

(g) a general reconnaissance channel covering the Indian Ocean;

(h) a long distance aircraft wave;

(j) a point-to-point channel to Batavia;

(k) a point-to-point channel to Manila;

(l) a Malayan aircraft wave;

(m) a Malayan point-to-point organisation.

In August 1941, it was the intention to operate these services from the following transmitting stations:—

(a) *Old Seletar.* This transmitting station had been built in 1931, but was unprotected. Attempts were made to provide some sort of protection. The station would work the point-to-point service to Rangoon, Hong Kong and Borneo, and two G.R. aircraft channels, and the long distance aircraft channel. The equipment to be used included three T.26 transmitters, three T.1087's and two T.77's. The receiving and control station was at Seletar.

(b) *Sembawang (Woodlands).* This was a new building nearing completion. The station would work inter-command, point-to-point Batavia and Manila, and Malayan point-to-point channels, using two SWB8 transmitters and two T.1087's (in addition, two SWB8's which were eventually to go into the new Seletar station would first be fitted at Woodlands). There was some doubt about the final arrangements for this station, as the Admiralty wanted to take it over, using existing R.A.F. transmitters. The receiving and control station was at Sembawang.

(c) *New Seletar.* This was a fully protected building for which provisioning action had been taken in 1938, but which could not be ready before September 1941 at the earliest. This station was to work the automatic service to the Air Ministry, the point-to-point service to Trincomalee, Mombasa and Durban, the point-to-point services to Melbourne and Wellington, and the Malayan aircraft wave. The equipment would be four SWB8's and two T.1087's, and a further eight T.1087's and three T.77's were to be housed eventually. The receiving and control station was the new Air Headquarters Far East location at Bukit Timah.

A change to this plan was necessitated, firstly because the Admiralty wanted to share the use of Sembawang and, secondly, because the new station at Seletar was delayed and not likely to be ready until mid-1942. The eventual plan was that some of the services which were to have been operated by Sembawang would be shared out between New Seletar and Tengah, the old Air Headquarters Far East location. Tengah was to operate further additional transmitters temporarily until New Seletar was ready. The W/T equipment actually in use for Singapore at this time was two T.26's and three T.1087's with five R.1084 associated receivers at Old Seletar, and three T.1087's and five R.1084's at Tengah.[1]

The Far Eastern war began on 7 December 1941, and all communications facilities were at once fully loaded. In spite of the many difficulties and the shortages of equipment and personnel, the communications network had been expanded from the original two stations at Seletar and Kai Tak to a total of seventeen stations by the outbreak of the Japanese war, and all the SWB8's were installed and tested.[2]

On 18 December, in view of the rapidly changing situation, the Air Ministry asked for information on future signals requirements in the Far East. Air Headquarters Far East were satisfied that the equipment on order would meet their requirements, provided Australia were able to supply their quota of transmitters and receivers. There was, however, a shortage of ancillary equipment. Experience under war conditions at once underlined the necessity for mobile W/T equipment, none of which had been provided; Air Headquarters Far East promised that, if sets could be provided, they would pass an equivalent amount of static equipment on to Burma. Two units equipped with the T.1087/R.1082 were constructed locally, with generating sets borrowed from the R.D.F. organisation. One of these units was sent to Ipoh and provided the only link with the squadron there, and later during its flights back to Kluang, finally becoming the Air Headquarters set at the second site to which the headquarters moved on 12 February 1942. The other unit was shipped to Bandoeng and was the last set to close down when the C.-in-C.'s staff was evacuated.

In the later stages of the struggle, before the final evacuation, men worked almost continuously in dismantling or re-installing equipment, in addition to their seven-hour watchkeeping schedules. In this way the last SWB8's were dismantled under shell-fire, and packed, transported and loaded on to ships under the same conditions. Many of these men were subsequently taken prisoner.

Every effort was made by the personnel available to fulfil communications requirements in the Far East, but the war was fought almost entirely with the equipment that had been already in the command in December 1941. In an effort to improve the situation, the Air Ministry proposed to

[1] A.M. File CS.10556.
[2] Narrator's interview with Group Captain Moloney.

send ground V.H.F. equipment for two squadrons plus 50 aircraft sets as soon as supplies permitted, and this was ready by February 1942, but by this time it was too late and the equipment was diverted to Burma. Similar diversions to Burma, and later India, were made of large quantities of equipment originally intended for Malaya.

India, Burma and Ceylon

With the collapse of Hong Kong, Malaya, Singapore and Burma, all between December 1941 and May 1942, Air Headquarters Far East ceased to exist and Air Headquarters India took over command. The few signals personnel who escaped from Malaya were withdrawn to India, and units and equipment in transit were diverted wherever possible.

The role of the air forces in India up to 1939, that of tribal operations within India's borders, was not one which demanded a high priority in the supply of modern equipment. The air forces in India thus remained dormant during a period of great technical advance in other theatres. There were only a few squadrons and stations, and no first-line operational aircraft. There was no more than a primitive point-to-point organisation between the small group of stations and no specialist equipment. The bigger airfields were all located in the north-west, and no provision had been made for the building up of signals and landline communications outside that area. As a result those units that moved to Bengal early in 1942 found themselves without the most elementary means of communicating with each other or with higher formations.[1]

Communications Requirements

By April 1942, however, plans were being laid for an all-embracing programme of expansion and modernisation. New aircraft were sent out to India, airfield expansion was given a high priority, and the task of providing signals facilities of all kinds was begun. Three main categories of wireless communications were urgently required; first, the provision of wireless aids to navigation; secondly, the setting up of W/T stations for air-to-ground and point-to-point organisations; and thirdly, R/T communications for the control of fighters. The broad organisation of forces in accordance with current ideas of operational control was effected by the setting up of No. 221 Group to control fighters, and the reconstitution of No. 224 Group, which had come out of Burma, to control bombers and G.R. operations.

Landline facilities in India were rudimentary, and the general shortage of circuits meant that, for the time being, wireless links for point-to-point communications for all services were imperative. Wireless thus became

[1] A.H.B./IIJ50/47/21.

at the outset the primary means of communication, physical circuits being merely a standby to W/T until it was possible to build up an efficient chain of telephone/telegraph carrier systems. The existing civil facilities were, however, hastily conscripted to aid communications and navigation.

Up to March 1942, there was no radar equipment in existence in India. Two A.M.E. stations became operational in Ceylon in that month, and within another three months a total of 36 equipments had arrived in India. Filter rooms were established in April 1942 at Colombo and Trincomalee in Ceylon, and in Calcutta. Further filter rooms were sited and plans were in process of implementation at Bombay, Madras, and Cochin, and several more were envisaged.[1] An observer corps system was in existence in the north-west region, but nothing was yet in existence in the east. However, an Indian Observer Corps (I.O.C.) network was brought into operation at Calcutta and around the industrial areas of Jamshedpur and Asansol, using the railway telephone network for the passing of plots. This network was not really suitable and Air Headquarters India asked on 18 March 1942 for a number of R.A.F. wireless units to be sent out. By the end of the year they were operating on the coast south and south-east of Calcutta, largely replacing the Indian units. By this time over 50 A.M.E. stations had been set up, with filter rooms at Calcutta, Colombo, Trincomalee, Bombay, Madras, Imphal, and Comilla. Thus by the end of 1942 a system of plotting and recording the tracks of enemy aircraft was on the road to full development.[2]

There was no V.H.F. ground or aircraft equipment at the outset, and fighter control was effected at first by making use of three H.F. D/F equipments as fighter fixer stations, the aircraft being fitted with H.F. R/T. By December 1942 Hurricanes operating in the Calcutta area had been provided with V.H.F., and this equipment gradually came into service elsewhere in India and Ceylon, though shortages persisted.

There was a shortage of transportable W/T stations, and on 18 March 1942, Air Headquarters India asked for fifty G.P. pack sets and twenty Marconi pack sets to be sent out on the next convoy.[3] In the following month a request was sent for fifty teleprinters on emergency priority as the only hope of providing satisfactory R.A.F. communications quickly. Telephone speech secrecy equipment was also requested. Air Headquarters India asked for the voice-frequency equipment which had originally been intended for Malaya; this would have to operate on carrier circuits, as no four-wire circuits were available. By September the majority of newly constructed airfields were equipped with pack sets for point-to-point communications, but even by the end of the year there were very few teleprinters and fullerphones in India, and the few that were installed were rendered practically useless by persistent line faults.[4]

[1] *See* R.A.F. Signals History, Volume IV : ' Radar in Raid Reporting '.
[2] A.H.B./IIJ50/47/21.
[3] A.M. File CS.10477.
[4] A.H.B./IIJ50/47/21.

Main point-to-point W/T stations were set up and working at Barrackpore, Calcutta and Asansol by September 1942, and shortly afterwards high-speed automatic circuits were opened between Air Headquarters India and Air Headquarters Bengal, and then between Air Headquarters India and the United Kingdom, Colombo and Bombay. A high speed automatic channel between Delhi and the Air Ministry had been opened in the previous month.[1] Hand-speed W/T circuits were employed to link command and group headquarters, the network being further extended from groups down to stations. The W/T network thus developed on standard lines. Where possible, physical circuits were used as standby teleprinter links.

The development of a comprehensive scheme of landline communications was begun by the Indian Posts and Telegraphs (P. and T.) Departments; in this they were aided by the Army. Over 10,000 miles of line was planned in Bengal alone, and some progress had been made by the end of 1942.[2] Nevertheless, line facilities over the distances involved remained one of the major problems of the theatre. The greatest limiting factors in the development of landline services were shortages of equipment and personnel. Both the Army and the Indian P. and T. Department were reinforced in 1942/43, but landlines remained scarce and unreliable.

To provide the local line communications at R.A.F. units, a number of Air Formation Signals units were formed, partly with Indian Air Force personnel, with a nucleus of personnel of the Royal Corps of Signals. The employment of these units fell under two distinct headings. First, in India, they had the static role of providing communications for the units and formations which were concentrating for the subsequent offensive against the Japanese. Their second role, for which such units were really designed, was to provide landlines for the R.A.F. mobile groups and units engaged in operations in East Bengal and later in Assam and Burma.

The Outline Signals Plan

A comprehensive signals plan for India and Ceylon, as the main supply base from which attacks were to be developed against the Japanese, was ready in September 1942, prepared at the Air Ministry from information supplied by Air Headquarters India. Fortunately the enemy in turn was engaged in consolidating his position in Burma and Malaya, and the build-up of forces and communications in India went forward without interference from enemy action.[3]

The number of squadrons to be provided for in India was based on an estimate for the end of 1942, but the communications facilities allowed for considerable expansion. The main formations planned for the R.A.F. organisation in India were Air Headquarters India and Air Headquarters

[1] A.H.B./IIM/A16/1.
[2] A.H.B./IIJ50/47/21.
[3] A.M. File CS.10477.

Bengal, four operational groups (a fifth operational group was to operate in Ceylon), one maintenance group and one training group. Some 51 squadrons and 100 airfields were involved. The lack of long distance landline facilities and the need for mobility made W/T links essential. The main W/T inter-command and inter-group communications channels planned for India were:—

(a) A.H.Q. India (Delhi) to Air Ministry (high-speed)
Bengal Command (using a mobile high-speed W/T set).
H.Q. No. 225 Group (hand-speed).
Karachi and H.Q. No. 223 Group Peshawar (hand-speed).
Bengal Command (hand-speed).
Command Wireless Station Ambala (hand-speed).

(b) A.H.Q. India (Ambala) to Middle East (high-speed).
Melbourne (high-speed).
Chunking (high-speed).
Bengal Command (hand-speed).
H.Q. No. 222 Group, Ceylon (high-speed).

(c) Bengal Command to H.Q. No. 225 Group, Bangalore (hand-speed).

(d) H.Q. No. 222 Group, Ceylon to H.Q. No. 225 Group, Bangalore (hand-speed).

The high-speed terminal at Bengal Command was to consist of a mobile W/T station and the remainder of the equipment for Bengal Command and for Chunking was put in easily transportable form.

The W/T requirements for Bengal Command (which included two operational groups, Nos. 221 and 224) comprised six main point-to-point channels, plus bomber and G.R. point-to-point channels between Headquarters No. 221 Group and four groups of airfields, fighter operations point-to-point channels between Headquarters No. 224 Group and three groups of fighter airfields, local point-to-point channels between 18 main airfields and their satellites, local point-to-point between Observer Corps centres, and aircraft guard, D.F., and V.H.F. R/T and homing facilities.

In India, point-to-point facilities were required for Nos. 223 and 225 Groups. Point-to-point channels were required between Headquarters No. 223 Group and three groups of airfields, sector point-to-point was required between six sector stations and their satellites, local bomber point-to-point was wanted between the group headquarters and four bomber stations in the Lahore area, also four in the Jacobabad area. Point to-point channels were required between Headquarters No. 225 Group and three groups of airfields. There were to be 11 main airfields, each linked by point-to-point to a number of landing grounds in their area. There was the usual requirement for aircraft guard, D/F and V.H.F.

Landlines

It was decided to construct a defence teleprinter network (D.T.N.) and a mass of new speech circuits involving the construction of some 35,000 miles of twin-wire line and the building of some nine main communications centres with suitable apparatus. The immediate plan was to provide R.D.F. group and sector lines in the Ceylon and Calcutta areas, and R.D.F. and filter room lines etc. in Madras, Bombay and Cochin on a single line basis. Within a year it was hoped to complete R.D.F. station linkage to filter rooms and sectors and other formations on a single line basis, and also linkage of air headquarters to groups and new stations as these were completed, together with the initial phase of the defence teleprinter network. The completion of the R.D.F. system, the full D.T.N. system, a meteorological system by teleprinter broadcast, and a system of alternative routeings, was planned within two years. The number and type of circuits between units and formations was laid down in the plan. Observer centres were to have one speech plotting and one speech liaison circuit to fighter wings and sectors. Radar stations were to have two speech circuits to their filter room. One speech circuit on a multi-phone basis was to link the filter room to wing headquarters and all sectors in the area. Filter room was to be linked to filter room by two speech circuits for inter-telling and movement liaison purposes. Two operational and one administrative speech circuit and two teleprinter circuits would link the fighter groups to their wings. Fighter wings would have two speech and two teleprinter circuits to their sectors. Sectors would be linked to satellites by two speech circuits. Two speech and two teleprinter circuits would link bomber groups to their wings. Bomber wings would be linked to bomber stations by two speech and two teleprinter circuits, one of each to be provided immediately and the second later. Air Headquarters was to be linked to its groups and wings by two operational speech and three teleprinter circuits. Groups and wings were to have rapid switching facilities on speech and teleprinter systems to give communication to maintenance units and supply depots.[1]

To provide good line communications for formations in the Bangalore area, to give alternative communication between Northern and Southern India not passing through Madras (which was vulnerable to air and seaborne attack), and to increase communications facilities to Ceylon, a communications centre was required at Wadi. This centre provided a line switching centre to serve Bangalore, Madras, Poona, Secunderabad, and Begumpet, and through services from the north and Bombay to Ceylon.

[1] A.M. File CS.10477.

The main D.T.N. circuits were to be shared with the Army, in accordance with an agreed scale. These circuits were as follows:—

Delhi to Karachi	12 voice-frequency channels
Delhi to Bombay	18 voice-frequency channels
Delhi to Lahore	18 voice-frequency channels
Delhi to Calcutta	18 voice-frequency channels
Mobile: Two 18 V/F channels at Delhi	
Wadi to Bombay	12 voice-frequency channels
Wadi to Bangalore	12 voice-frequency channels
Wadi to Begumpet	6 voice-frequency channels
Wadi to Madras	6 voice-frequency channels

A list of the main trunk private wires for operational and administrative traffic between the main headquarters and depots in India was included as a part of the plan. These connected Air Headquarters Delhi to Air Headquarters Bengal, to Calcutta, Allahabad, Ambala, Karachi, Bombay and Lahore; Lahore to Peshawar; Bombay to Bangalore; Air Headquarters Bengal to Begumpet, Madras, Cochin and Colombo; Calcutta to Raipur and Nagpur; and Bhopal to Nagpur, Bombay and Allahabad. Teleprinter circuits were to be superimposed on the Calcutta—Raipur, Calcutta—Nagpur, and Bhopal—Nagpur circuits.

Meteorological Communications

W/T and landline communication facilities were required to disseminate meteorological information within the Royal Air Force in India. The organisation consisted of an administrative headquarters at New Delhi with 24-hour forecast centres at Karachi, Delhi, Calcutta, the headquarters of Nos. 221, 222, 223, 225 and 227 Groups, and Air Headquarters Bengal. These centres received meteorological data and transmitted forecasts etc. to the subsidiary forecast centres situated at Headquarters No. 224 Group and a large number of bomber, fighter sector and balloon barrage centres. Some of these subsidiary forecast centres transmitted in their turn to other subsidiary formations. Regional transmissions began on a temporary basis in June 1943, using two T.1190 transmitters installed at Barrackpore.[1] W/T equipment was provided on the basis of two receivers (one spare) and part use of a transmitter at the subsidiary forecast centres. Mobile equipment was provided at Air Headquarters Bengal and Air Headquarters No. 221 Group, and at all subsidiary forecast centres within these two formations and in No. 224 Group, some 30 centres in all. In addition, there were regional synoptic reports, international synoptic messages, route forecasts and actual broadcasts by the civil stations at Calcutta, Delhi, Poona, Karachi, and by stations on the trans-India and South India routes.

[1] A.H.B./IIM/A16/1.

A system for collecting and broadcasting meteorological information in clear by landline was also installed, with a central meteorological station in Delhi. A teleprinter network incorporated in the D.T.N. system was installed giving Delhi a direct line to Calcutta, Lahore, Karachi and Wadi. Nos. 221 and 224 Groups were connected in parallel at Calcutta. Delhi was provided with facilities to work Calcutta, Lahore, Karachi, Wadi and Bombay in omnibus. The network also connected Wadi directly to Begumpet, Bangalore, Madras and Colombo, Wadi being the collecting centre for these stations. This landline system had its own W/T standby point-to-point organisation.

Ceylon

Up to the end of 1939, W/T facilities required by the R.A.F. in Ceylon were provided by the Royal Navy. Early in 1940, however, it was decided to establish an R.A.F. W/T station at Trincomalee to provide facilities for a G.R. squadron to be based there. These facilities were:—

(a) A point-to-point service to Singapore (SWB8/R.1084).

(b) A transmission to enable aircraft to take D/F bearings.

(c) Ground-to-air communications on H.F.

To carry out these services, three transmitters type T.1087 and three receivers R.1084, were provided, together with a G.P. pack-set. This equipment was installed in a temporary W/T building, and arrangements were then put in hand to increase the scope of the station. M.F. and H.F. D/F were planned and by mid-1941 both were completed and in operation. A receiving W/T station was provided in a new operations block, and a new W/T transmitting building was erected. The following services were in operation at the end of 1941:—

(a) Point-to-point services to Mombasa, Singapore, Aden, and islands in the Indian Ocean.

(b) Two operational channels for G.R. aircraft.

(c) Aircraft H.F. and M.F. D/F services.

(d) H.F. and M.F. channels for naval co-operation.

(e) An aircraft long-distance service.

(f) W/T and R/T for Fleet Air Arm aircraft.

The equipment provided to meet these requirements included two SWB8's, four T.1087's, two T.77's, five R.1084's, and a D.F.G. 10 and D.F.G. 12.

Following the collapse in the Far East, an outline signals plan was prepared for Ceylon at the same time as the plan for India. In Ceylon, accommodation and facilities were required for some 16 squadrons with a group headquarters at Colombo. The island was split into three areas: North-East, with a sector operations room and associated filter room at Trincomalee; South-West, with a sector operations room and associated filter room at Colombo; and Central, with a sector operations room and filter room at Dambulla to link with the North-East and South-West. R.D.F. facilities for complete coverage were required, and a 20-post wireless observer system was to be provided to give overland warning to Colombo.

Full V.H.F. and R/T homing and fixer facilities were required for each of the three sectors, and mobile V.H.F. was required in three other areas. W/T or R/T reporting was required from the fixing stations to the appropriate operations room. W/T links were required between the sector operations rooms and Headquarters No. 222 Group, between the sector operations rooms themselves, between the sector operations rooms and the three mobile areas, and between each sector headquarters and the stations in its sector.

W/T point-to-point requirements included Air Headquarters No. 222 Group to Air Headquarters India and Air Headquarters No. 225 Group; to stations in the Indian Ocean; point-to-point from Air Headquarters No. 222 Group to stations in Ceylon not connected to fighter sectors, such as Ratmalana, China Bay, Puttalam and Kogalla; meteorological channels; and point-to-point at Ratmalana to Bangalore, Madras, and Trinchinopoly for aircraft movement. Communications for R.D.F. included landline and W/T channels between some 25 R.D.F. stations and their associated filter rooms. A filter room was constructed at Dambulla to replace Trincomalee, which later became an information centre.

The general landline organisation was based on the establishment of signals centres at Colombo and Dambulla. Speech circuits were required between the two filter rooms; between the filter rooms and their R.D.F. stations; between Headquarters No. 222 Group and Puttalam, Trincomalee (fighter operations), Dambulla (fighter operations), and Kogalla (flying-boat operations); between D/F stations and their fighter sector operations rooms; and between Colombo and Madras filter rooms. Teleprinter circuits were required between Headquarters No. 222 Group and Puttalam, Trincomalee, Dambulla and Kogalla; Dambulla and Trincomalee; Dambulla and Vavuniya airfield and Dambulla and Minneriya airfield.[1]

Civil and Services Aeronautical W/T Organisation

The implementation of these comprehensive signals plans for India and Ceylon was continued for the remainder of 1942 and throughout 1943/44. By the beginning of 1943, radio facilities for operational aircraft had been provided almost entirely from R.A.F. sources, and the civil facilities, considerably augmented by R.A.F. personnel and equipment, had reverted to their original function of providing communications for non-operational aircraft. Allocations of transmitters E.T.4332 and receivers R.1084 for stations on the main routes were made in June 1943. This network, which was known as Civil and Services Aeronautical W/T Organisation

[1] A.M. File CS.10477.

(C.A.S.A.W.) eventually provided both M.F. and H.F. D/F stations, air-to-ground channels, point-to-point communications for the passing of aircraft movement signals, and low power R/T for local airfield control. It was expanded rapidly to cover the whole of India, and was linked with the networks already established in other commands to provide facilities over the reinforcement routes from the United Kingdom to Calcutta and Ceylon.[1]

Equipment Situation

In the early months of 1943, shortages of equipment continued to prevent any large-scale development of the point-to-point organisations, the majority of channels being operated with low power sets of a mobile or semi-mobile type. Mobile equipment was in any case the most suitable for the forward areas. However, there were sufficient deliveries of R.A.F. standard equipment and of American transmitters in early 1943 to enable a start to be made with the installation of fixed W/T stations in the more static areas. In March 1943 there were only ten R.A.F. stations in the theatres which possessed fixed W/T installations, but a further 25 were installed in the ensuing six months, and 21 more by February 1944. Similarly, the number of point-to-point channels, which had reached only 41 by March 1943, rose to 97 in August and 217 in February 1944.

The improvements in the facilities for the operational areas during this period were largely confined to increased mobility. All signals planning for future operations was undertaken with mobility as the keynote.[2] It was decided to produce specialist signals vehicles within the command designed to meet the peculiar needs of the theatre. Between March and August 1943, a number of prototypes were produced for different types of signals and radar vehicles, and a total of over a hundred vehicles were converted and equipped in this period. This figure was doubled by February 1944.

W/T point-to-point systems continued to bear the brunt of signals traffic throughout 1943, and the command W/T organisation improved considerably in the course of the year, though there was still a general shortage of equipment and personnel. Landline communications continued to be poor, channels being extremely limited and often unserviceable. It was a frequent occurrence for all lines between Calcutta and Delhi and between Delhi and the forward areas to be completely out of action for long periods.[3] Eventually all telephone circuits in Bengal were taken over for Service use, civilian traffic being handled when conditions permitted. Meanwhile, full use was made of W/T links, though these channels were necessarily slow owing to the need for encyphering and decyphering messages. The conversion of the whole of the Bengal Command fighter R/T organisation to V.H.F. began in March 1943.

[1] A.H.B./IIJ50/47/21.
[2] A.H.B./IIJ50/47/4.
[3] A.H.B./IIJ50/47/9.

Formation of Signals Wings

Two Signals Wings were formed in No. 221 Group, Nos. 181 and 183, and one in No. 224 Group, No. 182, in August 1943. These wings provided the essential chain of responsibility between the group commanders and the signals units within their group. In No. 221 Group the wings were responsible for all A.M.E. stations and wireless observer units. No. 182 Wing took over the administration and technical control of all early warning equipment and of all permanent W/T and D/F stations in No. 224 Group.[1]

A signals centre was established at Silchar in No. 221 Group, with the help of Air Formation Signals, and a transmitting station and signals block was built at Imphal. The main stations in No. 224 Group were connected by a teleprinter network which included headquarters, advanced headquarters, Ramu, Cox's Bazaar, Dohazari, Chittagong, Fenny and Comilla. Comilla relayed to Agartala. Construction was also completed in 1943 of a standby transmitting and receiving station for the group headquarters, the receiving station also housing a standby switchboard. Two W/T channels were employed between group headquarters and advanced group headquarters in addition to the teleprinter link. The supply of signals equipment improved but there was still a great scarcity of some items. Certain types of W/T valve were practically unobtainable, and all stations in No. 224 Group were out of action at one time or another for this reason. Most of the R.1082 and R.1084 receivers were inefficient owing to the impossibility of obtaining spares. V.H.F. R/T ground equipment remained scarce. Continual rearrangement of the disposition of units made detailed communications planning difficult. There was a continuing shortage of personnel, and at only one W/T station in No. 224 Group was it possible to maintain a four-watch system. The trades particularly under strength were wireless operator and wireless electric or wireless operator mechanic. In the latter case the strength in No. 224 Group in November 1943 was still only 40 per cent of establishment. A number of wireless mechanics arrived from the United Kingdom, but in almost all cases they were posted overseas direct from training school and they needed two or three months training before they became fully efficient. This training was carried out at units. A training school was opened at Ambala at the end of 1943, and signals officers courses in organisation and A.F.S. duties were held in Delhi; but the standard of training could not be raised to a satisfactory level as signals personnel were fully engaged on operational commitments, and the greater part of essential training still had to be carried out by units in the field.[2]

The main limitation to the operation and efficiency of Wireless Observer Units (W.O.U.s) was the shortage of spares for the W/T sets and for petrol/electric generators. The generators suffered particularly from the effects of the high humidity. The personnel manning these units carried

[1] A.H.B./IIJ50/47/9.
[2] A.H.B./IIJ50/47/49.

out their duties and operated mainly at advance posts cut off except by W/T from all contact with the outside world for weeks at a stretch. Some contribution to the alleviation of the personnel shortage was made in July 1943 when the Indianisation of these units was begun.[1] Early in 1945, 120 Collins 18Q pack-sets were issued to the I.O.C. as replacements for the T.1803/R.1082, and the supply of 1260 watt petrol-electric sets was by this time much improved.[2]

Formation of Air Command, South East Asia

The eighteen months following the Japanese conquests of 1941 and early 1942 was a period of consolidation, during which plans and preparations were made for the eventual re-conquest of Burma and Malaya. The end of this period of pure consolidation was in sight when, in August 1943, the Quebec conference decided that a unified command was needed to wage war in the Far East. South-East Asia Command (S.E.A.C.), with headquarters at New Delhi, was formed on 16 November 1943, with Air Command, South-East Asia as the subordinate air command. Under A.C.S.E.A. a new operational command was formed, known as Eastern Air Command. This new command, necessitated by the requirement for operational integration of 10th U.S.A.A.F. and the R.A.F., was set up in December 1943 at Calcutta to control all air operations on the Burma front.[3] Eastern Air Command comprised the 3rd Tactical Air Force (also formed in December 1943 from the two R.A.F. groups and the formations already operating on the Burma front), the Strategic Air Force (which was predominantly American), and units of Troop Carrier Command, U.S.A.A.F. In addition, a new air headquarters was established in Ceylon.

The existing communications difficulties were accentuated by the large increase in traffic resulting from the creation of these new headquarters. When S.E.A.C. and its associated headquarters were first formed they relied for their radio and landline facilities on those already provided for the C.-in-C. Eastern Fleet, G.H.Q. India. and A.H.Q. India, supplemented by local Post and Telegraph Services. These facilities, however, were inadequate, and large expansion programmes were started in India and Ceylon. In 3rd T.A.F., for instance, a vast network of W/T communications was built up and in use by the middle of 1944. In addition to the automatic channel from Comilla to Delhi, there were main channels from Comilla to Imphal (three channels), Chittagong (two channels), the headquarters of Nos. 222 and 225 Groups, Cuttack, Barrackpore (two channels), Calcutta (three channels—one to the main W/T station, one to Headquarters Strategic Air Force, one to Headquarters No. 293 Wing), Kunming, Kanjikoah (U.S.A.A.F.), Chandpur, Agartala and Sylhet. There was a vast network fanning out from Chittagong, to Jalia, Hay, Chittagong airfield, Fenny, Ramu, with each of these stations controlling its own network of

[1] A.H.B./IIJ50/47/9.
[2] A.H.B./IIM/A44/1.
[3] A.H.B./IIJ50/47/33.

two, three or four further stations. Chittagong was also connected by W/T to Bawli Bazaar, 81st Division Advanced Headquarters 5th and 6th Brigades, No. 227 Air/Sea Rescue Unit, and through Bawli Bazaar to Ratnap. In addition to the two main channels to Comilla, Chittagong had direct W/T circuits to Delhi, Calcutta, and Imphal. Imphal was also connected direct to Calcutta, and the network fanned out from Imphal to Jorhat, Broadway, Khumbirgram, Palel, and Silchar.[1]

Meanwhile, the construction of long-distance overhead carrier systems by the reinforced Indian Posts and Telegraphs Department proceeded. Static W/T and teleprinter networks were built up and reorganised by establishing signals centres at Delhi, Bombay, Calcutta, Karachi and Colombo, these centres being made responsible for all administrative traffic under their control. All these centres were functioning by July 1944. Additional high-speed channels were brought into operation between Delhi and Comilla and Delhi and Ceylon, and the delivery of further teleprinters lightened the load on W/T circuits. But shortage of personnel continued to hamper the expansion of signals facilities, and in an effort to relieve the situation an airgram service was instituted, designed to carry traffic not meriting signals handling.[2]

The signals branch of Headquarters South East Asia Command consisted of an integrated staff which included representatives of the Royal Navy, the U.S. Navy, the Royal Corps of Signals, and the Royal Air Force, the various responsibilities being divided under the four senior officers. The co-ordination of all signals and radar matters in this theatre was carried out by a Combined Signals Board under the chairmanship of the Signals Officer-in-Chief. Various committees were formed to deal with matters of detail and to make recommendations to the Board.

Move to Ceylon

In April 1944 the Supreme Allied Commander moved his headquarters to Kandy in Ceylon, and as the Allied Air Commander received his operational policy direction from the Supreme Commander, it was essential for the air staff to be in close touch with the supreme headquarters. The Air C.-in-C. therefore decided to move with his air staff into a new headquarters near the Supreme Allied Commander at Kandy. This placed an additional strain on signals communications, much effort being necessary to construct new facilities right away from the active theatre of operations. All the signals planning and organisation staff moved to Kandy; but the command was still dependent on the resources of India for the major part of its administration and sustenance (except for technical equipment and R.A.F. personnel), so it was equally important for the staffs of the administrative services to be in touch with the Government of India. The outcome was the formation in Delhi in October 1944 of Headquarters Base Air

[1] A.H.B./IIM/A42/2A.
[2] A.H.B./IIJ50/47/49.

Forces, South-East Asia (B.A.F.S.E.A.), which was to control all equipment problems, including Signals. Eventually B.A.F.S.E.A. was to become a separate command, controlling all non-operational units in India, with certain technical and supply responsibilities for the operational units. But for some time B.A.F.S.E.A. acted as a sort of rear headquarters to A.C.S.E.A. —largely due to shortage of staff, which prevented effective segregation. All this posed further signals problems. Cypher traffic, for instance, increased from 11½ to 15½ million groups per month. Traffic between A.C.S.E.A. and B.A.F.S.E.A. was passed on the Delhi—Colombo high-speed channel, Kandy being connected to Colombo by teleprinter. A sub-signals centre was opened in Kandy in November 1944.[1]

Mobile Operations

In the planning of communications for offensive operations, mobility was the keynote. Within the Burma theatre, roads and railways were almost non-existent. Those that did exist ran in a north-south direction along the mountain valleys, whereas a great deal of the movement required —especially during the withdrawal—was in an east-west direction, involving the crossing of high mountain ranges. Dense jungle, bush and swamp made surface movement extremely difficult, and combined with surface erosion during the monsoon periods to render wheeled vehicles almost useless. Under these conditions, the manhandling of equipment and the use of pack animals was the only transport solution; but very little of the early radio equipment was designed in such a way that it could readily be broken down for such treatment and still remain reasonably safe from damage. Equipment often had to be dismantled from the vehicle intended to render it mobile, and the vehicle itself abandoned. Great difficulty was found in moving repairable equipment back from the field to the servicing depots, and in moving replacement equipment forward. These almost insuperable difficulties bred an exceptional power of improvisation in signals personnel, but the need for a well organised system of mobile and transportable signals units remained.

Up to the end of 1943, field units were provided with W/T pack-sets, which were loaded into trucks when they were required to be moved. In 1944, however, a mobile signals unit system was introduced, similar to that introduced at this time in other theatres, under which specialist vehicles designed to meet the peculiar needs of the theatre were produced within the command and allocated, with personnel, in a 'ready to use' state to groups and wings.[2] A number of conferences were held in January 1944 dealing with the building of the specialist vehicles. The result was the production of a vehicle, built from chassis level, to be used as a universal shell body to take all communications equipment. Large consignments of British and American equipment were sent from the United Kingdom and

[1] A.H.B./IIJ50/47/49.
[2] A.H.B./IIJ50/47/49.

then assembled at the base signals units. Much delay was caused, however, by difficulty in identifying packing cases. M.S.U.s were fully mobile in all respects; they were robust and able to stand up to bad road conditions and heavy handling. The first V.H.F. animal pack-sets were produced early in 1944 by No. 2 Base Signals Unit (B.S.U.).

Static establishments in operational units in 3rd T.A.F. were converted to mobile units, with the result that group and wing headquarters were self-contained and fully mobile. Three base signals depots (B.S.D.), or units, provided the cadre for operational training under field conditions. Personnel thrown up by the Indianisation of the Wireless Observer Units were among the first to use these training facilities. It was thus possible to establish a group control centre and a mobile air reporting unit to replace the existing organisation in 3rd T.A.F. of group operations and filter rooms, etc. In April 1944, arrangements were put in hand to despatch 1,000 Collins 18Q equipments to India to replace T.1083/R.1082's, of which over a hundred were allocated to the W.O.U.s.

Mobile signals units were introduced initially into the Bengal area in May 1944, by which time some 180 units of all types had been formed. These were made up as follows: Type 'A' (8 low power H.F. W/T channels) 4, Type 'B' (4 low power H.F. W/T channels) 14; Type 'C' (4 very low power H.F. W/T channels) 2; Type 'D' (2 low power H.F. W/T channels) 7; Type 'E' (4 low power H.F. W/T reinforcement channels) 8; Type 'G' (2 very low power H.F. W/T reinforcement channels) 2; Type 'K' (1 very low power H.F. W/T channel) 26; Type 'L' (1 H.F. D/F channel) 7; Type 'M' (1 M.F. Beacon) 2; Type 'P' (2 V.H.F. R/T channels) 57; Type 'Q' (1 V.H.F. D/F channel) 57.

Both air transportable and mobile signals units were required for offensive operations planned for the end of 1944 and for 1945. Prototypes of a transportable equipment were produced at No. 4 B.S.D. Bombay, and when approved, construction was carried out at both No. 4 and No. 5 B.S.D. (Calcutta). Construction was 80 per cent complete in November 1944. To mount these operations it was first essential to make up the deficiencies of personnel and equipment in the M.S.U.s of 3rd T.A.F., which amounted to 754 signals vehicles, 566 signals personnel and 254 non-signals personnel. An extensive signals vehicle production programme was begun at No. 4 B.S.D., and a large percentage of the vehicle deficiencies had been made good by the end of November 1944. Personnel from incoming convoys were attached to No. 7 B.S.U. Sambre for a three weeks' acclimatisation and refresher course before proceeding to the 3rd T.A.F. area.[1]

The move into Central Burma, which opened in December 1944, and which gathered considerable momentum within a few weeks, kept the

[1] A.H.B./IIM/A44/1.

communications facilities and mobile signals units of No. 221 Group in a state of perpetual activity and mobility. A mobile signals servicing unit was built up to full establishment at No. 7 B.S.U., and acted as a central servicing organisation for mobile signals units in No. 221 Group. W/T and cypher traffic was extremely heavy, resulting in considerable delays to signals, particularly to those units outside the group, such as Eastern Air Command in Calcutta, and No. 224 Group in the Arakan. Equipment from rear bases was still being delivered for assembly, the existing channels were overloaded, and delays were inevitable. Relief W/T channels were opened as quickly as possible, and considerable use was made of the airgram service. Sufficient W/T equipment was not always available for the tasks allotted, the shortage of medium-powered transmitters being especially acute. Until an SWB8 was forthcoming, the highest-powered transmitter at Headquarters No. 221 Group, working Eastern Air Command, was 350 Watts. When the advance gathered momentum in 1945, there were times when priorities lost all semblance of their true values, 'Immediate' signals in some cases taking several days to clear. There were occasions when messages of a most urgent operational nature, cancelling some operation at short notice or laying on an immediate strike, could not be passed by telephone or teleprinter and had to be passed by W/T, with the consequent risk that vital information would not reach wings and squadrons in time.

The growth and development of air supply made a further heavy call on wireless resources. Landline facilities under these circumstances rarely existed, and the only means of efficient control were point-to-point wireless links specially reserved for the air supply organisation. In anticipation of a rapid drive back into Burma by our armies, a plan was evolved to transport signals equipment by air, as road conditions were hopeless for the transport of sensitive equipment, and it was important to get communications organised quickly for the opening of new airfields and forward headquarters. Once essential communications were established, it would be possible to bring mobile signals units up carefully by road. The plan foundered because very little of the air transportable equipment, except that made up locally in No. 221 Group, was ready in time, the main cause of delay being the inadequate supply of wooden cases and the poor quality of those supplied, and to add to the difficulties it was not possible to bring wings up to their full establishment of mobile signals units before the advance into Burma began. At no time during the Burma campaign was there ever sufficient men or material to operate the signals services with full efficiency. It was not until after the campaign was over, when preparations for the invasion of Malaya were in progress, that all units were brought up to scale in mobile and transportable signals units. Air transportable equipment made in the United Kingdom had still not arrived.[1]

[1] A.H.B./IIJ50/47/49.

Visual Control Posts

The requirement for Visual Control Posts (V.C.P.) arose in October 1944, when the need was felt for a mobile means of direct control of aircraft operating in a close support role. The first visual control posts were equipped with TR.1143 transportable V.H.F. sets and with H.F. pack-sets (Collins 18Q, and later, because this proved too heavy, Army Type 22), all fitted in a Jeep trailer. Precautions were taken to ensure that the equipment was not adversely affected in transit, but these were not always successful and the trailer was not completely satisfactory. An improvement was provided by the installation of all the equipment—sets, power supplies, aerial and controls—in the rear of the Jeep, spares and personal kit only being carried in the trailer. It was soon found, however, that visual control posts were required to operate in areas where Jeeps were useless and even mule transport was not always available. The TR.1143 was therefore fitted as a mule pack-set, and a new V.H.F. pack-set was produced by No. 221 Group which, like the Army Type 22, could be man-carried. Fifty of the mule-carried pack-sets were constructed on high priority in December 1944. Apart from some teething troubles, this equipment gave satisfactory service.

Each V.C.P. was equipped with one V.H.F. mule pack-set, one man-carried V.H.F. pack-set, one Collins 18Q pack-set, and two Jeeps and trailers.[1] The next demand was for an air transportable visual control post, capable of being dropped by parachute, and for this purpose the American AN/TRC-7 was requested. The performance of this set was almost equal to that of the TR.1143, and it was much lighter in weight and more easily transportable. It stood up well to the air drop, and to operations in heavy monsoon rains.

A number of lessons were learned from experience of the use of visual control posts in Burma. Remote control of the R/T transmitter up to a quarter of a mile was desirable as the aerial was apt to give away the post's position to the enemy.[2] The equipment must be water and dust proof. Adequate tools and spares for elementary servicing must be carried. And it was important that the personnel operating the post be instructed not only in the maintenance of the technical equipment but also in the servicing of the vehicles in which it was carried.[3]

Frequencies

The frequency problem was an acute one, particularly as the land and air forces built up and the call came for communications over ever-increasingly distances involving a large number of high-power transmitters. The

[1] A.H.B./IIM/A44/1.

[2] The desirability of the remote control of all very low power transportable and mobile W/T equipment was agreed in A.C.S.E.A. in early 1945 and an investigation made into the possibility of providing all such equipment with this facility.

[3] A.H.B./IIJ50/47/49.

control of frequencies in India and other territory under India Command came under the W/T Board, India, which on the formation of S.E.A.C. became the Combined W/T Board, India and S.E.A.C. The main problem was to allocate frequencies and agree directivity and power in such a way as to maintain the desired separation between channels. Frequencies below 550 kc/s were allotted on individual application. Frequencies between 550 and 7000 kc/s were allocated on a block basis, frequencies within blocks being sub-allotted by the holders. Frequencies above 7000 kc/s were allotted on individual application, block allocation being considered unsuitable because of the central co-ordination of these frequencies by the W/T Board, London, to which details were forwarded from time to time. Mobile wireless units not exceeding 10 Watts could operate on any frequency within their tuning range allotted by their controlling formation.[1]

Growth of Landline Network

The major difference between communications services in the Far East and those in the European theatre was the far greater dependence in the Far East on W/T communications as opposed to landlines. Over long distances, and during rapid advances, W/T was the only reliable means of communication. Generally speaking, landlines in Burma were in the form of localised networks inter-connected by W/T because distances between formation headquarters and their units and between units and their subordinate detachments were too great for landline communications. The delays attendant upon the increase of cyphering and coding involved were a handicap that had to be accepted.

Nevertheless, from a situation at the start of the war in the Far East in which landline circuits in India and Burma were practically non-existent, a comprehensive telephone and teleprinter system on the lines of the D.T.N. system in the United Kingdom had been practically completed by the end of 1943, as a result of the combined efforts of Army signals units and the Posts and Telegraphs Department of India. Speech thus became possible between places as far apart as Delhi and Bombay, Kandy and Calcutta.[2] Even so, the great distances involved precluded the raising of the standard to anything approaching that maintained in the United Kingdom: for the most part speech facilities were on a common-user basis; the problem of maintenance was a difficult one, particularly after tropical storms, when branches torn from trees played havoc with overhead lines; and the degree of serviceability left much to be desired. Other problems included the depredations of native peoples and the destructive power of animals, particularly monkeys.

The particular landline needs of the R.A.F. were provided for by Air Formation Signals. The first Indian Air Formation Signals unit was formed

[1] A.M. File CS.13287.

[2] Progress with the installation of telephone carrier and V.F. telegraph systems up to October 1944 is shown at Appendix No. 17.

in December 1941, and by the end of 1943 this had been increased to a total of six units. These units did especially well considering that they were deficient for a long period of a large number of personnel—some 7 officers and 270 other ranks, for instance, on the 1943 target.[1] To establish good liaison between R.A.F. and Army Signals, and to provide technical advice for R.A.F. C.S.O.s on the provision of landlines, A.F.S. staffs were formed for employment with all major R.A.F. formations.[2]

It was found necessary to keep three A.F.S. units permanently employed in the construction of communications on the large number of airfields which were being prepared in India as air bases for the campaigns in Burma and beyond. By the middle of 1945, local telephone communications had been provided on 122 airfields in India and Ceylon, and on some 25 of the more important ones, semi-permanent underground mobile systems with relatively large switchboards were installed. Field mobile systems, which required continual maintenance and rebuilding, were built on the remainder. As only a proportion of these airfields were in use at any one time, wing and line sections were kept continuously on the move to keep pace with the ever-changing situation. The magnitude of the task can be judged from the fact that each unit was responsible for an area covering over a quarter of a million square miles.

Telephone systems were installed by A.F.S. at the headquarters of Air Command, Base Air Forces, and groups, and operational circuits were provided for filter operations rooms, A.M.E. stations, and flying control and meteorological centres. By the end of the war some fifty private speech circuits and over 190 common-user trunk services had been provided. R.A.F. telegraph circuits amounted to nearly 300, and there were more than 50 common-user telegraph circuits available.

In the field, the disposition of R.A.F. forces and Air Formation Signals units was that, at the end of 1943, 3rd T.A.F. was stationed at Comilla, with Headquarters No. 221 Group at Imphal and Headquarters No. 224 Group at Chittagong; No. 6 (Indian) A.F.S. unit was based at Imphal and was responsible for No. 221 Group and its units, one company being detached to Comilla to serve Headquarters 3rd T.A.F.; and No. 4 (Indian) A.F.S. was serving No. 224 Group in the Arakan. During the offensive operations in Burma and China in 1944, No. 6 (Indian) A.F.S. advanced some 600 miles with No. 221 Group to Rangoon, the leading sections often being flown in to forward airfields, and No. 4 (Indian) A.F.S. remained with No. 224 Group throughout their successful operations in the Arakan. The Calcutta/Barrackpore area was the responsibility of No. 1 (Indian) A.F.S.[3] These six A.F.S. units, however, were insufficient to cope with increasing commitments in late 1944, when company headquarters, wing signals sections, line

[1] A.H.B./IIJ50/47/4.
[2] A.H.B./IIJ50/47/49.
[3] A.H.B./IIM/A42/2A.

sections and telephone operating sections had to be withdrawn from existing commitments to refit and train for new formations.[1]

In December 1944, No. 19 A.F.S. arrived from the United Kingdom with up-to-date carrier-telephony and voice-frequency telegraph equipment, the first A.F.S. unit in India to be so equipped. The unit was committed on the lines of communication in East Bengal and the Arakan, and was responsible for airfield communications for the Combat Cargo Task Forces supplying the Fourteenth Army in Burma. It thus offered no relief to existing resources. This unit later advanced to Rangoon and built up the communications for Base Headquarters, and later, Air Headquarters Burma. Outstanding demands, however, still totalled three complete A.F.S. units and nine telephone operating sections. One new unit, No. 7 (Indian) A.F.S., was ready in September 1945.

Experience with the operation of A.F.S. units suggested that, to meet the demands of both mobile and static operations, one standard type of unit, independent of pool transport and with 100 per cent mobility, was wanted; the great delays encountered in moving sections by road, rail or sea transport necessitated the formation of air transportable sections to keep pace with the rapid movement of R.A.F. forward echelons. Wing signals sections, which were always in the vanguard of an advance, also needed to be air transportable, holding jeeps and jeep trailers instead of heavier transport. Each unit needed at least one line section organised on a light scale as an air transportable reserve, to follow up wing signal sections should the line commitment become extensive before the normal lines of communication could be opened. Adequate multi-channel carrier and voice-frequency telegraph equipment was regarded as likely to be invaluable in reducing delay in the provision and maintenance of circuits. Experience showed a tendency to underestimate the quantities of internal wiring stores required for the large headquarters.[2]

Owing to the shortage of Service switchboards, a miscellaneous collection of Posts and Telegraphs magneto switchboards were installed on airfields. By the end of 1944, however, Service equipment was becoming available in large quantities, and this was used to replace P. and T. equipment, which by this time was becoming worn out. Units did not hold carrier and voice-frequency telegraph equipment on their war equipment table, and as there was an acute shortage of overhead trunk circuits a considerable delay in the provision of communications was caused until adequate open-wire systems were constructed. Teleprinters were not available in sufficient quantities to meet R.A.F. telegraph circuit requirements, and this shortage persisted until the end of 1944, when more machines were made available from the United Kingdom and when American teletypes were obtained. The supply of essential teleprinter spares remained critical throughout.

Efficient message distribution and traffic handling was an important

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[1] A.H.B./IIM/A44/1.

[2] A.H.B./IIJ50/47/49.

part of the signals organisation at the Supreme Allied Commander's headquarters, and a nucleus of W.R.N.S. and W.A.A.F. who had experience of handling inter-Service messages at a combined operations headquarters was brought out from the United Kingdom. A number of United States W.A.A.C.s later joined the Headquarters. Although a large measure of co-ordination in signalling was achieved by the use of combined signals publications, each Service had its own signals language and detailed procedure, and the women traffic officers thus had to learn the work of the British and American Services in some detail.

Experience showed that the use of priorities must be rigorously controlled from the highest level downwards, otherwise the best of communications systems was liable to break down. The throttle of security, too, needed careful control, delays to signals traffic caused by encyphering and decyphering being very great.[1]

As the Supreme Allied Commander wanted to be able to travel freely throughout the Far Eastern theatre, he decided that he must have a flying wireless station to accompany him. This was set up in a Dakota aircraft, using American equipment. Similar flying wireless stations were provided for other commanders in this very dispersed command.

Supply, Storage and Maintenance

The supply arrangements for signals equipment in India were never entirely satisfactory, and even in 1944 there was some doubt as to whether forthcoming plans could be met. At first, the theatre was hopelessly short of all kinds of signals equipment, but this situation improved gradually, large deliveries being made in 1943 and 1944. Nevertheless, all types of signals stores were in short supply throughout this period, resulting in many improvisations and the erection of temporary installations which did not always give efficient service and often aggravated the maintenance problem. Many delays were caused through these shortages, some of which constituted a serious handicap to the progress of operations.[2] By the end of 1944, the major anxieties were due to losses of shipping *en route* and to delays in delivery. These two factors considerably increased the inevitable shortages resulting from the expanding needs of the theatre and the claims of other theatres. There was, too, another factor which further aggravated the situation—the damage done to equipment in transit and in store.

The problem fell under two major headings—pack-ups and general supply. The system with pack-ups was that equipment required for large tasks was despatched in cases marked with a code-name to ensure rapid recognition; but difficulties arose when, as often happened, cases arrived spread over a long period or with large deficiencies. To be effective the pack-ups had to satisfy a number of conditions. They must normally arrive in the same

[1] A.H.B./IIJ50/47/49.
[2] A.H.B./IIJ50/47/49.

ship, and they must be complete in all items, since local manufacturing capacity was limited and minor parts could not be turned out at short notice. Any unavoidable deficiencies needed to be signalled ahead so that manufacture in India could be put in hand and the items could be ready when the pack-up arrived. But in practice, parts of the same installation were liable to get separated and arrive not merely in different ships but at different ports. Other parts suffered serious deterioration *en route*, and a great deal of equipment was lost or stolen.

On the question of signals equipment from general supply, stores containing signals equipment were, by the end of 1944, generally well filled; many items were in abundant supply, and it was the few deficient items which held up progress. The arrangements for the receipt and storage of equipment, however, left much to be desired. It was not unusual to find a line of packing cases some half-mile in length by about six cases deep, which had been delivered from the docks and were waiting to be dealt with. In November 1944 there were over 15,000 cases awaiting unpacking at No. 305 M.U. 5,000 cases were arriving each week and only 1,500 were being unpacked.[1] It was often impossible to sort out or recognise any particular packing case, and selective unpacking was not feasible. In the normal course, any one case would stand in the open for some six weeks before being unpacked. The problem was not simply a question of personnel, since even if the unpacking staff could have been doubled there was not the necessary storage space for uncased items. There were also transport difficulties. In order to facilitate the build-up of communications requirements pending the offensive planned in 1945, increased establishments of signals equipment had been requested, and vigorous action was needed to ease the problem of handling and despatch from the supply units. But what was needed above all was a container which would keep equipment in a serviceable condition indefinitely. The troubles experienced with signals equipment were largely due to its inability, as packed at this time, to withstand rough handling and prolonged exposure in transit and while stored in the open. The requirement was for an air-tight, shockproof container which could stand indefinitely in the open without damage to the equipment; such containers should be capable of being opened and then resealed.[2] By the end of the year, a container on these lines was in the process of production by the Director of Communications Development; but it was not ready in time to affect the situation in South-East Asia before the end of the war.[3]

The three base signals units or depots which were formed towards the end of 1943 at Bombay, Calcutta, and at Sambre, were responsible for prototyping and producing specialist vehicles, special equipment, spares, etc.; for the maintenance, overhaul, salvaging and reconditioning of equipment; for carrying out an air inspection service throughout the Command;

[1] A.H.B./IIM/A44/1.
[2] Report on visit of Director of Telecommunications to India, December 1944.
[3] A.H.B./IIJ50/47/33.

for work of a development, research, and experimental nature; and for providing fitting and installation parties throughout the theatre.[1]

In all the circumstances the adequacy of the equipment provided in the forward areas was surprising, complaints being invariably of a few inadequate components rather than of a whole equipment. Power packs were the weak points everywhere, and every signals wing and maintenance unit was provided with gear for rewinding transformers; nevertheless only minor modifications to the power-packs were necessary. The arch-enemy of radio serviceability was the high humidity, condensation being particularly severe about dawn, when equipment not artificially heated was liable to be drenched. Much ingenuity was used in drying out equipment, the T.1190, for instance, being slowly dried out by a low input over a number of days after it had been standing for a long time, after which it could be operated normally. Aircraft equipment was rarely fully serviceable until it had dried out in flight, and where ventilation and heating failed to circulate, fungus grew rapidly. Insulation grew brittle in the heat and broke down. Radio equipment had to be specially designed to withstand heat, moisture and fungus; but it was not until the closing stages of the war that the tropicalisation of equipment was tackled successfully.

The shortage of equipment and personnel was a pressing problem throughout the Far Eastern campaign. The lack of good ground communications receivers was particularly acute; in the early stages the majority of ground stations used the R.1084, but this set was replaced by American receivers as these became available. Another factor militating against the efficiency of communications was the fitness of personnel, physically and technically. By far the biggest wastage was at the hands of tropical disease, especially in the first Arakan campaign. The sickness rate was greatly reduced in later campaigns by medical science, but the menace remained. And technically, signals personnel arrived in the Command having spent many weeks or even months at sea and in transit camps, during which time they were rarely afforded adequate facilities for refresher or specialist training. In many cases personnel had lost the tentative grasp of basic principles inculcated in the shortened *ab initio* training courses at home; few of them had had adequate training under field conditions. Thus the command had a bigger training commitment than it was designed for, bigger than it could afford to shoulder.

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[1] A.H.B./IIM/16.

CHAPTER 10

THE LIBERATION OF N.W. EUROPE

Planning

An inter-Service planning staff to plan the liberation of Europe was formed at Norfolk House, London, in May 1942, the staff including an R.A.F. signals representative. As planning proceeded, however, it became apparent that there was very little hope of making a successful assault on the continent of Europe while the Mediterranean theatre was dominated by the enemy. The campaign against North Africa was therefore planned and executed first, preparations for the landings in Europe being relegated to a secondary priority.

In June 1943, the responsibility for planning the part to be played by the air forces in the liberation of Europe was delegated to the A.O.C.-in-C. Fighter Command, whose Chief Signals Officer was made responsible for the signals planning and organisation.[1] A signals planing staff was set up in Norfolk House, composed of specialist officers who were to study the various signals problems that the operation presented. In November 1943, Headquarters Allied Expeditionary Air Forces (A.E.A.F.) was formed, and the planning staff was joined by U.S.A.A.F. staff officers.

The telecommunications side of signals planning comprised cross-channel strategic and mobile communications, and landlines. A Chief Air Formation Signals Officer was appointed, and he and his planning staff joined the existing staff at Norfolk House in November 1943.[2]

It eventually became clear that the coastline between the Cotentin Peninsula and Le Havre was the only suitable area where a beachhead might be established from which it would be possible to capture ports of sufficient capacity to maintain the considerable forces that would be involved. The decision to undertake an assault at a point some 80 miles or more from the English coast introduced serious difficulties from the signals point of view, both in respect of cables and of cross-channel wireless communications.[3]

It became obvious that the supporting air forces would have to be controlled from the United Kingdom in the early stages of the operation, that it would be some time before headquarters air control centres on the Continent would be able to assume this responsibility, and that it would be still longer before aircraft would be able to operate from bases on the Continent. It thus became necessary to provide a communications organisation which would

[1] Group Captain R. G. Hart (later Air Vice-Marshal Hart).

[2] In September 1943 the War Office, at the request of the Air Ministry, recalled Brigadier J. H. Cameron-Webb to the U.K. from the Mediterranean theatre, where he had held the appointment of C.A.F.S.O. for nearly three years, to fill the same appointment at H.Q., A.E.A.F.

[3] A.H.B./IIS1/34/1.

ensure the efficient control of a large allied air force in England in the initial stages of the assault, to install cross-channel communications so as to make it possible to transfer control from the United Kingdom to the Continent, and to provide an intensive network of communications which could be moved to the Continent so that complete control could be exercised from headquarters and control centres in Europe, based on information obtained by communication with Great Britain and from mobile radar and intelligence organisations in Europe. In addition to these operational communications requirements, a separate network had to be planned for administrative purposes.

Certain fundamental principles were followed in providing communications for the air forces. Communications for operational control, intelligence, meteorological services, and administration were to be by landline wherever possible. In order to ensure a rapid build-up of communications across the Channel, and to increase flexibility and mobility, communications other than those required within the United Kingdom were to be provided by W/T and R/T until cables and landlines could be provided to replace wireless channels. R/T was to be provided for operational point-to-point aircraft control channels, and V.H.F. R/T was to be used for ground-to-air communication throughout the A.E.A.F. wherever this satisfied operational requirements. High power V.H.F. transmitters, together with other special devices, were to be made available for use in the event of enemy jamming.

The communications required were divided broadly into two categories, tactical and strategic. The tactical communications were essentially operational channels required mainly during the assault phase. These were to be operated from a combined control centre at Hillingdon, Uxbridge (2nd T.A.F. and Ninth U.S.A.A.F.) and an executive control centre at Headquarters No. 11 Group, to the assault forces, headquarters ships and fighter direction tenders (F.D.T.). The strategic communications were those to be used following the assault for communications between headquarters established on the Continent and Headquarters A.E.A.F. for as long as it remained in the United Kingdom. The strategic communications included a number of important administrative W/T channels. A number of high-speed automatic W/T mobile signals units were formed for use on the main operational and administrative links between the United Kingdom and the Continent.

Communications for H.Q. A.E.A.F.

Consideration was given in the summer of 1943 to the provision of administrative telephone facilities for Headquarters A.E.A.F. and other formations which were to be set up at Stanmore. The existing switchboard at Stanmore, which had already been enlarged on the fusion of Fighter Command and Army Co-operation Command, was not equipped to deal with a further increase in traffic, and in fact needed enlarging to cope satisfactorily with existing traffic. It was decided to provide separate suites 'A' and 'B', accommodation being found in the underground operations block for a six-position 'B' suite, with room for expansion, the existing twelve-position switchboard being used as an 'A' suite. The suites were arranged so that, to economise in personnel, the 'B' suite could be closed at night.

The main difficulty in the provision of these facilities lay in the considerable amount of external circuiting required. Practically all the main cables in the Uxbridge, Stanmore and Watford area were already taken up, and a new cable being laid between Colindale and Watford was not ready until the end of 1943. In addition, various cable projects already in progress, particularly for Bomber Command, were fully occupying all cable manufacturing output. It was essential that details of the external private wire circuits required by the new Headquarters should be decided upon as soon as possible.

An attempt was therefore made in August 1943 to make a forecast and the requirements were listed under two headings — those required by the end of October 1943 and those required by the end of December. An increase of 50 to 60 private wires in all was forecast up to the end of 1943. A full list of lines was sent to the G.P.O. by the Air Ministry, who agreed the arrangements on 24 August 1943. A switchboard with a capacity for a total of 240 exchange and private wires was installed. The switchboard was capable of operating 24 positions at full capacity, 16 on the 'A' suite and 8 on the 'B' suite. In the event, the 18 positions already provided proved sufficient.

V.H.F. South Coast Radio Scheme

The setting up of a direct telephone service from the United Kingdom to the H.Q. Ships, F.D.T.s, and air forces on the Continent was one of the most important communications needs of 'Neptune'. A scheme was developed in 1943 for the provision of such a service using V.H.F. R/T. The scheme was considered under two heads, the simplex links, which were to be employed during the initial phase to provide communications with H.Q. Ships and F.D.T.s, and the duplex links, which were to be set up later for cross-channel working.[1]

Sites suitable for the erection of V.H.F. apparatus were selected at various points along the south coast. The air simplex links were to be set up at Dover, Willingdon Hill, Godlingston Hill, Ventnor and Start Point to work H.Q. Ships, and a second channel was to be set up at Ventnor to work the F.D.T.s. The air duplex links, to provide cross-channel communications with stations on the French coast, were to be set up at Dover, Willingdon Hill and Ventnor. In France, the R.A.F. plan was to provide two duplex and two simplex cross-channel links, one of each to work each

[1] A.H.B./IIS/110/9/26.

composite group in the early stages of the operation, finally to be absorbed in the main Base Signals Centre. The target date for the completion and operational readiness of the entire scheme was 1 March 1944.

The V.H.F. sets originally planned for use in the scheme were Admiralty sets, the scheme starting as a Combined Services project in which the air forces shared. But doubts about the provision of the scheduled apparatus became evident, and at a special Headquarters No. 26 Group meeting on 11 December 1943, it was agreed that if it was decided to continue with Admiralty equipment, the target date could not be met. The possibility of substituting R.A.F. equipment was explored and it was decided to set up the air force part of the scheme independently, using standard R.A.F. V.H.F. apparatus as far as possible.

A new list of minimum R.A.F. requirements had been agreed a fortnight earlier, the installations needed being seven 100 W. simplex mobile installations, six 100 W. duplex, four 30 W. simplex and four 30 W. duplex plus fifteen 7 W. simplex and six 7 W. duplex hand-cart installations. A total of 100 wireless and R/T operators was needed for the scheme, which involved some 30 channels in all. These were provided by a Radio Communications Unit, specially formed and trained in No. 26 Group to meet these requirements. When the R.A.F. took over the scheme, the installation of some of the Admiralty apparatus had already been made, and two 100 W. Stratton transmitters were taken over by the R.A.F. at each of Dover, Willingdon Hill and Godlingston Hill. These were static installations. R.A.F. mobile equipment was to be installed at Ventnor and Start Point. It was decided to use 50W T.1131 transmitters with amplifiers to replace the other Stratton transmitters, with SCR.522 receivers to replace the G.E.C. receivers of the original scheme, and to back these circuits with circuits provided by 500W S.B.A. transmitters which No. 26 Group modified and developed to provide one R/T and one teleprinter circuit simultaneously. The teleprinter circuit was obtained by adapting standard Army S. and D. lines equipment to give a simplex two-tone teletype channel superimposed on the R/T carrier. The teleprinter circuits were set up to operate to Headquarters Ninth Tactical Air Command, No. 83 Group and No. 483 Group Control Centre (G.C.C.) on the Continent from the teleprinter rooms at Headquarters 2nd T.A.F. and Headquarters Ninth U.S.A.A.F. At a later stage the teleprinter terminals on the Continent were scheduled to be re-terminated direct to the Base Signals Centre and Headquarters No. 85 Group, and in the United Kingdom at Headquarters A.E.A.F. or Headquarters No. 11 Group.

All V.H.F. R/T terminals on the far shore were provided by mobile signals units, which were formed and trained in No. 26 Group for duty with No. 85 Group, from which formation they were attached to 2nd T.A.F. and Ninth U.S.A.A.F. as required, to provide communications for these formations in the assault area. Three types of unit were used. Type 'T' and 'U' both used the T.1131/SCR.522, Type 'T' being a simplex installation working on frequencies between 65 and 85 megacycles and Type 'U' being a duplex installation working between 85 and 96 megacycles. Type 'W' was the modified S.B.A. transmitter plus teleprinter working on frequencies in the 30—40 megacycles band; these circuits were code-named 'Racehorse' to distinguish them from the other duplex circuits. The United Kingdom terminations of the circuits, other than those provided by the static Admiralty sets, were provided by the same types of M.S.U.[1]

A meeting was held on 23 December 1943 to discuss landline and control facilities for the scheme. For the duplex circuits, four-wire landline circuits from the transmitter/receiver sites were arranged to pass through a control switchboard at Portsmouth Combined Headquarters (C.H.Q.), from which they were extended by radio telephone to the Combined Control Centre. Extensions were taken to the Executive Control Centre, the Air Ministry, and Headquarters A.E.A.F. Authority to use the radio telephone service was limited to officers directly concerned with the mounting or control of the operation. The simplex circuits were extended from the switchboard at Portsmouth to Uxbridge, the circuit working the F.D.T.s being terminated on head and breast telephone sets at a control point in the Combined Control Centre. The circuits working the British and H.Q. Ships were terminated on head and breast telephone sets at control points in the Executive Control Centre.

As standby to the three V.H.F. simplex circuits, three H.F. transmitters and receivers were installed at Portsmouth and provided with facilities to enable them to be remotely operated either on radio telephone or on W/T from the Combined Control Centre and the Executive Control Centre, the standby controls being located adjacent to the V.H.F. controls. Facilities were provided to enable a modulated tone to be transmitted as required on the V.H.F. carriers to enable speech point-to-point W/T to be used should interference prohibit speech on any V.H.F. simplex circuit. Arrangements were made to enable the V.H.F. R/T circuits to be operated from the Battle Room at Headquarters A.E.A.F. or from Portsmouth C.H.Q. by effecting a change-over of control lines at Uxbridge. Similarly, facilities were provided to enable the simplex R/T circuit on the F.D.T. liaison wave to be operated from Tangmere if the need arose, and for the simplex circuit terminal at Start Point on the U.S. H.Q. Ship's wave to be operated from Headquarters No. 10 Group at Rudloe.

After the initial stages of the assault and when the major Air Force headquarters and signals centres had moved over to the Continent the V.H.F. R/T duplex circuits ('Racehorse') provided by the South Coast Radio Scheme were used to provide the standby speech and teleprinter circuits to the submarine cable circuits which by this time had been provided. The Radio Communications Unit in the United Kingdom and the Mobile Signals Units Type 'W' on the Continent were utilised as radio

[1] A.H.B./IIS1/34/1 and A.H.B./IIS/110/9/26.

terminals. These circuits were longer than those originally planned and for which the equipment had been designed, but nevertheless they worked satisfactorily.[1]

It was decided to increase the range of these circuits much further, and one circuit was worked with two 'A' units working back to back as a relay unit. This circuit gave fair results but was considerably improved when the two 'W' units were substituted by a 'C.A.' unit which had been designed specially to work as a relay. The main differences between two 'W' units working back to back and one 'C.A.' unit was that the 'S' plus 'D' and Two Tone equipment was not provided in the 'C.A.' unit, thus removing a considerable amount of superfluous equipment and making the circuit quieter and more stable.

It was found that a considerable amount of unserviceability on 'Racehorse' circuits was caused by incorrect settings of modulators and volume controls, due to no standards being available for these to be set to, especially in a circuit containing a relay point. On these circuits a terminal R/T operator was apt to increase the volume to overcome increased attenuation, when in fact the attenuation had occurred in a link over which he had no control.

Experiments were carried out in co-operation with Headquarters No. 26 Group, and a lining up procedure was drawn up detailing the standards to which modulation and volume had to be adjusted to give the least overall attenuation consistent with the most stable conditions and best signal-to-noise ratio. A procedure was then introduced so that the radio link was lined up to these standards daily and the overall circuit, i.e. terminal to terminal, was lined up weekly in co-operation with the G.P.O. and Air Formation Signals.

Each cross-channel circuit consisted of three sections, each maintained by a different service. The United Kingdom terminations and landlines were provided and maintained by the G.P.O., the radio equipment by the R.A.F., and the continental termination and landlines by Air Formation Signals. To prevent faults to any of these services being reported unnecessarily, terminal operators 'localised' faults as far as possible before reporting and then reported to the appropriate service, e.g. if the United Kingdom operator could not speak to the continental operator, but could speak to the radio operator at the United Kingdom radio terminal, it was obvious that the portion of the circuit maintained by the G.P.O. was not faulty; such faults would, therefore, be handed over to the radio terminal for them to deal with.

Normal R/T procedure was used on the speech links, all users having R/T call-signs. After the need for strict security and the camouflage of the names of formations had ceased, R/T procedure was dropped and

[1] A.H.B./IIE/159.

normal telephone procedure substituted, with the addition that users were still warned that these were being connected to a radio channel. On the teleprinter links, W/T procedure was used at first in the absence of any alternative, but with the issue of a procedure manual, the radio teleprinter procedure was used as laid down. The subject matter of all messages was still encyphered.

It was decided by Headquarters 2nd T.A.F. that 'Racehorse' circuits could be used to provide communications to the tactical groups during periods of advance, and a number of 'W' and 'C.A.' units were called forward to the Continent for this purpose, and quite extensive use was made of the facilities provided by these units during the final stages of the campaign in Europe.

'Racehorse' circuits provided an essential link in the communications chain during the initial stages of the assault; and although during the period of comparative stability of the major headquarters, when submarine cable circuits became more plentiful and more reliable, the services of the 'Racehorse' circuits were not called upon to any great extent, they nevertheless provided an excellent insurance against complete isolation due to submarine cable failures, and during the latter stages of the war in Europe, when formations were moving quickly, 'Racehorse' units once more came into their own and enabled communications to be maintained. Without a doubt the use of 'Racehorse' proved to be one of the most reliable methods of communication by both speech and teleprinter. Serviceability and performance were excellent and often these circuits were the only means of communication between the various formations using them.

Cross-Channel Communications

Cross-channel cable and radio speech circuits for the Air Forces were terminated in the United Kingdom on a switchboard at Headquarters No. 11 Group known as the cross-channel P.B.X. This P.B.X. had direct circuits within the United Kingdom to all major formations using the cross-channel telephone system, plus two speech circuits to Goodge Street P.B.X. giving access to the S.H.A.E.F. common user circuits. The authority to make cross-channel telephone calls was limited to as few officers as possible, and for this purpose a list of authorised users was maintained, each formation issuing its own individual list. Normal 'scrambler' facilities were available on the cable circuits.[1] Cross-channel calls took priority over all other telephone calls, such other calls being broken down if necessary. Cable circuits were used wherever possible in preference to radio circuits. The radio circuits existed primarily as a standby against failure of the corresponding cable circuits. There was no security on radio circuits and no 'scrambling' facilities. The P.B.X. operator established a call over

[1] The 'scrambler' device did not ensure the security of a conversation, but only prevented operators from overhearing.

a radio circuit only with the concurrence of the caller, and invariably warned officers receiving incoming calls by this system.[1]

Separate W/T receiving stations were set up at Hillingdon complete with traffic, cypher and teleprinter offices for 2nd T.A.F. and Ninth U.S.A.A.F. respectively, to enable these headquarters to communicate with H.Q. Ships in the assault and units under their command in the assault and in the early stages ashore.[2] In addition, the W/T receiving rooms of Headquarters No. 11 Group was enlarged to enable the A.O.C. to communicate with the fighter director tenders and with G.C.I. stations which went in with the assault. Twenty R.1188 receivers for 2nd T.A.F. and five for No. 11 Group were provided and installed by No. 26 Group. Ninth U.S.A.A.F. provided and installed ten receivers, the installation being assisted by a No. 26 Group fitting party.

A transmitting station for the combined use of the three receiving stations was set up at Uxbridge some two miles from the receiving sites. Twenty-seven T.1190's were installed, and later two BC.610 transmitters were provided by Ninth U.S.A.A.F. Remote control circuits were provided to the three receiving stations. Because of the limited area of the site the aerial systems were not elaborate. Two additional transmitters were made available for operation from the 2nd T.A.F. receiving station; these were an SWB8 at Greenford and a 20 kW. naval M.F. transmitter at Horsea. These two transmitters were operated simultaneously on the area command wave, which functioned as a broadcast wave on D-Day and later became a point-to-point link with all headquarters ships, fighter director tenders and G.C.I. stations. Keying facilities were provided to enable these transmitters to be operated automatically at hand speed where necessary; this apparatus was installed following reports of unsatisfactory morse sending during the many pre-operation exercises, and effected a great improvement over hand operating on long transmissions.

It was decided to make use of the W/T station at the Combined Headquarters, Portsmouth, as a forward W/T relay station to guard against the effect of ' skip ' on the main tactical W/T links between Uxbridge and the Continent. It was also decided to use the receiving station as a forward listening post on certain V.H.F. aircraft operational frequencies and to provide standby H.F. R/T facilities to be used if necessary for talking to the H.Q. Ships and F.D.T.s, should the V.H.F. R/T links provided for this purpose prove unsatisfactory. For this purpose a number of additional facilities were provided. Ten H.F. receiver positions, including three R.1188's, were provided for the reception of R/T, with facilities for switching the received signals to line through to the combined control centre or executive control centre Uxbridge; C.R.100 receivers were installed in the other seven positions. Three T.1179's were installed for standby H.F. R/T, in addition to six H.F. transmitters already available; but shortly before the operation the Joint Signals Board imposed a ban on the use of trans-

[1] A.H.B./IIH/243/169(B).
[2] A.H.B./IIS1/34/1.

mitters within three miles of the combined receiving stations at C.H.Q., and it was not possible to operate them. These transmitters were held in reserve. A combined transmitting station for use by all Services at C.H.Q. Portsmouth was built, under arrangements made by the Joint Signals Board, outside the three mile limit, and the Air Force's allocation of transmitters from the combined pool was sufficient to meet all demands. The combined transmitting station was equipped with about 60 low-power transmitters installed in five sites within ten miles of C.H.Q. Four V.H.F. receivers were set up for reception on aircraft frequencies in the area, and were connected by uni-directional landline to the combined control centre at Uxbridge. The R.A.F. teleprinter facilities at C.H.Q. were increased, and included a special teleprinter circuit from the receiving room to the 2nd T.A.F. receiving room at Uxbridge for the passing of intercepted signals traffic. The R.A.F. receiving station provided standby monitory watches on many operational frequencies. The R.A.F. Signals Section, C.H.Q. Portsmouth, was placed under the operational control of C.S.O. 2nd T.A.F.

The strategic W/T communications of the A.E.A.F., those circuits which linked the air headquarters of the Air Forces on the Continent with Headquarters A.E.A.F. in the United Kingdom, consisted of both high-speed automatic W/T circuits and of circuits operated at hand speed linking Headquarters A.E.A.F. with the Headquarters of 2nd T.A.F., Ninth U.S.A.A.F. and No. 85 Group, and with the Base Signals Centre. To provide communications in the United Kingdom a W/T receiving station was set up at Stanmore and two new transmitting stations were built, one at Garston and the other at Weyhill.[1] The receiving station at Stanmore had 20 H.F. receiving positions, with an associated traffic office and signals distribution centre. All W/T reception at this station was at hand speed. Coaxially fitted vertical aerials were erected on triatics supported on 60-ft. G.P.O. masts near the receiving station; one aerial was made to serve three receivers simultaneously.

The transmitting station at Garston served the receiving station at Stanmore; it was capable of holding 35 T.1190 transmitters, of which 25 were actually installed. In addition to housing transmitters for the strategic links operated from Headquarters A.E.A.F., this station provided transmitters for the Movement Liaison Service and for No. 46 Group. All H.F. transmitter aerials were coaxially fitted verticals supported on triatics between 105-ft. wooden towers. The existing A.D.G.B. transmitting station at Bushey was arranged to provide a limited number of H.F. transmitters for use in emergency should Garston be unserviceable through enemy action or other causes. A number of mobile M.F. transmitters were set up for the purpose of broadcasting friendly aircraft movements and enemy aircraft tracks to the assault forces, three being set up at Garston and two at Bushey as a standby. Considerable difficulty was experienced in finding

[1] A.H.B./IIS1/34/1.

frequencies suitable for consistently good reception, and simultaneous broadcasts on two transmitters were arranged so as to provide 100 per cent reception during the operation.

The United Kingdom terminations of the high-speed automatic W/T links with the Continent were set up at the Air Ministry W/T Station at Chicksands, from which SWB8 transmitters installed at the new transmitting station at Weyhill were operated. Two duplex and one simplex tied teleprinter circuits were established between the signals centre at Headquarters A.E.A.F. and Chicksands to enable outgoing encyphered signals to be passed to Chicksands for transmission by high-speed automatic W/T and incoming signals to be passed in the reverse direction as quickly as possible. In addition, the teleprinter facilities at Headquarters A.E.A.F. and Chicksands were increased to facilitate the rapid despatch of signals to the main addresses in the United Kingdom, such as the Air Ministry, Forward Equipment Unit, and B.P.S.O. The Forward Equipment Unit was provided with a direct teleprinter circuit to Chicksands and the B.P.S.O. with a direct circuit to Headquarters A.E.A.F.

A Movement Liaison Section was set up in the filter room at Headquarters No. 11 Group, and a W/T receiving station was built adjacent to this filter room, housing ten R.1188's, together with three R.1084's which were provided for M.F. working in conjunction with the mobile M.F. transmitters at Garston. At each of these positions auto W/T keying facilities were provided, in addition to hand keys. These facilities were provided because, during operation exercises, H.Q. Ships and F.D.T.s reported that unsatisfactory morse sending had produced faulty plots. Arrangements were also made for the M.L.S. receiving station to key H.F. transmitters at Garston or Bushey for M.L.S. point-to-point links to Ninth Air Defence Command and No. 85 Group.

The W/T organisation of the A.E.A.F. had a number of links between 2nd T.A.F and Ninth U.S.A.A.F., and also between Headquarters A.E.A.F. and the two air forces; and the policy decided on for manning these joint lateral links was that both terminals of any W/T lateral link between the two air forces were manned by operators of the same Service. In actual practice however, it was not necessary to enforce this rule rigidly, as the employment of combined procedure (C.C.B.P.1) smoothed out the differences between the British and U.S. methods.

Separate traffic and teleprinter/teletype offices were set up at Hillingdon for 2nd T.A.F. and Ninth U.S.A.A.F., manned by R.A.F./W.A.A.F. personnel in the case of 2nd T.A.F. The traffic office at Headquarters A.E.A.F. at Stanmore was run on a combined basis with a proportion of the U.S.A.A.F. personnel working with R.A.F. personnel under the control of an R.A.F. traffic master. The signals distribution section was also set up on a combined basis. The teleprinter room was manned entirely by R.A.F./W.A.A.F. personnel.[1]

[1] A.H.B./IIS1/34/1.

2nd T.A.F. and Ninth U.S.A.A.F. planned their own communications forward of their headquarters in both cases. Operational communications were centred on the main headquarters, and administrative communications on the rear headquarters. The communications of No. 85 Group were less complicated, both operational and administrative communications being centred on the headquarters. The communications rearward of 2nd T.A.F. and Ninth U.S.A.A.F., comprising links to Headquarters A.E.A.F., were planned by the latter headquarters. These communications were the main operational and administrative links to the United Kingdom.

Heavy mobile W/T units for the passing of operational traffic to the United Kingdom were based on main Headquarters 2nd T.A.F. and Headquarters Ninth U.S.A.A.F. For administrative traffic, a special mobile signals unit known as the Base Signals Centre was established on the lines of an inter-Command W/T station, with direct hand-speed W/T links to main and rear Headquarters 2nd T.A.F., Headquarters Ninth U.S.A.A.F., and tactical groups and ancillary units in No. 85 Group and 2nd T.A.F. such as A.S.P.s and R.S.U.s. The centre also had direct high-speed automatic links to the United Kingdom. It became the main centre of the R.A.F. base teleprinter network and the collection and despatch centre for all R.A.F. administrative signals traffic passing from the forward areas to base and to the United Kingdom and in the reverse direction.

Direct cross-channel communication by W/T and/or teleprinter was established in August 1944, from Headquarters A.E.A.F. in the United Kingdom to Headquarters 2nd T.A.F. and Headquarters Ninth Air Force on the Continent. The Advanced Headquarters of A.E.A.F. on the Continent had its own W/T system direct to A.E.A.F. Rear and to 2nd T.A.F., manned entirely by the R.A.F. As a rule, W/T was used for all short messages and teleprinter for lengthy messages that could be sent in clear. The mobile signals units (Type 'T') that were established for simplex cross-channel communications became redundant, but continued to fill a need on the Continent by being employed at No. 85 Group to alleviate the many landline difficulties experienced under conditions of rapid mobile warfare.

By the end of August 1944, the rapid advance of ground and air forces in France had made it frequently impossible for landline construction to provide essential strategic communications from Advanced Headquarters A.E.A.F. back to the United Kingdom and downwards to 2nd T.A.F. and Ninth Air Force. An urgent operational requirement existed to provide this essential communication by some other means. As it stood, when landline communication could not be provided, the only alternative was A.D.L.S. or W/T, neither of which was a satisfactory solution for communications between such headquarters, and which were wholly unsuitable for personal conversation between the Air C.-in-C. and his sub-commanders. Shortly before this need became apparent, the War Office made available to the Air Ministry a newly developed pulse communication radio equipment designed to provide six high quality speech circuits or the equivalent number of teleprinter circuits or any combination thereof up to a distance of about a hundred miles.[1] The equipment operated on a very narrow beam and the security of the speech was comparable to that of the telephone. This equipment was the only type likely to satisfy the requirement, and authority was requested to establish a mobile multi-channel communication unit consisting of a headquarters and two echelons of eight sections each. The unit was established in No. 26 Group, trained at Chigwell, and later transferred to Headquarters A.E.A.F. One of the echelons linked routes to the cable terminal from the United Kingdom and the other provided links laterally to 2nd T.A.F., Ninth Air Force and the Cs.-in-C. Command Post, such as could not be provided in time by landline. Mobile signals units Type 'W' and 'C.A.' had already been approved to provide mobile communication links between 2nd T.A.F. and its subordinate formations, and the operational role of these units became complementary to that of the new unit. The new equipment was called Army Type 10. Unfortunately, it came very late in the day, fulfilling a need that had existed for some time. It resembled radar equipment in essence, and trained radar operators and mechanics were required for its use.

The Ninth Air Force was established at St. Cyr (Versailles) on 1 September 1944, alongside Advanced Headquarters A.E.A.F., who had their own P.B.X. operated by Air Formation Signals personnel. But first there was a shortage of trunk routes and Advanced Headquarters A.E.A.F. used the Ninth Air Force lines to 2nd T.A.F. and their P.B.X. was connected to the Ninth Air Force exchange. They had two lines to the 12th Army Group trunk exchange, which joined them to the Army network. S.H.A.E.F. provided the lines down to their level.

Owing to serious delays to urgent W/T messages caused by the overloading of priorities, it became necessary in September 1944 to provide a further priority, to be available only to A.Os.C. and their direct representative, i.e. S.A.S.O. or A.O.A. No delegation to staff of the new priority could be made. It was known as 'Flash' and it had no normal operational or administrative use. The new priority took precedence over all existing priorities and, in effect, messages allotted this priority were dealt with to the exclusion of all other traffic.[2]

By November 1944, the number of circuits on the cross-channel telephone switchboard at Uxbridge was reaching the maximum that could be handled on the three positions which this P.B.X. contained. There was no room for extending the P.B.X. on its existing site, and as it was anticipated that the demand would grow, it was decided to take over the existing operations P.B.X. belonging to Headquarters Fighter Command at Stanmore, which was a six-position heavy control board, after the departure of Headquarters

[1] A.H.B./IIS/110/5/304.
[2] A.H.B./IIS/110/5/304.

2nd T.A.F. and Headquarters Ninth Air Force to the Continent. A new four-position P.B.X., capable of expansion, was installed in the underground block for Headquarters Fighter Command, the Fighter Command circuits and extensions were transferred to this P.B.X., the cross-channel circuits at Uxbridge were transferred to Stanmore, and the Uxbridge P.B.X. was recovered. At this stage the concentration point in the United Kingdom was split into two, Stanmore serving the needs of the R.A.F. and Headquarters U.S.S.T.A.F. at Bushey serving the U.S.A.A.F.[1] The transfer was completed early in January 1945.

The cross-channel communications in November 1944 consisted of five speech circuits by submarine cable (two to S.H.A.E.F., one to Base Signals Centre at Ghent, one to Ninth Air Force at Chantilly, and one to T.A.F. Main at Brussels); five duplex R/T radio links (four through Dover and one through Willingdon, two to the Base Signals Centre, two to T.A.F. Main, and one to S.H.A.E.F.); two H.F. W/T links for groups and sectors; and three H.F. W/T meteorological interception watches. By the end of 1944, the total of submarine cable circuits had increased to nine.[2]

The move to Stanmore, however, proved to be only a temporary one. It soon became apparent that a considerable increase in apparatus and accommodation would be required at Stanmore if it was to continue to house the signals equipment for both A.E.A.F. and A.D.G.B. It was therefore for consideration whether some other site might be found which would be more suitable than Stanmore. An analysis and appreciation of the cross-channel telephone services was effected in January 1945, and a report with recommendations was issued in the following month. It was eventually agreed to form a new cross-channel signals centre at Chicksands 'B', which was already housing standby automatic W/T circuits to the Continent. The original decision to form the new centre was taken in November 1944, shortly after the move from Uxbridge to Stanmore. The first plan was for accommodation at Chicksands to house four auto duplex circuits, seven hand simplex circuits, and some 25 landline and teleprinter circuits, with 17 typex positions, book cypher facilities, and a traffic office capable of handling up to 250,000 groups per day. Equipment to cope with the majority of these requirements was already in existence at Chicksands 'B' but it was necessary to alter the layout to enable traffic to be handled efficiently and to provide room for expansion. Later the plans were expanded, so that the traffic and cypher offices could handle a peak load of 500,000 groups per day. The target date for completion of the buildings and installation was 14 March 1945. The new schedule of W/T circuits to be operated was one auto duplex circuit to S.H.A.E.F., three duplex circuits to advanced base signals centre, base signals centre rear and 2nd T.A.F., with four spare auto duplex circuits and 12 spare hand simplex circuits. A schedule of landline and teleprinter circuits was prepared for the G.P.O.,

[1] The American cross-channel switching centre was later moved to High Wycombe.
[2] A.H.B./IIH/243/169(B).

eight of which were via the D.T.N. and cross-channel cables, and four via ' Racehorse '.[1] However, these requirements were considerably reduced in April 1945 in view of developments in north-west Europe. The transfer of circuits from Stanmore was not finally completed until August 1945.[2]

Base Signals Centre

The function of the Base Signals Centre was to enable a large volume of signals traffic to be passed between the forward and base areas on the Continent and the United Kingdom. Operational control was vested in No. 85 Group. The Centre had a R.A.F. W/T section and an Air Formation Signals Company responsible for the manipulation of the teleprinter organisation and telephone cable system. The R.A.F. section was formed by amalgamating two heavy mobile W/T units and three mobile signals units Type ' A ', providing in all two duplex high-speed automatic circuits and 24 hand-speed simplex circuits. It was planned that the Base Signals Centre would later take over the operation of the radio telephone and teleprinter duplex circuits of the V.H.F. south coast radio scheme, and would become the main R.A.F. cable and teleprinter switching centre in the base area and a terminal to the D.R.L.S. and A.D.L.S. systems. A large traffic office staff was therefore provided, capable of handling at least 60,000 groups daily. Experience gained during the training period resulted in the amalgamation of the mobile signals units into one establishment, eliminating their individual status and effecting a considerable saving in technical personnel.

The four beach squadrons were equipped with transportable H.F. W/T and R/T apparatus, to provide R/T communications between sections and beach flight headquarters and R/T and W/T between beach flight headquarters and beach squadron headquarters. The beach squadrons' headquarters opened watch with the ' A ' Echelon No. 83 Group, with Portsmouth C.H.Q., and later with Main Headquarters 2nd T.A.F. A standby H.F. W/T link was arranged to enable the beach squadrons to operate to H.Q. Ship and Headquarters 2nd T.A.F., but this link was not needed.

The static communications were exercised as much as possible for a considerable period before D-Day to enable weaknesses and faults to be remedied and W/T operators and cypher staffs to obtain practice. Many communications exercises were arranged in the three months prior to D-Day, and these were mainly concerned with exercising those communications channels which were scheduled to be set up between the H.Q. Ships and F.D.T.s and the United Kingdom during the operation. Many difficulties were overcome in this period, mainly in the selection of frequencies. Communications between shore and ships and ground and air were exercised to maximum capacity in some fifteen exercises between February and May 1944.

[1] A.H.B./IIM/B26/1A.
[2] A.M. File CS.23930.

The majority of communications which opened on D-Day were W/T and R/T links controlled by Headquarters 2nd T.A.F., Headquarters Ninth U.S.A.A.F. and the Combined Control Centre. The first V.H.F. R/T duplex circuit, between the radio P.B.X. at Uxbridge and No. 483 G.C.C., was established on D plus 7. Initial communication was brief but good results were obtained next day. ' Racehorse ' No. 1 was set up on D plus 8 to No. 83 Group. R/T to the radio P.B.X. was good and the teleprinter worked successfully within 48 hours. The quality of speech on the cross-channel V.H.F. R/T circuits was very good, but calls via the radio P.B.X. were comparatively few, due to the restriction on users of the service and the lack of security on radio telephone circuits. Communications were successfully established in nearly all cases on the Task Force, H.Q. Ship and F.D.T. waves, although some interference was caused from radar transmissions. The interference was cleared by changing the frequency of the interfering radar station.

The W/T links were established between the 2nd T.A.F. and No. 83 Group Main Headquarters, and between Headquarters Ninth U.S.A.A.F. and the Ninth Tactical Air Command, in accordance with the Signals Plan. The scale of communications was ample and signals delays were small.

In order to deal with the many communications requirements from the signals staffs at 2nd T.A.F. and Ninth U.S.A.A.F., a Signals War Room was set up at Headquarters A.E.A.F. on D plus 2. All W/T and R/T channels scheduled to be set up between the two headquarters and their subordinate formations were displayed. Reports of the state of W/T and R/T circuits were made twice daily by 2nd T.A.F. and Ninth U.S.A.A.F., and schedules were amended accordingly for inspection by staff officers of A.E.A.F.

Aircraft Warning and Control

The amphibious nature of the early stages of ' Neptune ' made it necessary to plan for a complete aircraft warning and control organisation, installed in ships, to cover the assault areas and the shipping lanes. The organisation had to be designed in such a manner that it could fit in with and act as an extension of the static organisation in the United Kingdom, to be transferred to the far shore without any break in the continuity of either warning or control. The major difficulties encountered with H.Q. Ships and F.D.T.s were the installation of technical equipment and the selection of suitable frequencies to avoid mutual interference between signals and radar equipment. On the British site three H.Q. Ships, each with a standby, took part in the operation. The communications available on H.Q. Ships and F.D.T.s were as follows :—

(a) *Air Command Wave:* This wave was controlled from the Combined Control Centre, Uxbridge, and was installed specifically for the use of the Air Force Commanders. It was also provided as an Air Force wave. Watch on this channel was maintained in all

H.Q. Ships and F.D.T.s. It was used mainly as a broadcast channel and only stations specifically addressed answered calls.

(b) *H.Q. Ships and Air Base Wave:* One W/T Air Base wave operated by the Combined Control Centre was shared by British Headquarters Ships. This wave was provided as a means of passing to other H.Q. Ships and back to the United Kingdom those signals which for security or other reasons could not be sent by R/T.

(c) *H.Q. Ships Air Liaison Wave:* This was a V.H.F. R/T point-to-point channel between the Commanders in the United Kingdom and their representatives in H.Q. Ships.

(d) *H.Q. Ships Standby Liaison Wave:* This was an H.F. standby to the V.H.F. air liaison wave.

(e) *H.Q. Ships/F.D.T.s Liaison Wave:* This circuit was for communication between controllers and Air Force representatives in H.Q. Ships and F.D.T.s.

(f) *Aircraft Waves:* Five V.H.F. R/T channels were available for communications with aircraft for operation of the controller in the operations room in H.Q. Ships and four channels were fitted for use by the F.D.T. controllers.

(g) *Home Shore Plot Broadcast:* This was a liaison wave for M.F. W/T plots from the United Kingdom of enemy and identified aircraft, made from the No. 11 Group filter room for reception by all H.Q. Ships and F.D.T.s.

(h) *M.L.S. Broadcasts:* This was a similar broadcast to the home shore plot broadcast for passing movements of friendly aircraft originated from the No. 11 Group filter room.

(j) *F.D.T. Plotting Wave:* An inter-F.D.T. H.F. W/T or R/T plotting wave.

(k) *Far Shore Plot Broadcast:* A watch on the liaison wave was kept by H.Q. Ships and F.D.T.s to receive the broadcast of tracks from Nos. 83 and 85 Group formations on the far shore.

(l) *F.D.T. Air Base Wave:* This was an H.F. W/T channel for communication between the Combined Control Centre and F.D.T.s. and was later extended to Base defence group units on the far shore.

(m) *F.D.T. Air Liaison Wave:* This was a V.H.F. R/T or W/T channel similar to the H.Q. Ship air liaison wave, but in this case shared by the F.D.T.s.

(n) *F.D.T. Air Liaison Standby Wave:* This channel used H.F. R/T or W/T, was brought into operation on D-Day, and worked well.

The communications plans envisaged a decentralisation of control from the Combined Control Centre and Executive Control Centre at Uxbridge to southern sectors of the A.D.G.B., to H.Q. Ships and F.D.T.s, and later to

A.E.A.F. units on the far shore. For this reason, the communications provided between the United Kingdom and H.Q. Ships and F.D.T.s were duplicated in F.C.C.s, Composite G.C.C.s, and No. 85 Group Base Defence sectors ashore, and in order that there should be no break in the continuity of communications responsibility for the control of air support and air cover in the assault areas was transferred from the F.D.T.s and H.Q. Ships to the Allied Air Commander on the far shore.

Radio communications in H.Q. Ships and F.D.T.s were generally satisfactory, and the internal communications proved entirely adequate. Tannoy speech amplifier equipment was not supplied in all cases but was found to be extremely useful where it existed. The accommodation available for R.A.F. personnel was inadequate, and this applied not only to working conditions but also to the space available for recreation and exercise. Standby H.Q. Ships were provided with sufficient communications equipment to take over from the H.Q. Ships in the event of the latter becoming casualties.

Mutual Interference

As the planning for Operation 'Neptune' progressed it became apparent that there would be a greater concentration of communications equipment and radar installations in the assault area than had ever been the case in previous operations. It became clear that if the radar and communications equipment were to function satisfactorily, a detailed study of interference possibilities must be made and careful control exercised in the allocation of frequencies and in the siting of equipment.

A meeting was held at the War Office on 27 September 1943, at which representatives of the three Services discussed the degree of interference which might be anticipated between radar communications equipment in a congested bridgehead area. Although much was already known about interference between radar and wireless equipment, little experience had hitherto been gained of the interference which might be expected when large quantities of equipment were used within a confined bridgehead. It was therefore decided that a practical trial should be conducted at an early date in which radar and wireless installations of 21st Army Group, 2nd T.A.F. and the Navy would be assembled together in a layout which would simulate the conditions in the early stages of a beach landing.

The trials were conducted in December 1943 near White Waltham, Berkshire, and an interim report was published on 29 December. This report provided information for the guidance of planners and resulted in certain modifications to equipment being undertaken with a view to minimising interference. The final report on the trials was not available until early in March. It contained the complete data available as a result of the trials, and it included a guide to the siting of the radar and communications equipment so as to avoid mutual interference, based on the results of the exercise.[1]

Although the trials provided much valuable information, they did not cover a number of equipments which were scheduled for use in the early stages of the assault. Further, the possibility of mutual interference between various communications networks used by the three Services had not been adequately covered. A paper was therefore presented to the Combined Signals Board by the Signals and O.R.S. staff of Headquarters A.E.A.F., pointing out the necessity for further trials and asking that a committee be appointed with adequate powers to perform the task. Pending the formal approval of the Combined Signals Board to the formation of a Mutual Interference Sub-Committee, investigations into the terms of reference were continued by inter-Service discussions and by the Radar Sub-Committee of the Combined Signals Board. A meeting of the Radar Sub-Committee on 14 March listed a number of interference problems requiring special investigation. They included interference to radar and communications equipment from the SCR.268; mutual interference in and between the V.H.F. point-to-point communications system and the V.H.F. south coast scheme; interference between V.H.F. ground/air communications and radar equipments; interference between naval radar equipment and the V.H.F. south coast scheme; and interference to radar and communications equipment by R.C.M. jammers. It was agreed that detailed investigation was required into all the problems listed and that practical trials would in some cases be necessary. In order that the work should start at once, a Technical Working Sub-Committee was formed to study the interference problems in detail and to organise the various trials required.

At a meeting of the Combined Signals Board on 15 March 1944, it was agreed that a separate Sub-Committee should be set up with the following terms of reference:—

(a) A Mutual Interference Sub-Committee of the Combined Signals Board should be formed under the Chairmanship of the Air Signals Officer-in-Chief, A.E.A.F.

(b) This Committee to deal with trials, research and the technical study of mutual interference with the object of providing information that would enable the users of radio and radar to avoid interference inherent in the use of radio and radar equipment.

(c) The Secretariat to be provided by the Basic Sub-Section Signal Division, S.H.A.E.F.

(d) This Committee to consist of members from Signal Division, S.H.A.E.F., A.N.C.X.F., A.E.A.F., E.T.O.U.S.A., First U.S. Army Group, and 21st Army Group.

(e) Scientific and other members to be co-opted by members as required.

(f) Reports to be submitted to the Combined Signals Board so that the necessary instructions could be issued.

[1] A.H.B./IIS1/34/1.

There was very little time left in which to organise trials if the results were to be of value in Operation 'Neptune', and many of the problems were solved as far as possible by theoretical calculation. In order to facilitate this work and to organise the various trials, a Tactical Study Group, consisting of selected members of the Committee, was set up on a full-time basis. The problems of interference were dealt with by the Committee under eleven major headings.

G.L. Mark II on the far shore was dealt with by restricting the frequencies on which it was to operate, trials showing that these restrictions enabled the equipment to be safely operated without causing serious interference; and no serious interference was in fact caused in the bridgehead area by this equipment. The same restrictions could not be applied to G.L. Mark II in the United Kingdom without imposing serious limitations on the operation of the equipment, and individual G.L. Mark II sets were checked and their frequencies modified where necessary. Only one case of interference was reported, and the trouble was located and cleared quickly. Severe interference to V.H.F. receivers of the south coast scheme was caused by the Naval Type 281 sets in trials and the frequency of operation of these sets was restricted, so that during 'Neptune' the V.H.F. south coast scheme was clear of interference from this source except for one brief and isolated case. The interference which V.H.F. ground/air and point-to-point communications equipment caused to radar equipments was reduced by the fitting of suppressors to the R.A.F. equipment.

The V.H.F. south coast scheme was originally planned on the assumption that no other communications equipment would be used in the frequency band of 65—69 mc/s. After the original scheme was worked out, it became clear that a large number of equipments operating in this band would be required for point-to-point communications on the Continent, and in addition, further demands were received from the Services for increases in the number of cross-channel circuits and point-to-point circuits working from south coast sites. The question of possible interference to the V.H.F. south coast scheme required the most careful investigation, and the Technical Study Group therefore conducted practical trials from which firm recommendations could be made which were submitted to the Combined Signals Board for approval and were accepted by all Services. The policy was that every endeavour must be made to avoid the use of frequencies whose harmonics would cause interference if transmitted within certain specified distances of the receiving cross-channel service. Further demands for additional cross-channel facilities were made the subject of similar investigations, and all the original circuits were able to operate throughout the assault phase without interference from other communications equipment. Two cases of interference by Gee stations were reported, but in each case the trouble was located and cleared without difficulty. From the information obtained in this investigation, it was found possible to produce a chart showing the necessary siting and frequency limitations to be observed in the bridgehead for interference-free point-to-point communications as well.

The powerful Gee/GH transmitters were capable of causing serious interference to communications, but after an investigation specific frequencies were agreed which avoided interference except in one or two cases of frequency drift. Frequencies were selected for C.H. stations on the south coast which allowed these stations to operate without causing interference to the south coast scheme. A number of tests were carried out to establish the interference likely to accrue from the use of R.C.M. jammers, and a chart was produced showing interference capabilities of all forms of R.C.M. jamming equipment in use.

Despite the precautions taken it was felt that real danger of interference still remained during the early days of the assault and special staffs were set up to determine and eliminate any instances of interference without delay, one at Portsmouth at the main terminal of cross-channel communications, and two in the bridgehead, one with the First U.S. Army and the other with the Second British Army. Useful work was done by all three parties. The far shore staffs assisted in siting equipment and tracing local interference, and the Portsmouth staff dealt with some 90 cases of V.H.F. interference between 5 and 18 June.

As a result of the precautions taken, very little interference was experienced in the use of radar and wireless communications in the assault phase of 'Neptune'. The three Services were thus enabled to take advantage of the vast assortment of communications and radar equipment which had been planned for their use.[1]

Allocation of Frequencies

A tentative frequency allotment for the Services taking part in the operation was discussed at a meeting at Norfolk House on 8 December 1943. The allotment covered the band 1·5 to 8 mc/s, this being the most useful band for communications purposes, and therefore the band which presented the most acute problems. Allocation was spaced at 5 kc/s, omitting only the most essential frequencies employed by the Admiralty, War Office and Air Ministry formations, and broadcast stations. Zones were quoted in which the frequencies might be employed, and maximum power limitations were listed against each registration.

Bids for the number of frequencies required had previously been made by the various Services and these far exceeded the number of frequencies available, so that a large amount of inter-Service sharing was resorted to. Of the 420 frequencies originally allotted to the air force, 189 were shared with other Services. This inter-Service sharing was undesirable in view of the co-ordination which it necessitated and the difficulties this co-ordination presented. A smaller number of frequencies specifically allotted to individual

[1] A.H.B./IIS1/34/1.

Services was preferable. The deficiency of frequencies required by the Air Force was particularly severe in the 3 to 4 mc/s band, and it was ultimately agreed by both ground and air forces to reduce the spacing of frequencies between 1·5 and 4 mc/s to 4 kc/s. In addition, a mutual exchange was made between Air Force and Army groups of certain allotted frequencies between 4 and 8 mc/s. This produced small blocks of consecutive frequencies, in which the spacing was again reduced to 4 kc/s. The final allocation was concluded in mid-April 1944, approximately 385 frequencies being allotted to the Air Force, all unshared by other Services. Estimated requirements were obtained from each of the formations concerned, and blocks of suitable frequencies allotted. The formations included the Headquarters of A.E.A.F., Ninth Air Force, 2nd T.A.F., Nos. 85, 46, 38 and 60 Groups, and No. 80 Wing, H.Q. Ships, and the R.A.F. Regiment. Priority was given to frequencies for H.Q. Ships because of their complex systems. Medium frequencies were specially selected and cleared for M.L.S. broadcasts.

The need for a sub-committee to plan frequency allocation became increasingly apparent on the Continent, and a Frequency Allocation Sub-Committee of the Combined Signals Board was set up in Paris in September 1944, and all requests for additional frequencies or for exchanges were considered by this Sub-Committee. Frequencies for circuits having terminals in the United Kingdom and the Mediterranean were cleared with the British Joint Communications Board (B.J.C.B.) or A.F.H.Q. as appropriate. The reduction of frequency spacing from 5 to 4 kc/s did not greatly increase interference. Transmissions were crystal controlled wherever practicable. The frequency requirements of 1st T.A.F. (Provisional), British and American Transport Commands, and other formations which subsequently came under Air Staff Control, were met by sharing within the block air allotment as far as possible and by obtaining a few additional frequencies from the Sub-Committee.

The congestion in the ether in 'Overlord' was greater than in any previous operation. Throughout the entire operation the officers engaged in frequency allocation wrestled with a problem which at the outset appeared to be almost insoluble, and it was mainly due to their skill and perseverance that the Services of the Allied nations were able to derive so much benefit from telecommunications, radar and radar navigational aids throughout all phases of the operation.

Submarine Cables

Submarine cables were planned to be laid across the channel under arrangements made by the War Office and the British Post Office under the general direction of the Supreme Comander. Allocations were made by the S.H.A.E.F. Combined Signal Board to all major arms, i.e., Army, Navy, Air Forces, Press, Foreign Office etc. Difficulties were experienced initially because of the number of wrecks on the sea bottom and the mines encountered, but the ultimate programme was completed as follows:—[1]

	Cable No.	Completed	
Southbourne—Longues	1	*1944* 13 January	4 channels
Southbourne—Longues	2	18 January	3 speech and 6 teleprinter
Swanage—Cherbourg	4	5 August	12 channels
Swanage—Cherbourg	5	3 August	12 channels
Cuckmere—Dieppe	6	12 September	12 channels
Dover—Andreselles	7	23 October	12 channels
Dover—Sandgate	8	24 October	12 channels
Dover—Sandgate	9	*1945* 11 January	12 channels
Dover—Sandgate	10	17 January	12 channels
Cuckmere—Dieppe	12	6 March	12 channels
St. Margaret's Bay—La Panne	1926 cable rehabilitated by 23 December 1944		16 circuits
St. Margaret's Bay—La Panne	1930 cable rehabilitated by 31 November 1944		14 circuits

It had been proposed to lay the No. 10 cable to La Panne, but the retention of the Dunkirk area by the Germans prevented this from being accomplished, and in consequence a second cable was laid to Dieppe. The rehabilitation of the 1926 and 1930 La Panne cables was not entirely successful owing to their proximity to shipping lanes into Antwerp, and in consequence one was retained out of service as a standby to the other. In addition two Type 10 links were installed by War Office Signals across the channel to serve as standby against cable failures. During the latter phases of the campaign, equipment was installed on the Cable No. 11 to Calais to provide 60 speech channels on one cable, and a second was being converted at the time of cessation of hostilities.

It was decided to maintain one or two centres in the United Kingdom to

[1] A.H.B./IIE/159.

act as switching centres for cross-channel circuits, so that the service could be made available to the greatest possible extent. It was deemed impracticable to do this on the Continent owing to the difficulty in providing and maintaining high grade circuits from any switching centre on the Continent. In this way it was also considered that greater control would be exercised over the users of cross-channel facilities.

The difficulties which were experienced with cross-channel submarine cable circuits were mainly confined to the Continental extensions from the cable head. In dealing with long distance landline communications generally, considerable use had to be made of French civil cables, which in the vicinity of the initial beachhead were very badly damaged. Early extension could be made from Longues on overhead constructions, but as the advance progressed beyond Paris this became impracticable. The cables at Longues and Cherbourg had to be relied upon until after the capture of Dieppe, as it was not practicable to lay a concentric cable to any intermediate point owing to the distances involved. As it was, only four channels were available on each Longues cable, compared with twelve in the Cherbourg area, on account of the additional distance.

The route which could be used for extension eastward was either Carentan—Bayeux—Falaise—Rouen—Paris, or Carentan—St. Lo—Avranches—Rennes—Le Mans—Chartres—Paris, and whereas the former was seriously damaged during the fighting, the latter was only badly damaged over the Carentan—St. Lo—Avranches portion. The former route was used for the extension of circuits to the British Forces, when suitably restored by the laying of cable east of Bayeux, and the latter was used for extension to the American forces by building an overhead rapid airline route from Carentan to Laval. Cross-channel circuits for the Ninth Air Force took the Laval route, and were successfully extended through Paris to Verdun on underground cable, and thence to Luxembourg on overhead routes, and though the serviceability at times was indifferent, operational contact was maintained throughout the summer and autumn. The extension of circuits to 2nd T.A.F. was more difficult, and after the Headquarters had moved north of the Seine, communication was unsatisfactory until the completion of the Dieppe cable. Once 2nd T.A.F. was installed in Brussels communications gradually improved both in quality and quantity as additional cables became available. The fact, however, that the centre of gravity for Continental communications moved north and east caused serious difficulties owing to the inadequacy of the main cables to Belgium from the Pas de Calais, and so the rehabilitation of the La Panne 1926 cables in December 1944 proved most valuable to 21st Army Group and 2nd T.A.F.

The provision and maintenance of teleprinter circuits to the United Kingdom provided a special problem. In the initial stages use was made of 'S' plus 'D' equipment in order that the small number of speech circuits could be used to the greatest effect, and although in certain cases satisfactory telegraph channels were obtained, it was found that unless the speech and telegraph channels were to work between the same points, the telegraph channel could not be guaranteed reliable. On the other hand, voice frequency channels are not capable of indefinite extension, and it was decided to open up a 12-channel system from the Base Signals Centre at Ghent to Stanmore (owing to equipment shortages at Stanmore, it was finally installed to Uxbridge). This system provided the bulk of the telegraph circuits to 2nd T.A.F. Headquarters, Eighth Air Force, Fighter Command and No. 72 Wing, as extensions were engineered on direct Air Force systems from the Base Signals Centre to the formations involved.[1]

With the amalgamation of S.H.A.E.F. and A.E.A.F. in October 1944, C.A.F.S.O. was made responsible for the co-ordination of all cross-channel requirements of the Allied Air Forces. This work was carried out by the Air Forces Landline Priority Committee under the chairmanship of C.A.F.S.O., and all sub-allocations to Air Forces and formations were made on an individual circuit basis. The requests had to be examined in detail to ensure that operational requirements obtained highest priority. During the latter part of 1944 and early 1945, however, there were increasing demands for communications by formations operating non-operational aircraft, as well as the requirements of the Joint Continental Airways Traffic Board, which had been set up in London to handle the control of aircraft flying between the United Kingdom and the Continent. Joint Airways Traffic Centres were set up in London, Paris and Brussels which required cross-channel communications and which to a certain extent duplicated and conflicted with those already requested by the various organisations associated with the operation of transport aircraft such as U.S.S.T.A.F., A.T.C., R.A.F. Transport Command and Continental Flying Control. In consequence a meeting was called by C.A.F.S.O. in January 1945, as a result of which it was decided to utilise the Joint Airways Traffic Centres at Paris and Uxbridge as Switching Centres for the various operating formations. It was, however, found possible to provide telegraph channels to meet individual needs, partly because they were more numerous and partly because the switching of telegraph circuits had not proved altogether successful or economical.

As the campaign came to a close the submarine cable facilities were so improved that consideration could again be given to the provision of the individual requirements in the Paris area because they could be provided on cross-channel cables in the Western Group, which for geographical and engineering reasons could not be extended into Germany.

Long Distance Continental Landline Communications

Army Groups, Tactical Air Forces and Com. Z [2] were each responsible for

[1] A.H.B./IIE/159.

[2] Communications Zone, Ninth Air Force.

developing a main line network, either by building new routes or by the rehabilitation of existing plant in their respective areas, according to a pre-arranged scheme calculated to meet the requirements of all formations and headquarters as they were phased over the Continent and moved forward along their axes of advance.

In the first instance the main line network was built by Army Group/Tactical Air Force Signals as a series of overhead routes following the main axes of advance; but as the advance became more rapid these overhead routes were linked up to existing underground cables which had been hastily rehabilitated. The work of rehabilitation was mainly carried out by Army/Air Force Signals personnel, later assisted to an increasing extent by the French P.T.T. In this connection the achievements of Ninth Air Force in extending two cross-channel circuits from Carentan to Luxembourg is worthy of note; the Headquarters never lost touch by telephone with the cross-channel switchboard in Stanmore except for limited periods of unserviceability.

In the early stages the only line communications outside the Army Group/Tactical Air Force sphere of responsibility were those serving echelons of Headquarters A.E.A.F., S.H.A.E.F., and Headquarters U.S.S.T.A.F., and the allocation of resources to meet these requirements was made by C.S.O., S.H.A.E.F. Up to the fall of Paris the numbers of extra Army Group/Com. Z circuits was very small, but afterwards, consequent upon the moves of various headquarters and formations to the Continent which were not under the command of the Supreme Commander, in addition to the normal base organisation, the allocation of long distance circuits passing through more than one of the Army Group/Com. Z areas became extremely difficult. With effect from 1 September 1944, the Supreme Commander assumed responsibility for the direct control and co-ordination of the main trunk telecommunication network on the Continent. A.E.F. Long Lines Control was therefore set up by C.S.O., S.H.A.E.F., in the Head Office of the P.T.T. in Paris to control the Com. Z allocation, the rehabilitation of the French P.T.T. system, and the allocation of cable pairs on certain specified main routes, up to and including designated forward repeater stations. Rehabilitation of cables and allocation of pairs beyond these stations on the main routes, and similar work on other cables in the Army Group areas, were handled by the appropriate Army Group/Tactical Air Force. A senior officer representing C.S.O., S.H.A.E.F., was responsible for the Long Lines Control and officers were attached from each of the Army Groups. Responsibility for the operation and maintenance of landline facilities was shared by Army Group/Tactical Air Force and Com. Z. Boundaries of responsibility were agreed upon and varied to correspond with the forward moves of Army Headquarters. As it was evident that a large number of long distance Air Force circuits would have to be cut up in the base area, C.A.F.S.O. made arrangements with C.S.O., S.H.A.E.F. for a part of C.A.F.S.O.'s staff to be detached for duty with A.E.F. Long Lines Control to look after the interests of the Air Forces. At the same time careful consideration was given to the possibility of establishing Air Formation Signals or U.S. Air Force Signals personnel at each of the main repeater stations, to assist the Com.Z/Army Group/P.T.T. staffs to look after the Air Forces' long distance circuits. The scheme, however, was found impracticable owing to manpower considerations, but the principle was agreed that wherever possible subordinate Air Forces should detach technical personnel to repeater stations handling their own circuits; and in consequence a small detachment of No. 18 A.F.S. was associated with the Paris Repeater Station. Subsequent experience proved that this action had achieved excellent results, particularly in the maintenance of Air Force circuits and the clearance of faults on them.[1]

Up to the amalgamation of Headquarters A.E.A.F. and S.H.A.E.F., C.A.F.S.O. had only been responsible for communications of Headquarters A.E.A.F. and the Tactical Air Forces. Afterwards, however, he was made responsible for the co-ordination of all Air Force landline requirements in the theatre, which included Headquarters U.S.S.T.A.F., A.A.C.S., Air Transport Command, R.A.F. Transport Command and Eighth Air Force Fighter Command. This co-ordination could not be carried out at A.E.F. Long Lines Control and in consequence an Air Force Landline Priority Sub-committee was set up under the chairmanship of C.A.F.S.O. consisting of D/C. A.S.O.(I), D/C. A.S.O.(II) and C.A.F.S.O., for the purpose of examining all requests for long distance landline circuits required by Air Force headquarters and formations other than the Tactical Air Forces. The Committee also dealt with conflicting requirements over routes controlled by A.E.F. Long Lines Control by the assessment of circuit requirements on a priority basis. This increase in the responsibilities of C.A.F.S.O. meant that the Air Force representative at A.E.F. Long Lines Control had to be reinforced and two additional officers were attached there.

The decision in January to move part of the Allied Airborne Army from the United Kingdom to the Continent created a special problem because the responsibility for providing long distance communications was partly Army and partly Air Force. It was therefore agreed with C.S.O., S.H.A.E.F. that the Air Forces would be responsible for the communications required within Ninth Troop Carrier Command on the Continent as well as any long distance circuits required by the ground forces which terminated on airfields. The First Allied Airborne Army had no construction personnel for main line construction, but considerable building effort was saved by locating two of the Troop Carrier Wings and their associated Groups at stations and airfields previously occupied by Ninth Bomber Division formations. Necessary construction in the American area was performed by Com. Z Signals personnel. The Third Wing was accommodated in the Amiens area, and C.A.F.S.O. was able to make arrangements with C.S.O., A.F.S., 2nd T.A.F. for the loan of some Air Formations Signals construction personnel to provide communications for the 52nd Troop Carrier Wing. Although time

[1] A.H.B./IIE/159.

was short, the First Allied Airborne Army expressed their satisfaction with the landlines set up for Operation 'Varsity'.

The shortage of signals construction battalions within the American Air Forces was of a serious nature. Originally, the Ninth Air Force had six signals construction battalions, which were distributed one to each of the two Tactical Air Commands, one to the Ninth Air Force Service Command, one to the Ninth Air Defence Command, and two to the Ninth Air Force Headquarters.[1] In order to simplify construction and maintenance, trunk lines which were common to the Air Force and ground forces were constructed under the supervision of the ground forces' headquarters, pooling the Air Force and ground force construction units that could be made available. This was notable in the case of circuits between Air Force and Tactical Air Command Headquarters, which largely coincided in routeing with the circuits from Army Group to Army Headquarters. Below Tactical Air Command Headquarters' level, many of the Air Force circuits were along routes differing from those used by ground forces by virtue of the fact that Wing and Group Headquarters were located so as to be near to airfields, whereas the Corps and Division Headquarters were located to be in favourable positions with respect to front line ground troops. This pooling of construction personnel was felt to be of material advantage in meeting construction requirements. The chief signals officer of the Ninth Air Force estimated that he obtained use of over 50 per cent of the circuits constructed in order to meet the large Air Force requirements but had contributed only about one-third of the construction troops involved in building these lines.

The construction effort available to the Ninth Air Force was reduced upon the formation of the Headquarters, XXIX Tactical Air Command (Prov.) to operate with the Ninth Army, and again when the Headquarters First Tactical Air Force (Prov.) was formed. A signals construction battalion assigned to each of these two headquarters resulted in a corresponding loss of two construction battalions from those previously serving Headquarters, Ninth Air Force, Ninth Air Force Service Command and Ninth Air Defence Command. In order to compensate for this loss a request was made through U.S.S.T.A.F. in November 1944 for three additional signals construction battalions to be assigned to the American Air Forces in the theatre.

The shortage of signals construction battalions was felt more strongly when Ninth Troop Carrier Command was moved to the Continent without any construction units available for assignment to that Command. The situation was still further complicated by Eighth Air Force units being brought to the Continent without signals construction units. In the United Kingdom the Eighth Air Force had relied on the G.P.O. to meet all line requirements.

In March 1945, it was learned that no signal construction battalions could be made available from the United States for a period of six months. It was found, however, that two construction battalions could be obtained from

[1] A.H.B./IIE/159.

the Mediterranean Theatre, and these were brought in. The first was assigned to the Ninth Air Force and the second to the First Tactical Air Force (Prov.). By this time it was evident that the war would not last for a further six months in Europe and the request made on the United States for additional battalions was cancelled.

The original six battalions assigned to the Ninth Air Force would probably have been sufficient if the original organisation had been continued. The introduction of additional Air Force headquarters into the theatre without the accompaniment of additional signals units, however, caused a severe weakening of the signals organisation. The lesson was that the formation of additional headquarters must always be accompanied by the provision of additional signals units to serve those headquarters.

Handling of Traffic on Landlines

Until the provision of submarine cable circuits, all traffic between the United Kingdom and the Continent was routed by W/T, thus causing unavoidable delay due to encyphering and decyphering. The provision of submarine cable circuits eased the situation, but initially these circuits were not too reliable due to faults while continental cables were being rehabilitated, and to the movements of the continental terminations.

Traffic from the United Kingdom formations was passed to the Cross-Channel Signals Centre at Stanmore in plain language. This not only avoided the United Kingdom formations having to hold all the cyphers in use on the continent, but avoided the useless encyphering of messages which would be routed via the cable circuits, Stanmore being the only centre knowing the minute-to-minute serviceability of the channels necessary to determine the routeing.

After the move forward in autumn 1944, communications between the United Kingdom and the major Air Force headquarters, and between these headquarters and their lower formations, became very unstable and considerable difficulty was experienced in disposing of traffic by normal means, so that frequent diversions to A.D.L.S. had to be made. Extensive rearrangements and extensions of the United Kingdom Cross-Channel Signals Centre, Stanmore, combined with the increased serviceability of the existing, and the provision of additional, cable circuits, however, enabled this critical period to be overcome. No further major difficulty was experienced in handling cross-channel traffic after this period.

One of the major difficulties in the handling of signals traffic was the lack of knowledge of the location of units. Routeing was done by formation rather than location, traffic being routed to the superior headquarters of the unit addressed, irrespective of the location of the unit. As a result some signals followed a circuitous route, but the advantage was that no widespread dissemination of unit locations by a central traffic control was necessary.

The method caused some confusion, however, during transition periods, when some units of major formations were on the Continent and some in the United Kingdom.[1]

Various minor difficulties existed between the major Air Force Signals Centres, mainly due to differing interpretation of instructions and lack of knowledge of the composition of some of the organisations. The difficulties were overcome by holding a series of conferences attended by officers dealing with traffic handling at the major headquarters and signals centres.

The large amount of through traffic which was handled at the major S.H.A.E.F. signals centres, coupled with the possibility of cable circuits becoming unclassified, made it desirable to introduce some scheme to reduce the time taken to handle messages at intermediate centres. This could be accomplished in two ways, by the switching of teleprinter/teletype circuits, and by the use of a tape relay system. For the operation of the first of these systems it was essential that the speed of all machines should be identical. Switching was carried out to a limited extent between British and American formations, but owing to the difference in speeds between the British teleprinter and the American teletypewriter, it could not be introduced throughout the theatre. The British equipment had the advantage that switching could if necessary be made with the United Kingdom and also with German machines, which ran at the same speed. A number of American teletypewriters were adjusted to work at the British speed. The advantage of the system was that the time taken by intermediate stations to re-transmit was cut out, thus not only speeding up the transmission of the message but also saving line and typewriting time and reducing the possibility of transmission errors. The disadvantages, apart from the necessity for all machines being capable of operation at the same speed, were that a slight increase in circuit provision was necessary, and switching could only be carried out via one intermediate centre.[2]

The tape relay system involved the receipt at the intermediate station of all through messages on a reperforator, and of obtaining a punched tape which could be fed through an auto transmitter to the next station. This system was also used to some extent, mainly by the American forces, as shortage of the necessary equipment prevented its introduction to any great extent within the R.A.F. Once again, British and American equipment was not fully interchangeable. The advantage of the system was that no increase in the number of circuits was required to cater for peak traffic, as during these periods traffic could build up and be disposed of in its turn.

Within the United Kingdom the D.T.N. was regarded as secure, classified material being carried in plain language. The possibility of interception by the enemy was considered remote. On the Continent, however, the situation was different as the enemy had had time to prepare plans for intercepting

[1] A.H.B./IIE/159.
[2] A.H.B./IIE/159.

our landline channels. Various instructions were issued to ensure the security of classified traffic.

With the provision of cross-channel cable circuits, the circuits on the radio P.B.X. at Uxbridge were gradually replaced until practically all radio circuits, except for a small number of 'Racehorse' circuits, were closed. The name of the P.B.X. was changed at this stage to the 'Air Force Cross-Channel P.B.X.'. Later it was found that the P.B.X. at Uxbridge was too small to cope with expansion and it was moved to Stanmore.

Signals Facilities for Transport Command on the Continent

The role of Transport Command in operations in support of the liberation of Europe was six-fold: the towing of gliders for individual operations, emergency supply dropping, transport of emergency supplies and personnel reinforcements by air, the ferrying of reserve aircraft and personnel, the evacuation of casualties, and the maintenance of Air Stores Parks (A.S.P.) in the field. The first two of these responsibilities were carried out by Nos. 38 and 46 Groups together, the last four by No. 46 Group alone. No signals facilities were required on the Continent for No. 38 Group, but for the more routine tasks undertaken by No. 46 Group, staging posts on the Continent with mobile signals facilities were essential. As a general rule, Transport Command did not make use of A.E.A.F. operational airfields, and an independent signals organisation for the aircraft of No. 46 Group was therefore required.

The requirement in England was for medium power aircraft guard, emergency standby point-to-point between group headquarters and their respective squadron airfields, and, for No. 46 Group, a number of low power point-to-point channels providing communication with Transport Command airfields and headquarters formations on the Continent. The requirement on the Continent was met by the allocation of air transportable signals units and mobile signals units for point-to-point, H.F. D/F, M.F. D/F, M.F. beacons, etc. The provision of line communications on the Continent was the responsibility of the A.E.A.F.

To meet the Transport Command requirement in the United Kingdom, three T.1190's belonging to the A.E.A.F. and operated from Garston were allocated for use by Headquarters No. 46 Group, to be operated from its Headquarters near Stanmore; and a further five T.1190's belonging to A.E.A.F. and operated from Uxbridge were earmarked for the use of No. 46 Group when no longer required by 2nd T.A.F. or Ninth Air Force. As these formations moved overseas their requirement for cross-channel point-to-point circuits decreased, and the laying of cross-channel cables further eased the situation, so that it was possible for the five T.1190's to be transferred to Garston and used by No. 46 Group in June 1944. The minimum operational requirements of No. 46 Group following the invasion were met by an

SWB8 at Northwood, remotely controlled from No. 46 Group Headquarters, and by the three T.1190's at Garston.[1]

Transport Command forward staging posts were established on suitable airfields near Headquarters 2nd T.A.F. and the Headquarters of Nos. 83, 84 and 85 Groups. There was a requirement for three types of W/T station, the air transportable signals unit (A.T.S.U.), the mobile W/T station, and the transportable W/T station. The A.T.S.U. was flown in to forward airfields to establish temporary point-to-point services and navigational aids before the arrival of more powerful and more durable equipment in the shape of the mobile W/T stations, which accompanied all the major headquarters. Transportable W/T stations were necessary in the base area for the main base airfields.

A number of additional channels were provided for increasing commitments in the course of 1944, and there was a general build up of A.T.S.U.s, mobiles and transportables. In addition, a special channel was opened to link the stations concerned in the evacuation of casualties from the Continent with the R.A.F. hospital at Wroughton. It was also decided that Transport Command units overseas must be able to receive all meteorological broadcasts, and also be in a position to broadcast 'actuals' themselves. The existing facilities in the various signals sections allowed for only one meteorological broadcast receiver, and it was decided in October 1944 to form Meteorological Broadcast, Reception and Transmission Signals Units (M.B.R.T.S.U.s). Until these units were formed, reception watches were carried out as far as possible from existing resources.[2]

In October 1944 it was decided to form a Continental Aircraft Control Centre (C.A.C.) to act as a safety and flying control centre for inbound and outbound non-operational Transport Command aircraft flying over the Continent of Europe. A six-position exchange at Uxbridge, thrown spare by the departure of Headquarters 2nd T.A.F. for the Continent, was taken over for this purpose. The scale of operational and administrative speech and teleprinter circuits to airfields under the C.A.C. sphere of influence was agreed, together with cross-channel teleprinter lines and remote control keying lines. On the W/T side, medium and short range day and night air-to-ground circuits were arranged, plus point-to-point circuits for aircraft movements, meteorological and administrative services. The transmitters in use at Uxbridge for No. 46 Group, which by this time amounted to nine T.1190's, were transferred to Garston, and new transmitters for C.A.C., including six T.1279's and two L.M.300's, were installed at Uxbridge in their place. The transfer took place in January 1945.

Additional requirements arose as the advance on the Continent continued and as the flow of aircraft to the Far East increased. In January 1945 a Joint Air Traffic Centre was set up at Uxbridge, to operate in conjunction with C.A.C. and to organise the movement of aircraft of all commands,

[1] A.H.B./IIS/110/9/50.
[2] A.H.B./IIS/110/9/50.

U.S.A.A.F. and R.A.F., on non-operational flights to the Continent.[1] It was considered essential that C.A.C. should exercise W/T control over all aircraft flying under their organisation until they reached their first stop. In order to embrace all existing and visualised air services, long range transmitters were required, and to accommodate these transmitters a number of existing transmitters used for training purposes and as spares were recovered. By April 1945 the total transmitter requirement for C.A.C. had been agreed, and included point-to-point channels for north-west and western Europe, and long and medium range aircraft guard circuits, plus a number of point-to-point channels connecting C.A.C. with the main Continental airfields.[2]

Landlines for Radar Navigational Aids

In the early conception of the role of No. 72 Wing it was emphasised that the Wing could only function effectively with landline communications, but a thorough investigation of the probable movements of the Wing and its stations indicated that the stations would be widely dispersed and would in the main be well within the tactical areas where good communications could not be guaranteed. A modified scheme was therefore prepared to utilise radio wherever practicable until such time as landlines could be provided to the required scale.

No. 14 A.F.S. was allotted to the Wing and was able to provide local routes, but the long distance circuits had to be provided through the Long Lines Control organisation, No. 14 A.F.S. being called upon to link up the stations with the Terminal Repeater Stations. Long distance communications in the British Zone were therefore arranged through 21st Army Group, and in the U.S. Zone through Long Lines Control, Paris. Two main difficulties were soon apparent. The first was that due to the fact that the main requirement for long distance circuits was parallel with the front and the main rehabilitation programme had been organised to build up the main axes of communications for the advancing armies and army groups, it was difficult, if not impossible, to obtain allocation of circuits. Secondly, the radar sites themselves were situated without any regard to the location of terminal repeater stations, with the result that long extensions had to be built, sometimes over mountainous country.[3]

In consequence of these difficulties it was decided to open a switching centre at Jemelle in the Ardennes, to which all Oboe stations could be connected, to provide a flexible system and to economise in communications. This centre was connected to No. 72 Wing and Ninth Bomber Division by speech and teleprinter lines, and by teleprinter to No. 8 Group in the United Kingdom. It proved to be quite effective, but had to be abandoned during the German push in the Ardennes in the close of 1944. The Oboe Stations were then concentrated in the Mons area.

[1] A.M. File CS.23782/I.
[2] A.M. File CS. 24108.
[3] A.H.B./IIE/159.

With the subsequent advance into Germany by the Allies, the Oboe Stations were again redeployed, but by that time Jemelle could no longer serve them as a switching centre, and the old plan had to be taken up again. Movement was, however, so rapid, and provision of communications so difficult, that nothing more than a skeleton network was built up by 'V.E.' Day.

Movement Liaison Service

Information on the movements of friendly aircraft flying between the Continent and the United Kingdom was needed by those formations concerned with identifying friendly and enemy aircraft, so as to avoid useless intercept sorties and the engaging of friendly aircraft, and to ensure that enemy raids were intercepted. For aircraft flying from the United Kingdom to the Continent, the United Kingdom Movement Liaison Service (M.L.S.) organisation at Hill House, Stanmore, was utilised, information being transmitted in advance to the Continent by W/T.[1]

M.L.S. Hill House was connected to the main operational Commands in the United Kingdom by teleprinter, and information of aircraft movements was passed to the M.L.S. When received at Hill House the information was encoded and transmitted on the M.L.S. Medium Frequency Broadcast. Adequate arrangements were made to see that traffic levels were maintained so that the enemy could get no information of impending raids from traffic peaks.

It was decided to split the M.L.S. broadcast into two halves, one transmitting movements which were mainly of interest to the U.S. Zone, and one to the British Zone. In practice the rules governing the overlap of the two Zones were so broad that all movements had to be transmitted on both frequencies. Later this caused considerable trouble, as the numbers of sorties were so large that messages got seriously delayed. Efforts were then made to reduce the overlap messages to ensure that only those movements were transmitted to the respective Zones which would definitely interest them.

Movement messages were given serial numbers. The object of this was to enable units to check that they had received all messages. If they missed one they could ask for a repeat on an H.F. channel upon which M.L.S. Hill House kept permanent watch. Hill House kept a listening watch on one H.F. channel for the British Zone and one for the U.S. Zone.

The system as originally established worked satisfactorily throughout the operation in so far as the British Zone (North Western and Northern France, Belgium, the Netherlands, and North Western Germany) was concerned. The only change made was to install a higher power M/F transmitter to counter attenuation as the distances increased, and to overcome the inter-

[1] A.H.B./IIE/159.

ference from German sources as our forces approached these sources and moved away from Hill House.

In the U.S. Zone the system worked satisfactorily at first, but as distances increased, particularly when U.S. forces approached the Swiss and Southern German frontiers, it became unsatisfactory. Some of the difficulties experienced were outside the scope of pure signals, but the fact also remained that the distances involved, the erratic areas of reception, and the interference from German sources, made reception of broadcasts difficult.

To try to overcome the difficulty both changes in frequency and increases in transmitter power in the Hill House broadcast to the U.S. Zones were tried, but neither was satisfactory over the whole 24 hours. It was thus clear that retransmission from the Continent would be necessary.

The Ninth Air Force had set up at Le Bourget an internal Continental Movements and Flying Control Organisation. It was decided to adapt this organisation to include the movements of aircraft from the United Kingdom to or through the U.S. Zone. The M.L.S. Broadcast from Hill House was received at Le Bourget and passed over an H/F network to the interested Ninth Air Force units. Ninth Air Force were also made responsible for passing the information to First T.A.C.A.F. units. Later a teleprinter circuit was provided between Hill House and Ninth Air Force, M.L.S., and wire circuits from Le Bourget downwards.

In the U.S. Zone the Ninth Air Force not only passed the information to Tactical Control Centres (T.C.C.), but also to the Air Force A.A. Brigades which would be affected by particular flights. A.A. Gun Operations Rooms (G.O.R.s) were notified from T.C.C.s through the Army A.A. Liaison officers on duty in the T.C.C. operations room.

Although the U.S. Continental system as described in the preceding paragraphs worked very well in its final form, some difficulties were encountered at first which caused, or at least contributed to, the unnecessary loss of mutual friendly aircraft.

Due to an apparent misunderstanding of S.H.A.E.F. and of Ninth Air Force instructions, the W/T transmitters from Le Bourget were used only as a 'standby' to direct reception of the Hill House broadcasts by the T.C.C.s, and were used only on the request of the T.C.C. concerned. Since this was a negative use in that it was manifestly impossible for the T.C.C. to know if it had failed to receive a complete Hill House message, many complete messages failed entirely to reach the T.C.C.s and G.O.R.s. Also, in the case of at least one T.C.C., the responsible officers had not been informed of the presence of an M.L.S. station at their location, and were depending upon operations channels from their Tactical Command Headquarters to supply them with M.L.S. information, which often arrived too late to be of value. Upon discovery and correction of the faults quoted above, the Movements

Liaison Service on the Continent operated satisfactorily to the end of the war in Europe.

It was considered that the complications of a wireless organisation for reporting movements to the United Kingdom would be so great as to make such a system unworkable and it was therefore decided to rely on the use of corridors for flights to the United Kingdom. The condition of the enemy Air Force helped to make this system satisfactory.

Air Formation Signals

It was realised in 1942 that the original Air Formation Signals Charter was out of date, and in 1943, with the need for a detailed plan for R.A.F. communications on the Continent following an invasion, an attempt was made to outline a provisional organisation. This was based on the principle that all operational ancillary units of the R.A.F. operating on a given Army front would come under the command of the A.O.C. of the composite group associated with that Army. The composite group included fighters, fighter bombers, support bombers, and reconnaissance aircraft, and the group headquarters was sited with the Army Headquarters and moved with it, being divided into Rear and Advanced Headquarters as in the case of the Army. The control of squadrons by the Advanced Group Headquarters was carried out through sectors, each with its own Mobile Operations Room Unit (M.O.R.U.). Rear Group Headquarters was responsible for the administration of all R.A.F. units and groups in the area. Although it was accepted that R.A.F. communications must be capable of being provided by wireless, a comprehensive landline system was required to replace and augment the wireless system as soon as possible. Landlines were required for operational use between Advanced and Rear Group Headquarters, from Advanced Group Headquarters to each M.O.R.U., from M.O.R.U.s to adjacent M.O.R.U.s, from Advanced Group Headquarters to the Rear for the control of heavy and medium bombers, perimeter cables at airfields, laterals between Advanced Group Headquarters, and local operational lines from Advanced Group Headquarters and M.O.R.U.s to Mobile Air Reporting Units (M.A.R.U s), A.A. Gun Operations Rooms (G.O.R.s), etc. For administration, lines were required from each airfield, each M.O.R.U., each R.A.F. installation (e.g., Air Stores Parks) and each Headquarters, to the nearest Army Exchange. The responsibility for the provision of landlines on the Continent lay with S.H.A.E.F., from whom it was delegated to the Signals Corps of the Armies. It followed that the Army line network must be supplemented to carry R.A.F. traffic, and that area exchanges or line centres were required as early as possible in the lines of communication and in G.H.Q. areas, wherever there were groups of airfields. In the early planning stages for the invasion, diagrams of telephone and telegraph circuit requirements and provisional signals layouts at the various R.A.F. formations and units were drawn up.

Two new Air Force Formations, one British and one American, were set up to form the Allied Expeditionary Air Force, and demands for landlines for these new formations were co-ordinated by a department under the chairmanship of the Air Signals Officer-in-Chief, A.E.A.F., which was set up in October 1943.[1]

The necessity for establishing and training units of Air Formation Signals within the A.E.A.F. was recognised, and the War Office, at the request of the Air Ministry, agreed to provide the requisite number of units. It was not until the autumn of 1943, however, that these units began to receive the specialist training necessary for the tasks that lay ahead.

In September 1943, Brigadier J. H. Cameron-Webb, who had been C.A.F.S.O. in the Middle East since 1940, was recalled to the United Kingdom specially to be appointed Chief Air Formation Signals Officer, A.E.A.F., and a branch was formed under him. The staff was an integrated one, covering both British and American aspects. The initial planning of Allied Air Force line and D.R.L.S. requirements was then carried out, in close collaboration with Headquarters 21st Army Group and Headquarters 2nd T.A.F.

In October 1943, many of the A.F.S. units had still not joined their respective Air Force formations, and they were getting little or no practical knowledge of R.A.F. organisation and requirements. Negotiations were therefore begun between the War Office and the Air Ministry which resulted in the handing over of all the required Air Formation Signals units to the R.A.F., where they were placed under the command of the Air C.-in-C. At the same time, C.A.F.S.O., A.E.A.F. took over responsibility for the tactical training of all A.F.S. units.

By the beginning of 1944, the majority of Air Formation Signals units had been moved away from their forming-up stations and had joined the Air Force formation to which they had been allotted. By 1 April, the allocation of units was:—

No. 11 A.F.S.	No. 83 (Composite) Group.
12 A.F.S.	H.Q. 2nd T.A.F.
13 A.F.S.	No. 84 (Composite) Group.
15 A.F.S.	No. 2 (LB) Group.
16 A.F.S.	No. 85 (Base) Group.
18 A.F.S.	H.Q. A.E.A.F.
17 A.F.S.	Theatre Reserve.

No. 85 (Base) Group was rather late in forming by comparison with the other groups, but it soon became apparent that its responsibilities on the Continent, which would entail not only the air defence of the Base and L. of

[1] A.H.B./IIS/110/3/79.

C. but also heavy administrative responsibilities, necessitated the allocation of a second unit. As a result, No. 17 A.F.S. was allotted to the Group on 30 May and a request was made to the Air Ministry for the allocation of No. 14 A.F.S. as a theatre reserve in its place. Detailed planning was carried out by headquarters and groups and by the A.F.S. units allotted to them under the general direction of C.A.F.S.O. and two Chief Signals Officers, A.F.S., one of whom was appointed to Headquarters No. 85 (Base) Group and one to Headquarters 2nd T.A.F. These two officers, like Cameron-Webb, were experienced men specially recalled for the Mediterranean theatre, and they were able to give units the benefit of their knowledge and experience and so avoid many of the mistakes made in previous campaigns.

During the planning stages it was apparent that the territorial restrictions on the beachhead would bring about confusion if all Air Formation Signals personnel were not under one command, and yet it was important that elements of No. 16 A.F.S. with No. 85 Group units should go into the beachhead on D-Day so as to construct the communications which they would ultimately have to maintain when the beachhead had been expanded. In consequence those elements of No. 16 A.F.S. which went ashore in the early phases were placed under command of O.C., No. 11 A.F.S. with No. 83 Group. Furthermore, as the campaign progressed it was necessary to place C.S.O., A.F.S., Base Area under the operational control of C.S.O., A.F.S., 2nd T.A.F., which arrangement remained throughout the campaign, due to the change whereby No. 85 Group was placed under command of the Air Marshal Commanding, 2nd T.A.F. Henceforth, the build-up of A.F.S. units on the continent continued until by the end of September 1944 all units had moved to the continent except No. 15 A.F.S. with No. 2 (LB) Group.[1]

Some difficulty was experienced due to the original conception that there should be one A.F.S. unit for every fifteen squadrons. Whilst this was considered to be a good guide, the large number of headquarters which had to be served in the A.E.A.F. made such a definition impracticable. C.A.F.S.O. obtained Air Ministry authority to treat the reserve unit, No. 14, as a Theatre Reserve for training purposes, without it being specifically allotted to A.E.A.F.

The decision to send No. 72 Wing to the continent precipitated further negotiations, for Air Ministry laid down that although No. 72 Wing could function with only very limited landline communications, it was imperative to provide a general link-up of the No. 72 Wing stations, despite the distances involved, otherwise only very poor results would be obtained. Air Ministry authority was therefore obtained in September 1944 for No. 14 A.F.S. to be allotted to No. 72 Wing, and to come under the operational control of C.S.O., A.F.S., Base Area.

The setting up of an organisation for No. 33 Wing was expected to require

[1] A.H.B./IIE/159.

a Composite Company of Air Formation Signals, and in view of the fact that there were to be only two echelons of Headquarters A.E.A.F., or later Air Staff, S.H.A.E.F., on the Continent, No. 3 Company of No. 18 A.F.S. was loaned to 2nd T.A.F. to cover the initial provision of communications. In January 1945 it was possible to withdraw the Company and to allot it to No. 107 Wing of Transport Command (which had been set up in Paris), for its associated staging posts throughout France.

Later, various other minor commitments arose in the Paris area, such as Continental Flying Control at Le Bourget, and the Joint Airways Traffic Centre. All these were conveniently covered by the company with No. 107 Wing. When No. 87 Group was formed by 2nd T.A.F. to administer all R.A.F. units in France, No. 3 Company, No. 18 A.F.S., was transferred to it from No. 107 Wing. By this time the commitments in the Paris area had grown to such an extent that the Company was not strong enough to deal with the additional responsibilites of No. 87 Group. This was only a temporary situation, because in due course Air Ministry planned to replace all Air Formation Signals operating personnel by R.A.F. or W.A.A.F. in accordance with the normal agreed policy. The Company was, therefore, reinforced by a section on loan from 2nd T.A.F.

By the time the decision had been made to move No. 80 Wing to the Continent, the Air Formation Signals and Army Signals manpower situation had become very acute. Communications had become very stretched, rapid advance had necessitated hasty improvisation, the Ardennes battle had necessitated considerable rehabilitation, and technical personnel had to be left behind in the rear areas to help the French Postes and Telegraphes to establish and maintain long distance and cross-channel landline communications. It was therefore quite out of the question to provide Air Formation Signals personnel for No. 80 Wing from Continental resources. C.A.F.S.O. therefore took up the case with the Air Ministry in December 1944 for the allotment of an additional A.F.S. unit in this theatre. No. 1 Air Formation Signals had just returned to the United Kingdom from Italy, and the Air Ministry and War Office agreed to allot it to No. 80 Wing, but on reduced establishment, there being insufficient time and trained personnel available to make this unit up to strength.

During the initial planning for Operation 'Apostle',[1] it had been visualised that there would be no requirements for Air Formation Signals personnel for that operation, as Scottish Command had accepted responsibility for providing all landlines for the R.A.F. elements. Early in 1945, however, Fighter Command commenced detailed planning, and when C.A.F.S.O. was consulted he recommended to Fighter Command that there should be an Air Formation Signals Composite Company added to the Order of Battle, and a small Air Formation Signals staff established on the Headquarters of the A.O.C. Air Ministry then requested Air Staff, S.H.A.E.F., to provide this Composite Company, as well as another Composite Company for Head-

[1] Code name for occupation of Norway, February to May 1945.

quarters, Air Division C.C.G. (B.E.). These commitments could only be accepted on the basis that 'Apostle' would not be mounted until some forty days after 'V.E.' Day, that No. 60 Wing would be withdrawn after 'V.E.' Day, and that C.C.G. (B.E.) would not require any Air Formation Signals before 'V.E.' Day.

Air Ministry gave a policy ruling regarding the withdrawal of No. 80 Wing, and C.A.F.S.O. was able to go ahead with the planning and instruct C.S.O., Air Formation Signals 2nd T.A.F. to earmark the company. As it happened, Operation 'Apostle' was mounted earlier than was planned, and considerable difficulty was experienced in getting the Composite Air Formation Signals Company to the communication area in the time available, with no small amount of disorganisation of communications, particularly at No. 87 Group, due to the sudden withdrawal of sections.

By the end of the campaign there were on the Continent nine Air Formation Signals units under C.A.F.S.O. totalling some 330 officers and 7,130 other ranks.[1] The redeployment of these units was a matter of considerable difficulty, for apart from the need to reorganise them to enable complete units made up of suitable men to go to the Far East as a matter of some urgency, the operational signals commitments showed no signs of reducing for some time.

The fundamental organisation of A.F.S. units remained the permanent allocation to various headquarters and wings, etc., of appropriate types and numbers of sections, the principle being that these sections formed part of the formations to which they were attached and moved with them. The build-up of A.F.S. units was therefore broken down into sections and parts of sections, and the appropriate elements accompanied their R.A.F. formations, simplifying the allocation of shipping space.

The line communications laid down in the operational plans and signals instructions were successfully installed on the Continent and the major difficulty experienced was through the constant cutting and destruction of cables and lines by Allied traffic, tanks, bulldozers, etc. In spite of all these difficulties, A.F.S. units succeeded in maintaining communications at a highly satisfactory level.

[1] A.H.B./IIE/159.

CHAPTER 11

MOBILE AND TRANSPORTABLE SIGNALS UNITS

Use of Mobile Units Pre-War

The use of mobile signals sections with R.A.F. units in the field was customary from the earliest days of wireless telegraphy in the Royal Air Force.[1] Their chief use in the years immediately following the first world war was with armoured car units in Iraq, and for point-to-point and ground-to-air communications in army co-operation squadrons.

Wireless tenders for W/T and R/T communications with aircraft consisted of four different types, each specially constructed for differing classes of communication. The wireless apparatus in use included the T.25 and R.31 for mobile ground R/T, and the T.32 and R.27, and later the R.40, for mobile ground W/T.[2] However, in 1935, a new transmitter, the T.1090, was produced, ostensibly to meet the Army requirement of R/T communication from ground-to-air in the artillery reconnaissance band. Four of these transmitters, mounted in Morris six-wheelers with improved layout and accommodation, completed Service trials in the same year. The general results were so satisfactory that the possibility of producing one standard wireless tender to carry out all functions was considered, and after further trials it was decided to proceed with the design of a general purpose wireless tender to cover all operational communications requirements for army co-operation aircraft. The standard Albion 2-ton chassis was used, and by 1936 the body design was complete, and the first design under construction. The main points of the layout were :—[3]

(a) Transmitter T.1090, with a battery driven generator of 200 watts, and one of 80 watts for low power operation and standby.

(b) Two receivers, one for permanent operation in the vehicle and one fitted on to a crate for removal and use at the end of a remote control line.

(c) Remote control up to a quarter of a mile with telephones, and a quarter of a mile of line for connecting to the G.P.O. or local telephone system.

(d) Petrol/electric charging set.

This general purpose wireless tender marked a great advance in wireless tender design.

It was also decided on the grounds of mobility that, in addition to the

[1] The use of mobile signals units in France, the Middle East and North Africa, the Far East and in A.E.A.F., is further described in the chapters dealing with those theatres.

[2] A.M. Files S.23564 and S.25783.

[3] A.M. File S.34961.

ground-to-air stations, point-to-point stations operating with the army co-operation squadrons should be mounted on a 3-ton prime mover and trailer of an improved type. It was decided to use Crossley 3-ton lorries, and the layout of the equipment was :—[1]

(a) One 7 kW. petrol/electric alternator.

(b) One T.77 transmitter.

(c) One T.58 transmitter, to be replaced as soon as possible by a T.1087 transmitter, with R.1084 receiver.

(d) A quarter of a mile of remote control cable.
Also mast gear, telephones, and charging apparatus for the wireless batteries.

Apart from the T.1090, which was specially built for army co-operation purposes, the equipment used in these mobile W/T stations was ordinary Service equipment and not specially constructed for mobile use. Of the new wireless tenders, none was delivered to the overseas commands before the outbreak of war.

Mobile Automatic High-Speed Stations—' Blue Trains '

Concern was felt immediately after the outbreak of war for the maintenance of communications with the R.A.F. forces operating on the Continent in the event of enemy bombing being directed against landline communications. Cable and telephone traffic with France was a War Office responsibility, and the War Office had made some provision for W/T sets for emergency communications, but it was clear that in emergency the War Office could handle only a fraction of the normal landline traffic. It was decided in October 1939 to despatch two high-power high speed mobile W/T stations to France.[2] Action was taken at once for the provision of the equipment and vehicles, which were fitted out at Marconi's. The units were styled Nos. 1 and 2 Heavy Mobile W/T Sections, and were formed at No. 2 Wireless Station at Yatesbury in mid-October. Each section comprised one officer and 77 other ranks. Two heavy tenders carried the transmitter unit, one heavy tender with fuel and mast gear towing the power trailer, and three single-deck buses of the 'Green Line' type housed the receiving equipment—making a total per section of six prime movers and one trailer. The W/T equipment was the SWB8B, giving approximately 2½ to 3 kW., with receiver and ancillary gear giving full duplex high-speed automatic reception and transmission. One complete watch per section was sent overseas initially, the balance being made available to be despatched rapidly by air should they be required. Both units went to France in October 1939. In the event, neither unit was utilised to its full capacity, but it was considered that the units would have been capable of handling as much traffic as circumstances demanded. The M/T was not altogether suitable but the

[1] A.M. File S.34961.
[2] A.M. File S.2173.

W/T gave good service. All W/T equipment with the exception of aerial and mast gear was evacuated safely to the United Kingdom, but M.T. and camp equipment was left behind.[1] No. 2 Unit was re-formed in August 1940 at No. 1 Signals Depot and posted to Aldergrove in mid-August.[2] No. 1 was sent to the Middle East. No. 3 Unit was formed to go to the Narvik area in May 1940; the greater part of its equipment was lost in the subsequent evacuation.[3]

Proposals in August 1940 for reserve W/T equipment to meet emergency requirements included four medium heavy mobile wireless stations, which were designed to provide emergency point-to-point and aircraft communications in the event of main overseas stations being put out of action. The only suitable transmitter which could be provided in reasonable time to meet this requirement was the R.C.A. E.T.4331. The stations were constructed at No. 1 M.U. Kidbrooke, and were numbered consecutively 4, 5, 6 and 7. Each of these stations was required to provide two W/T services, a long distance main W/T channel using the E.T.4331 and a local W/T channel using a low power transmitter serving as a standby to the main equipment, and providing for a local point-to-point service from the mobile station to any other mobile or fixed W/T station operating in the area.[4]

By December 1940, not only had No. 1 Heavy Mobile Unit gone to the Middle East and No. 2 been sent to Northern Ireland, but two of the four reserve medium heavy mobile stations had also gone to the Middle East. Arrangements were put in hand to replace these four stations on the reserve, and an additional requirement included mobile high power transmitters type SWB8 for the five operational bomber groups, so that they might operate a second high power W/T channel when required, and six emergency and reserve transmitters for use in any desired location in the event of any of the main Air Ministry W/T stations at Greenford, Dagnall, Bodmin, Stubbington and Symington being damaged; these were also to be mobile SWB8's.

A number of other requirements, mostly overseas, necessitated the formation of several more heavy mobile automatic W/T stations as the war progressed. Nos. 8 and 9 were formed in December 1941 at No. 1 Signals Depot, West Drayton, for use in Iraq; personnel were withdrawn from No. 2 in Northern Ireland to provide a nucleus of experienced personnel.[5] Early in January 1942, it was decided to divert No. 8 to India, and No. 10 was formed to take its place in Iraq.[6] No. 11 was formed to meet a special commitment in connection with 'Torch' in 1942, and Nos. 12 and 13 were sent to North Africa early in 1943 to provide headquarters communica-

[1] A.M. File S.2173.
[2] A.M. File S.64259.
[3] A.M. Files S.61016 and S.3620.
[4] A.M. File S.5066.
[5] A.M. File S.2766/I.
[6] A.H.B./IIE/151/13-14.

tions.[1] No. 14 was formed in January 1943 at No. 1 Signals Depot for despatch to Tunis; the personnel were provided by H.Q. Middle East, who transferred them from No. 6, which was withdrawn to Cairo for refitting.[2]

The despatch of these units overseas meant that there were now no heavy mobiles left in the United Kingdom, and it was decided in 1943 to form two new mobiles for the future requirements of Headquarters Tactical Air Force, to provide adequate communications back to main stations. The two units were formed in Fighter Command, using manpower resources released by the disbandment of two G.C.I. stations. On completion of training, the units were transferred to the Tactical Air Force. A further heavy mobile unit was supplied to Headquarters Ninth Air Force, to provide one high-speed auto channel between Headquarters Allied Expeditionary Air Force and Headquarters Ninth Air Force; this unit was manned by U.S.A.A.F. personnel.[3] Further units were formed at Chigwell as an operational reserve, and a number of units were sent to B.A.F.S.E.A. By 1945, some 25 heavy mobile units had been formed in all.

Transportables

By March 1940 it had become apparent that in meeting certain emergency requirements, circumstances might arise in which wheeled vehicle mobile W/T stations could not be employed. In some theatres, the available shipping facilities could not handle large vehicles; in others, roads and tracks suitable for mechanical transport did not exist. There were also cases where a W/T service was needed on a semi-permanent basis only, and the use of vehicles was extravagant. In all such circumstances the solution was to employ transportable stations which could be broken down to units of such size and weight as could be transported by air and handled by men and pack animals. Small transportable pack sets, mostly using the T.1083/R.1082, were already in existence, but these were of insufficient power for the envisaged point-to-point requirements and wholly unsuitable for ground-to-air services. It was therefore decided to make use of the new Marconi T.1154, which was coming into service in large quantities, and a duplex station using a T.1154/R.1084 combination was mocked up for trials in a standard sectional H.F. D/F hut. Four stations were made at Kidbrooke, and 50 in all were ordered on 28 March 1940. The commitment included four stations on islands used by the G.R. squadrons in the Indian Ocean, and quantities for Leopard Force,[4] the Far East, Aden, the Middle East, India, and the United Kingdom. Half were made with H.F. D/F huts and half without; each unit was self-contained in its own packing case, the total weight being approximately 6 cwt. The power supply was provided

[1] A.M. File S.93261.
[2] A.M. File S.92765 and A.H.B./IIE/151/17.
[3] A.M. File S.93261.
[4] Code name for the large air striking force which was to be sent to Turkey in the event of invasion. February to June 1940.

by petrol/electric generator sets. By the middle of 1940 the first few sets were already being used in the field.[1]

By the end of 1942, it had become apparent that the policy on the provision of W/T pack sets needed fresh consideration. In the intervening years a variety of types had been built according to the availability of equipment, particularly in the Middle East, and used more or less indiscriminately. The types available were the T.1083/R.1082, T.1087/R.1084, T.1154/R.1155, and the T.1154 with a variety of receivers other than the R.1155. A new type, the T.1403/R.1224, was about to be tried out. A meeting was therefore held at the Air Ministry on 31 December 1942.[2] The production of ultra-light sets was not considered as the view was that the R.A.F. requirement was different from that of the Army, where a man might be required to carry a wireless set and fight at the same time. The R.A.F. problems were simply those of getting a suitable set to the point at which it was to operate and of getting the maximum output which could be obtained from a set which a man could carry. There were two distinct requirements, first for the R.A.F. Regiment, which was closely allied to the Army requirement since only short ranges were needed; and secondly, requirements for ground-to-air and point-to-point communications when it was impracticable to use standard transportables or radio vehicles owing to the particular type of operation or to difficult terrain. The types of unit likely to be engaged on such operations were Advanced Landing Ground Signals Sections and Field Force Headquarters Signals Sections.[3]

At the meeting at the Air Ministry on 31 December 1942, the types of transportable set required were classified as:—[4]

(a) Pack-set. This was defined as 'Equipment capable of animal transport'.

(b) Light transportable. This requirement was for equipment needed where M.T. could not travel (beach landings, mountainous country, jungles etc.) and for which the governing factor was that it must be capable of being manhandled. The power input was bound to be small as the power unit would have to be carried. No single load must be greater than 40 lb.

(c) Medium transportable. The requirement was that no one package was to exceed 120 lb. in weight and that each package should be designed for ease of handling by not more than two men; and that, in addition to compactness, the design should include safeguarding of internal fittings and components under conditions of general transportation.

In addition to these special requirements, the essential features of pack or transportable sets were that transmitters must have both crystal and

[1] A.M. File S.3682.
[2] A.M. File CS.17914/I.
[3] A.M. File CS.17914 and A.H.B./IIE/151/65(A).
[4] A.M. File CS.17914.

master oscillator control; that A.C. mains units were required for medium transportables and for a limited number of light transportables; that remote control facilities were required on both light and medium transportables; that some form of click-stop tuning mechanism on transmitters was essential; and that every effort must be made to attain the minimum power drain.

There was no suitable pack-set in existence that met the pack-set specification; the nearest approach to the light transportable requirement was the Army Type 22; and the American Collins 18Q seemed the most suitable medium transportable. Although it was hoped to make use of both the Army Type 22 and the Collins 18Q, the supply of both sets was uncertain, and it was therefore necessary first to make the best possible use of existing resources. In the case of the pack-set it was clear that for such uses as wireless unit communications the T.1083/R.1082 must continue to be used in large numbers.[1]

It was realised that the previous policy of using obsolescent aircraft radio equipment for transportable W/T stations, and of converting Army and American equipment for R.A.F. use, could never be expected to meet operational requirements fully, and in May 1943 the Director of Communications Development (D.C.D.) was asked to provide newly-designed H.F. apparatus to cover the three main types of transportable W/T station. Production of such equipment, however, could not possibly be expected to begin until late 1944, and it was therefore necessary to continue to improvise with existing equipment in the best possible manner to meet operational requirements over the intervening period.[2]

An instruction was issued on 17 May 1943 by the Air Ministry on the building of transportable W/T and R/T stations, clarifying responsibility for the construction of equipment. It was decided that the Air Ministry should cover the provisioning and authorise the issue of the animal pack-set (T.1083/R.1082), the existing contract being allowed to lapse on completion of current orders; and that Headquarters No. 26 Group should prototype six other types:—

(a) A light transportable W/T station embodying the Army Type 22 equipment.

(b) A hand-cart transportable W/T station embodying the Army Type 22 equipment.

(c) A medium transportable W/T station embodying T.1154/R.1155 equipment.

(d) A medium transportable W/T station embodying American Collins 18Q equipment.

[1] A.M. File CS.17914. For a description of the work of Wireless Units, see R.A.F. Signals History, Volume V—' Fighter Control and Interception ', Appendix No. 5.
[2] A.H.B./IIE/48.

(e) A medium transportable W/T station embodying T.1154/H.R.O. equipment.

(f) A medium transportable R/T station in the standard Army hand-cart embodying TR.1143 equipment.

At the same time, planned construction figures for 1943 were decided.

The prototyping of equipment was carried out by Headquarters No. 26 Group in the summer of 1943, but by the end of the summer it was apparent that, partly as a result of the non-availability of equipment, the production programme agreed in May 1943, and being carried out by No. 26 Group units, was very seriously in arrears. The original programme had been based on anticipated delivery dates of equipment the supply of which had fallen short of expectations.[1]

Production of most items did not begin until October 1943; this was carried out at the two signals depots, No. 1 Signals Depot taking much the largest part.[2] By the beginning of October, a revised building programme had to be issued.[3] The equipment accorded the highest production priority for 1943 was the medium transportable Collins 18Q.

In addition to the six equipments prototyped by Headquarters No. 26 Group as a result of the programme agreed in May 1943, it was decided in November 1943 that two new animal pack-sets should be prototyped, one comprising the Army Type 22 and the other the TR.1133. This was as the result of a requirement stated by Air Headquarters India. Their first requirement was for a set with a range of up to 800 miles with which units could work back to air bases in thick jungle and mountainous country. The equipment was to be carried by mules and no mule load was to exceed 160-180 lb.; loads were to be of equal weight to balance on either side of the mule, with no top loads. This requirement was stated by the R.A.F. officer attached to the Chindits; interchangeability between Army and R.A.F. equipment was regarded as desirable.[4] The second requirement was for a V.H.F. animal pack-set, to embody the TR.1133 (later the TR.1143 was substituted), to be a self-contained station with charging facilities packed for loading on mules. The equipment was to be robust and capable of running for three hours without battery charging, at an estimated 75 per cent on receive and 25 per cent on transmit; side loads of 80 lb. maximum each were required.[5]

Since deliveries of the new equipment under development by D.C.D. were not expected to begin before late 1944, it was necessary to continue the production of the interim equipment throughout 1944. A building programme was therefore prepared, to be carried out by the signals depots. Monthly production meetings were held at Headquarters No. 26 Group to

[1] A.M. File CS.17914/1.
[2] A.H.B./IIE/151/65(A).
[3] This is reproduced at Appendix No. 18.
[4] A.H.B./IIE/151/65(A).
[5] A.H.B./IIE/151/65(A).

approve prototypes and review production figures. It was decided that, until the new equipment was available, the major production for the future should be centred on the R.A.F. Type 20 and R.A.F. Type 22 medium transportables (the Collins 18Q and the TR.1143). These two sets were given top priority for completion of drawings and specifications so that the question of placing contracts could be investigated as soon as possible. The types of transportables still in production in April 1944 were the Type 15 (T.1154/R.1155), Type 18 (Army Type 22), Type 20 (Collins 18Q), Type 22 (TR.1143), and Type 24 (TR.1196). The requirement for a transportable TR.1196 had arisen in April 1943; it was needed for local aircraft control on new airfields, and no single load was to exceed 120 lb. The prototype was completed in November 1943 and a small number only were built at the signals depots. In addition to these five sets, various types of responder beacon were in production. The policy of using the Army Type 22 sets was unchanged, but it was not expected that the equipment would have any wider range of use owing to its low output and generally poor engineering when compared with R.A.F. sets.[1]

The new equipment under development by D.C.D. had only reached the stage of the fixing of the technical characteristics and associated circuits. There were two main types under development, the T.1514/1515 pack-set and the T.1522 vehicle set. The specification to which the R.A.E. were working, in the case of the pack-set, was that of a transmitter and receiver operating in the H.F. band of 2—15 megacycles per second, together with aerial, battery, and pedal generator, the whole forming three loads of 40 lb. each. Permission for the use of light alloys for the chassis and cases was obtained, but the use of miniature components was avoided due to the supply position. The original requirement was for weather-proofing of equipment; this was later amended to a requirement for the equipment to be capable of withstanding actual immersion for short periods. It was regarded as most important that the three units should be totally and separately enclosed in completely watertight containers with lids to allow them to be easily operated. Both the pack-set and the vehicle set gave every promise of proving to be satisfactory equipment; but progress at first was slow. The T.1514/R.1515 pack-set was still under development in April 1944 but the following month the experimental models had been completed and were ready for trials. The progress of the T.1522 was not so advanced. A crash programme of 100 of each equipment was scheduled to be completed early in 1945.[2] The sets did not come into use before the end of the war.

Standardisation of Mobile Signals Units

The need for standardisation of mobile signals units in all theatres was evident by 1943. Only by adopting this system could the necessary training

[1] A.M. File CS.17914/I.
[2] A.M. File CS.17914/I.

be given to personnel before going overseas. Basic trade training was not enough; it was most important that special training should be given to airmen who were to be employed on this type of work, and such training could only be given satisfactorily if they were crewed up as complete units before despatch overseas. The difficulty was that M.S.U.s were built of component vehicles the contents of which had hitherto been determined to some extent by local requirements. Some of the units in use at home were not necessarily suitable for general adoption.

However, it was possible to agree many existing types as standard, and special vehicle types were referred to the Air Ministry, who allotted the new vehicle a type number and published it to all concerned.

The Tactical Air Force, which was being prepared in the United Kingdom for operations on the Continent, was the prototype for the mobile signals unit system, and was planned to include advanced and rear air headquarters, base signals units, two composite groups (fighter and close support bomber), one light bomber group, and one reconnaissance wing. The base signals units (B.S.U.), mobile signals units (M.S.U.), and mobile signals servicing units (M.S.S.U.), together comprised a complete signals organisation for an air force in the field. Provision was made, with the addition of advanced landing ground signals sections (A.L.G.S.S.) and field force headquarters signals sections (F.F.H.Q.S.S.), for the preliminary assault stage. With slight modifications to establishment, the B.S.U. could become the keystone of a static signals organisation.

The signals facilities for Advanced and Rear Air Headquarters and for all groups were provided by M.S.U.s. Composite groups included a mobile operations room unit (M.O.R.U.) and a mobile air reporting unit (M.A.R.U.) complete with their own mobile signals sections, wireless unit screen, and A.M.E. stations. Composite groups were allotted M.S.U.s to meet the requirements of their own advanced and rear headquarters, airfields, air stores parks (A.S.P.), and repair and salvage units (R.S.U.); an M.S.S.U.; and one or more F.F.H.Q.S.S. and A.L.G.S.S. The light bomber group was allotted M.S.U.s in accordance with its requirements. The policy was to allot a B.S.U. to a formation of three groups, as was the case with T.A.F.

The terms of reference of the B.S.U.s were:—

(a) The receipt and testing of all signals and radar equipment consigned to the theatre prior to issue to units in the field.

(b) The servicing of equipment returned to base as beyond the capacity of the M.S.S.U.s.

(c) The holding of a reserve of signals and radar units.

(d) The installation of fixed signals and radar stations.

(e) The fitting of approved modifications.

(f) The development and manufacture of apparatus to meet special requirements.

(g) The examination and analysis of technical reports and defect reports from units and the transmission of summaries thereof to the Air Ministry.

A base signals unit was formed at Chigwell, fully mobile as part of T.A.F. It was employed from June 1943 on the task of assembling and training mobile signals and radar units for despatch overseas, either immediately (as for 'Husky') or as part of T.A.F.

The M.S.S.U.s were intended to move into an operational theatre at as early a stage as possible. They held three months' spares for M.S.U.s and mobile radar units, and constituted the sole servicing and holding unit for such technical equipment until the B.S.U. was established.

The work of preparing and despatching mobile units at Chigwell was carried out in three sections, the first for assembling, testing and issuing technical gear, the second for servicing, testing and issuing M.T. and motor-cycles, and the third for issuing barrack pack-ups. Training was given in morse and procedure, and in practical work, carried out in a hangar in which were mounted side by side the chassis of all types of signals vehicles. Crews were assembled, equipped and trained as a team, every effort being made to fit them for overseas conditions and for mobile operations. Instructions were given to officers on the task of administration in the field.

By the middle of 1943, a total of 16 types of mobile signals unit had been laid down by the Air Ministry, each providing standard signals facilities according to its type. The types were designed to fit together, like building blocks, into any likely total of requirements. Not all these types had been formed by June 1943, but a large number of standard types of M.S.U. were in use by 1944, each providing different facilities.[1] The units were numbered in four series, according to their function, as follows:—

(a) M.S.U.s Type 'A'—'Z'. These constituted the first series of M.S.U.s to be formed. The signals equipment used was the same as that used for the transportable units, with a number of additions. The units were allotted identification letters consecutively in the order of their function, as:—

Type	
'A'	8 low power H.F. W/T channels
'B'	4 low power H.F. W/T channels
'C'	4 very low power H.F. W/T channels

[1] A.H.B./IIM/B26/1A. H.Q. No. 26 Group O.R.B. Appendices, August—December 1944.

Type	
'D'	2 low power H.F. W/T channels
'E'	4 low power H.F. W/T channels (reinforcement)
'F'	2 very low power R/T W/T channels (reinforcement)
'G'	2 very low power H.F. W/T channels (reinforcement)
'H'	4 V.H.F. R/T point-to-point channels
'J'	1 V.H.F. R/T point-to-point channel
'K'	1 very low power H.F. W/T channel
'L'	1 H.F. D/F channel
'M'	1 M.F. beacon
'N'	1 Radio Track Guide
'O'	4 V.H.F. R/T channels
'P'	2 V.H.F. R/T channels
'Q'	1 V.H.F. D/F channel
'R'	1 high power H.F. W/T channel (reinforcement)
'S'	1 10-watt simplex V.H.F. channel
'T'	1 50-watt simplex V.H.F. channel
'U'	1 50-watt duplex V.H.F. channel
'W'	1 500-watt duplex speech plus teleprinter channel

On the completion of this series, it was decided to sub-divide additional types of units into three double-letter series, as listed in (b), (c) and (d) below.

(b) M.S.U.s Type 'CA'—'CZ'. This series comprised units designed to provide purely communications facilities.

(c) M.S.U.s Type 'RA'—'RZ'. This series comprised mobile radar units other than A.M.E.S.

(d) M.S.U.s Type 'SA'—'SZ'. This series comprised units designed to provide special facilities (e.g. R.C.M.) outside those covered in Types 'CA'—'CZ' and 'RA'—'RZ'.

By the end of the year, double-letter types already formed included 'CA' (high power speech plus teleprinter twin-channel relay units); 'RA' (mobile Eureka 'H' beacons); 'RJ' (enemy jamming investigation units); 'SJ', 'SM', and 'SR' (R.C.M. units); and 'SS' (mobile signals security units). Other miscellaneous units formed included heavy mobile automatic W/T units, light automatic W/T units, mobile air reporting units (M.A.R.U.s) etc. The units were formed at Chigwell.

The existing policy regarding the supply of equipment for and the production of mobile and transportable stations was changed in April 1944, when a new unit, the Radio Vehicle Storage Unit, was established at Bowlee. A re-statement of the functions of the units concerned was then made. Briefly, the Signals Depots were responsible for installing and testing radio equipment prior to issue to the Radio Vehicle Storage Unit, for executing all major modifications, and for the prototyping of new installations; the new unit was responsible for storage of, minor modifications to, and testing and completing to scale of new equipment, the servicing and storage of Service equipment, and the despatch of stations for home and overseas; Chigwell was responsible for the training of units and their issue to form composite mobile and transportable signals units.[1]

Flying W/T Stations

In November 1941, in planning for combined and other operations overseas, it became apparent that a requirement might arise for airborne W/T stations to cater for the following conditions:—[2]

(a) To act as flying repeater stations to relay to distant bases, by W/T, messages passed to the aircraft by low-power W/T or R/T ground stations (e.g. calls for air support by ground forces during an opposed landing).

(b) To act as emergency ground stations to operate until mobile or transportable signals stations could be brought up to the scene of operations.

(c) To fly transportable equipment to the scene of operations to be set up as semi-permanent ground wireless stations.

In May 1942, it was agreed that the roles of both airborne and ground stations could be met by the use of a Whitley Mark V. This was the only aircraft which filled the specifications of range and low landing speed for crash landing purposes, and it was also specially suitable on account of its greater roominess. In the following month the R.A.E. produced a report on

[1] A.M. File CS.179141/I.
[2] A.M. File CS.12097/I.

an installation of the required equipment in a Whitley. The requirements, and the equipment used to meet them, were :—

H.F. point-to-point and H.F. R/T to other aircraft	— Portable T.1422/R.224A (with sectionalised aerial mast)
H.F. D/F for other aircraft	— T.1154/R.1155 aircraft installation with aerial loop.
V.H.F. communication with fighters, including a channel for passing homing directions	— Portable TR.1133D
V.H.F. homing of fighters	— R.1132
Power Supplies	— Three portable petrol/electric charging sets with 12-volt accumulators.
Local communication	— Six field telephones and three drums of electric cable.

It was envisaged that the Whitley would operate in two main roles, one in the air and one on the ground. In the first role it would act as a relay link between landed forces and the base, using the standard aircraft equipment (T1154/R.1155), and in the second role, with local supremacy attained, the aircraft would land (with the undercarriage retracted if necessary, i.e. not necessarily on an airfield) and then operate as a forward sector station. With the exception of the H.F. D/F and V.H.F. D/F equipments, which remained installed in the aircraft, the equipment was in transportable form, and could be dispersed over an area within a radius of half a mile from the aircraft, the necessary links being made by the telephone sets and cable. Ancillary equipment included a loading ramp, water tanks, spare valves, etc.

By mid-July 1942 the R.A.E. had completed the trial installation, and Service trials were carried out in Army Co-operation Command in August. The aircraft was returned to the R.A.E. at the end of August, for other modifications. A contract was then placed with Marshall's of Cambridge for the fitting out of six Whitleys. Wireless equipment was consigned to Marshall's, but in October it was decided that it would not be possible to allocate the six Whitleys due to aircraft supply difficulties, and the project was postponed. The original Whitley V was allocated to No. 1473 Flight in November 1942 for operational trials. Meanwhile, every effort was made so that Marshall's should be in a position to install the requisite equipment in the Whitleys directly they were available, and the fitting out of one aircraft, which was already at Marshall's for other reasons, was allowed to be proceeded with. Allocation of three more Whitley V aircraft was authorised on 16 January 1943, and by 23 January arrangements were in hand for the construction of all five stations, and the personnel requirement was under consideration.

Meanwhile, the operational trials were completed; and arising from them, a suggestion was made that the TR.1143 should be substituted for TR.1133D. Complaints were made about the performance of the R.1224A, and changes were made to the V.H.F. D/F aerial system. The main suggestions were incorporated, and results were generally satisfactory. The first five Flying W/T Stations were authorised to be formed in March 1943 at Hinton-in-the-Hedges under the control of Headquarters No. 26 Group (to be known as No. 1478 Flight).[1]

No. 1478 Flight began to form in April 1943. Arrangements were made to train aircrews and the flying W/T station crew, and to give technical, field and defence training. The Flight formed with an establishment of 4 plus 1 aircraft, its proposed use being in future operations on the Continent or elsewhere as necessary. The requirements of operations in North Africa, however, showed that there was an immediate need for a unit of this kind, and in May 1943 it was decided to post No. 1478 Flight to Mediterranean Air Command. One aircraft was retained in the United Kingdom.[2] This one aircraft was the sole reserve backing for No. 1478 Flight, and the transfer of the other four aircraft meant that there were no stations in being for training with a view to future operations with the Tactical Air Force. In addition, a demand for similar equipment was expected from India. It was therefore proposed in June 1943 to form two new flights, using Manchester aircraft, as Whitleys were no longer available. A Manchester was prototyped at the R.A.E., and it was arranged that Marshall's should again carry out modifications;[3] but serious difficulties with the supply of Manchester aircraft and spares were forecast, and in the same month it was decided not to equip any more flying W/T stations, on the grounds of economy in aircraft and manpower, specific transport aircraft being no longer available for permanent employment in this role. Meanwhile No. 1478 Flight, after further training, were standing by to act as reserve to the signals vehicles engaged in the Sicilian operations.[4] They were not, however, brought into use. The Whitleys returned to the United Kingdom from Algiers in November 1943, ostensibly for transfer to Headquarters 2nd T.A.F.[5]

Air Transportable Signals Units (A.T.S.U.)

The Air Ministry had always held the view that the flying W/T station was not a satisfactory method of providing forward communications; they considered that what was ultimately wanted was air transportable equipment which was capable of being removed in its entirety from the aircraft

[1] A.M. File CS.12097/I.
[2] A.M. File CS.12097/II.
[3] A.M. File CS.19167.
[4] A.H.B./IIM/B26/1A.
[5] A.H.B./IIS/110/9/27.

and set up and operated independently. Experience in Mediterranean Air Command had confirmed this view. In June 1943, when it was decided not to equip any more flying W/T stations, the requirement became that a suitable pack-up should be arranged which could be easily accommodated in any transport aircraft which might be available. The operational requirement was for two channels of H.F. W/T or R/T, one for communication with aircraft and one for point-to-point; two V.H.F. R/T pack sets with four channels per set, one set for local control and one for passing bearings to aircraft; one portable V.H.F. D/F station; one D/F loop and receiver for H.F. D/F; one responder beacon for homing aircraft fitted with A.S.V.; and the requisite test equipment and power supplies; the whole to provide an air commander with air transportable signalling equipment to enable him at short notice to deliver, operate and maintain, for a period of four days, at an advanced base or landing ground, a W/T station providing these services. It was a fundamental requirement that the equipment comprising such a W/T station should be capable of being carried in a transport aircraft.[1]

The equipment recommended by Headquarters No. 26 Group to meet the operational requirement stated was two Collins 18Q equipments for the two channels of H.F. W/T or R/T; two TR.1143 equipments for V.H.F.; and an R.1132A for V.H.F. D/F. Work on a prototype responder beacon was in progress.

The original requirement was for a total of 20 composite units in all for use with the A.E.A.F. Subsequently, a requirement arose for similar units to be employed in the Mediterranean Air Command and at mobile staging posts in Transport Command. The Transport Command requirement was stated in December 1943, and it varied slightly from requirements of the A.E.A.F. and M.A.C. units, which were the same. Transport Command needed a number of units for the forward staging posts they intended to establish on the Continent, and they also required similar units in various other overseas theatres.

The first eight air transportable signals units were earmarked for employment with the A.E.A.F., but in January 1944 it was decided to transfer four of these when completed to Transport Command. The next four sets to be completed were also earmarked for the use of Transport Command, at forward staging posts. Nos. 13—19 A.T.S.U.s were later earmarked for use by Transport Command in other overseas theatres.

In March 1944, the make-up of the two types of unit was finally confirmed :—[2]

(a) *A.E.A.F. and M.A.C. Type.* Two medium transportable H.F. W/T R/T stations (2 Collins 18Q); 2 medium transportable V.H.F.

[1] A.M. File CS.19756/I.
[2] A.M. File CS.19756/I.

R/T stations (R.1132A); 1 transportable A.I. and A.S.V. responder beacon (TR.3236); 1 Eureka beacon (when available); 1 test set; 6 field telephones Type F; 1 10-line field switchboard; 4 miles of D8 cable; personnel establishment—2 officers and 14 other ranks.

(b) *Transport Command Type.* 2 medium transportable H.F. W/T R/T stations (2 Collins 18Q); 2 medium transportable V.H.F. R/T stations (2 TR.1143); 1 medium transportable H.F. R/T station (TR.1196); 2 medium transportable V.H.F. D/F stations (R.1132A); 1 meteorological broadcast receiver (R.1224A); 1 test set; 1 medium transportable very low power H.F. beacon (T.1154); 2 medium transportable H.F. D/F stations P.4 (R.1217); 1 Eureka Beacon (when available); field telephones, switchboard and cable as for the A.E.A.F. and M.A.C. type; personnel establishment—2 officers and 26 other ranks.

The total requirement for individual equipments forming a part of the air transportable signals units was added to the requirement for mobile and transportable signals units, and the production programme adjusted accordingly. The same equipment was used for both purposes. Headquarters R.A.F. Middle East, Headquarters M.A.A.F., and Headquarters India were given drawings, specifications and ' consisting of ' schedules for use in completing their own sets. However, requests for composite A.T.S.U.s continued to be made from overseas, and on 2 April 1944 is was decided that only the immediate requirements of A.E.A.F. and Transport Command would be met initially. These requirements were, for A.E.A.F. four complete units with personnel and three sets of equipment without personnel. For Transport Command, four complete units with personnel for temporary commitments and four complete units with personnel for forward staging posts. When this commitment of 15 units had been met, six complete sets of equipment were sent to North Africa.[1]

The four A.T.S.U.s issued for the Transport Command forward staging posts on the Continent (Nos. 9, 10, 11 and 12) were not sent to the Continent in their original form, but were disbanded in June 1944 for economy reasons on instructions from the Air Ministry. It was decided that, to economise in manpower, the four A.T.S.U.s earmarked for the forward staging posts should be manned by the personnel already established to operate the mobile signals units on forward staging posts, the air transportable equipment being made available to the latter. The remaining four A.T.S.U.s in Transport Command (Nos. 5, 6, 7 and 8) were required to operate independently to meet temporary commitments on advanced landing grounds where there was no anticipated requirement for a forward staging post. The requirements of Transport Command (No. 46 Group) were therefore four A.T.S.U.s

[1] A.M. File CS.19756/I.

complete with personnel for advanced landing grounds and four without personnel for the forward staging posts.

In September 1944, with the extension of the Continental areas open to aircraft of Transport Command, plans for the formation of six new staging posts were made. Transport Command proposed meeting the signals requirement in three phases — phase 1 by A.T.S.U.s of Transport Command type, phase 2 by mobile signals units, and phase 3 by hutted equipment.[1] Experience with the Transport Command type of A.T.S.U., however, showed that there were serious shortcomings in the equipment, necessitating the introduction of extensive modifications. When Nos. 13—19 A.T.S.U.s were ordered, a request was made by Headquarters Transport Command for certain modifications, but it was not possible to arrange for these to be done at the time, and owing to the difficulties in obtaining the necessary equipment, many of the modifications were still outstanding. By March 1945, it was realised that a complete revision of the A.T.S.U. would be impracticable at that stage in the war, but Transport Command still complained of the lack of remote control in the Collins 18Q and between the R.A.F. Type 22 and Type 25 equipments. A number of other shortcomings were complained of, but little of a short-term nature could be done and the long-term policy became that A.T.S.U.s would not be required in the future.[2] Nos. 1—4 A.T.S.U.s, which had been used with the First Allied Airborne Army, were withdrawn from the A.E.A.F. in November 1944.

Air Transportable Signals Units for the Far East

In May 1944, Air Command, South East Asia, asked for two each of a number of transportable equipments to be shipped to the Far East for test purposes, so that full advantage could be taken of the work already carried out in the United Kingdom and so as to avoid the ordering of large quantities of equipment which might subsequently prove unsuitable for the Far East theatre. The equipment ordered was two sets each of the Collins 18Q (Type 20), R.1132A (Type 25), R.1224A (Type 31), and T.1154 (Type 32); and one set of TR.1133 (Type 28). This equipment, together with two sets of TR.1143 (Type 22), plus miscellaneous spares etc., was sent in June 1944.[3] However, in the meantime, the overall requirements of telecommunications equipment for use in the Burma and Pacific Zones generally, including teleprinter and high-speed W/T facilities and various types of air transportable equipment, together with suitable hutting, had been discussed at Headquarters No. 26 Group. Hutted W/T stations, and telecommunications equipment which withstood tropical conditions, had already been evolved in Australia; a portable hut was built to the drawings supplied by the R.A.A.F., and it proved superior in design to any so far produced in the United Kingdom. It was readily erected and dismantled and was capable of being transported in a Dakota.

[1] A.H.B./IIE/151/56.
[2] A.M. File CS.19756/II.
[3] A.M. File CS.19756/II.

Difficulties of production and supply presented themselves, and every effort had to be made to use existing signals equipment modified as necessary.[1] In July 1944, the Air Ministry gave instructions for the prototyping of nine types of A.T.S.U. for use in the Far East. The commitment covered included H.F. W/T, H.F. D/F, V.H.F. R/T point-to-point and air-to-ground, V.H.F. D/F, and M.F. beacons. The basic equipment used was the same as that used for mobile and transportable equipment in other theatres. The operational requirements for each type of equipment, excluding the purely signals requirement, were:—

(a) *Aircraft*

(i) Each unit to be capable of transportation in Dakotas.

(ii) Each fitted case to be capable of being manhandled to and from the aircraft, and for short distances.

(iii) The design of each unit to be such as to enable transport by air with the minimum number of aircraft.

(b) *M.T.*

(i) Each unit to be capable of being carried in container form in either Jeeps or Jeep trailers, and of being towed on skis or wheels.

(ii) The technical signals equipment to be capable of ready operation in its container form from either tents or tropical huts, vehicles of the 3-ton type in the case of low-power units, and Jeeps and Jeep trailers in the case of very low-power units.

(c) *Details*

(i) Each container to be sealed against all tropical conditions during periods of transit; weatherproof; and designed for easy handling.

(ii) All equipment to be tropicalised as far as possible.

(iii) Technical equipment to be capable of being operated from 230 volts A.C.

(iv) Remote control facilities to be provided to permit associated transmitters to be keyed or modulated as necessary up to a distance of 880 yards.

(v) Each unit to be capable of operating under black-out conditions, to be planned on a four-watch basis, and to be capable of being self-supporting for a period of seven days.

Existing equipments were modified as practicable, and standardisation was adopted as far as possible. Light-weight readily-transportable aerials were provided. The target date for the completion of all prototypes was 15 September 1944.[2]

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[1] A.H.B./IIE/151/66.

[2] A.M. File CS.19756/II and A.H.B./IIE/151/66.

The various types of signals equipment were assembled and inspected at No. 1 Signals Depot on 2 August 1944. A further meeting for final decisions was held on 9 August, when it was decided that the problems of prototyping of tropical damp-proof containers for all types of equipment should be investigated by No. 1 Signals Depot, and that Headquarters No. 26 Group should then arrange for the manufacture of such containers. No. 1 Signals Depot manufactured a prototype of each component item as design details became available, and Headquarters No. 26 Group then issued orders on production. The target date for the assembly of 25 per cent of the units was 15 April 1945, and the date for the completion of the commitment was 1 June 1945. Modifications to some of the items were carried out by No. 2 Signals Depot. The production programme agreed upon provided sufficient air transportable signals equipment for one composite group only. The intention was that subsequent units should be formed, trained and equipped overseas.[1]

[1] A.H.B./IIE/151/66.

CHAPTER 12

TRAFFIC HANDLING

Air Ministry Central Telephone and Teleprinter Exchange and W/T Receiving Station

One of the main items in the development of Air Ministry landlines policy in the years immediately prior to the war was the decision to establish a central telephone and teleprinter exchange outside London.[1] The location of such an exchange turned largely on the location of existing and projected G.P.O. cables. It had been suggested that the new exchange might be located at Dagnall, but in June 1937 it was decided to locate it elsewhere, although near Dagnall.[2] After discussion between the Air Ministry and the G.P.O., and following a meeting of a sub-committee of the Defence Services Line Telecommunications Board in November 1937, a site was chosen near Leighton Buzzard.

It was most desirable from the point of view of communications that the main Air Ministry W/T receiving station should be located alongside the central teleprinter point: the idea of placing the two centres in close proximity had been put forward in early discussions on landline systems in March 1936, in view of the great saving in landlines and personnel that would result from such an arrangement.[3] The Leighton Buzzard site was five miles from the new transmitting station at Dagnall, but this was not considered a serious drawback. Tests indicated that Leighton Buzzard was a thoroughly satisfactory site, no interference between telephone/telegraph gear and wireless being likely provided concentric feeders were used in conjunction with suitable aerial arrays.

The Air Ministry sent preliminary proposals for the layout of buildings to the G.P.O. on 13 January 1938.[4] A revised personnel requirement drawn up a year later listed 231 personnel, of whom about 150 were wireless and teleprinter operators and 34 telephone operators. The station was opened early in May 1939, and in the ensuing weeks equipment and personnel were transferred from the Air Ministry W/T stations at Adastral House and Cardington. No accommodation was built, however, and Service and civilian staff lived out in the area. The new transmitting station at Dagnall was not yet completed, and the transmitting stations at Greenford and Cardington were still in use. Dagnall did not come into operation until the autumn of 1940.[5]

By May 1940, in view of the increasing signals personnel necessary to

[1] A.M. File 679488/37.
[2] A.M. File 420378/35.
[3] A.M. File 679488/37.
[4] A.M. File 679488/37.
[5] A.M. File 420378/35.

handle the expanding signals traffic at Leighton Buzzard, it was agreed that the existing system of billeting and hostels was unsatisfactory and that the only ultimate solution was to build a new camp. The very heavy pressure on works services of all kinds, however, delayed action being taken at Leighton Buzzard, and the accommodation problem remained.

The telephone switchboard at Leighton Buzzard was now equipped for 320 lines, of which 315 were either in use or earmarked. Further lines were needed, and by July 1941, with the continuing and very great rise in W/T signals traffic from overseas, due largely to the heavy delay in ocean-borne mails and the cutting of the Mediterranean cables between Malta and Gibraltar, the capacity of Leighton Buzzard had been stretched to such a point that serious delays were occurring to important messages to and from the Middle and Far East. Increased accommodation for teleprinters and for signals handling was urgently needed. The teleprinter centre had been housed in the main building, but now that the existing accommodation was too small, the Director General of Signals ruled in agreement with the A.O.C. No. 26 Group that to enlarge the existing building or to build a new teleprinter centre alongside it would only increase what was already a dangerously important target.[1] For this reason it was decided to look elsewhere. Suitable accommodation was found in the assembly rooms of the Town Hall and Corn Exchange in Leighton Buzzard itself.[2] This was centrally placed for billets and also provided good recreational accommodation; and, perhaps most important, it saved time and productive effort in the erection of a new building. The assembly rooms in Leighton Buzzard now became the centre of the entire Defence Teleprinter Network.

The requirements for the capacity of the Leighton Buzzard Central teleprinter switchboard, however, continued to increase, and the erection of a new teleprinter building within the camp boundaries at Leighton Buzzard, to replace the signals centre now housed in the assembly rooms, was suggested in May 1942.[3] In addition to continual R.A.F. expansion, an entirely new commitment had arisen for the American air force units now reaching Britain. In addition to the establishment of a number of commands and wings, the number of bomber stations being taken over by the Americans was increasing, and at the same time maintenance and personnel centres were being formed and a rapidly-growing volume of teleprinter traffic was in prospect. American units and formations were joined to the D.T.N. and fell in with British operating procedure. Already new central exchanges were being established at Blackbrook (North-West Central) and Cheltenham (South-West Central), and British practice was for maintenance and training establishments to be joined to North-West or South-West Central and operational stations and groups to be joined to Leighton Buzzard. The question was,

[1] A.M. File S.76607.
[2] A.M. File S.1610/I.
[3] A.M. File S.1610/II.

could the existing Leighton Buzzard teleprinter switchboards handle this additional operational load, as well as R.A.F. expansion.[1]

Air Ministry recommendations on the extent to which accommodation at Leighton Buzzard should be increased were delayed while details of the operation of North-West Central, and of other action to relieve congestion at Leighton Buzzard, including the transfer of certain overseas W/T circuits to Birdlip, were awaited. The Air Ministry view, however, was opposed to locating the teleprinter switchboard and signals handling centre near the telephone exchanges and the W/T receiving station on the ground that one bomb might destroy all. The erection of a new camp was in fact planned, to include a bulding in or near the camp to house the signals and teleprinter centre, but this scheme was cancelled when the relinquishment by Fighter Command of their emergency filter and operations room at Leighton Buzzard released accommodation for re-housing these centres. Approval to transfer equipment from the assembly rooms was given in November 1943.[2] The wiring, however, was allowed to remain so that the assembly rooms could act as a reserve during and immediately after the changeover.

Various safeguards were taken in the course of the war against the possibility of Leighton Buzzard being put out of action or failing for any reason. All possible steps had been taken to camouflage the Leighton Buzzard and Dagnall sites and to erect dummy sites nearby in the summer of 1940.[3] A scheme was put forward in 1940, and put into action in 1942, to allow for Air Ministry traffic to be handled in emergency at Cardington, where certain special W/T traffic was already being handled.[4] The necessary aerials and receivers were available at Cardington, and it was a question of arranging landlines so that this station could key the transmitters at Dagnall in emergency, and so that originated and received traffic could be passed to and from the Air Ministry. A second measure to safeguard communications was the erection of an emergency telephone exchange adjacent to the main exchange, to which circuits could be diverted in the event of damage to the main switchboard. This standby P.B.X., including routed cabling between Leighton Buzzard, Dunstable and Dagnall, was completed in July 1943.[5] In deciding which circuits were to be connected to the emergency switchboard, care was taken to include circuits to all those establishments which were entirely dependent on the Central exchange, the policy being to retain as many circuits as possible to the more important switching centres rather than one or two circuits to all switching centres. This meant that, in emergency, groups would have to rely on their command headquarters and on other switching centres for access to the rest of the Service network. Review of the emergency arrangements and a revision of schedules was carried out at three-monthly intervals. By October 1944,

[1] A.M. File S.1610/II.
[2] A.M. File S.76607.
[3] A.M. File S.62196.
[4] A.M. File S.1610/I.
[5] A.M. File S.1610/II.

however, it had been decided that it was not necessary at that stage of the war to carry out any further revisions or improvements to the emergency telephone switchboard; and later, in March 1945, the emergency P.B.X. was closed down and all switching arrangements for the diversion of circuits were recovered by the G.P.O. On the W/T side, all operational circuits at Cardington were transferred to Leighton Buzzard and associated teleprinter circuits recovered. And on the D.T.N. side, by September 1944 the new signals centre was equipped to cater for the maximum traffic that it might be required to handle, so the reserve equipment remaining at the assembly rooms was recovered.

Accommodation

The accommodation problem at Leighton Buzzard has already been briefly referred to. This station, as the Central Signals Centre and Exchange for all landline communications for the R.A.F. and also as the main intercommand W/T receiving station, was an indispensible unit which by its very nature was tied to its existing location. The work of the unit expanded enormously as the European war progressed, and it was also fully committed for the Far Eastern war and as a permanent peacetime requirement. The small unit that existed at the beginning of the war was housed in billets and in a number of requisitioned properties nearby, but with the increased size of the unit and the wartime expansion of the civilian population in Leighton Buzzard, further billeting and requisitioning became impossible.[1] An additional factor, which added to the accommodation problems, was the fact that sufficient trained R.A.F. personnel were not available to meet the personnel requirement and as a result it was necessary to substitute W.A.A.F. personnel, and to a proportion higher than that normally allowed under the substitution scheme. In order to accommodate the extra personnel, particularly the W.A.A.F. personnel, it had to be decided what further accommodation could be built, requisitioned or otherwise made available.

A number of proposals were formulated for the construction of a new camp, and for the temporary enlargement of the existing accommodation meanwhile. This accommodation was scattered over a wide area and was in some cases extremely unsatisfactory. The building of a new camp would have taken some time, and it was realised that during this time the existing conditions could not be tolerated, but that considerable temporary improvements would have to be made even though a new camp was in prospect. Such a course was plainly uneconomic, and in any event the labour and materials required for such a camp were even more urgently needed elsewhere. It was therefore finally decided in November 1942 not to proceed with the erection of a new camp on the proposed site at Stanbridge nearby but to extend the existing accommodation and to bring it up to a more acceptable standard.[2]

[1] A.M. File S.76607/II.
[2] A.M. File S.76607/II.

A site known as the Marley Tile site had been requisitioned, partly in 1939 and the remainder in 1940, to provide office and domestic accommodation at Leighton Buzzard. This was the part of the camp chosen for additions and extensions. The plan was to construct a hutted camp, on the Marley Tile site and an adjoining site, using the Marley Tile site buildings as the nucleus of the necessary domestic accommodation and supplementing this by the construction of further buildings, both on the Marley Tile site and the adjoining site. However, mainly as a result of shortage of labour and the overriding priority accorded to operational expansion, construction of the new accommodation was considerably delayed.[1]

Dissatisfaction with the existing conditions continued and reached a political level in 1943. The root of the trouble lay in the fact that a small pre-war unit, satisfactorily accommodated mainly by billeting and a small amount of requisitioning, had grown out of all recognition. The strength of the unit towards the end of 1944 was well in excess of 1,000, of whom about three-quarters were W.A.A.F. While increases in size had been small it was reasonable to meet the position by additional billeting and requisitioning, but the continuation of this expedient had led to the occupation of property further away in all directions from the place of work. These disadvantages were accentuated by the fact that work had to be carried on at Leighton Buzzard for 24 hours a day, aggravating all the many administrative problems, besides resulting in irregular hours for personnel on watchkeeping duties—a constant source of irritation to billetors. When in May 1945 the new accommodation was completed and ready for occupation, the unit's domestic accommodation then comprised:—

(a) Two requisitioned properties in Leighton Buzzard, used as sleeping accommodation for R.A.F. other ranks, station sick quarters, dental centre, etc.

(b) Dormitory accommodation on the requisitioned site adjoining the Marley Tile site, allocated to W.A.A.F.

(c) The Marley Tile site with its original buildings and new construction providing the whole of the station's communal acommodation.

This situation, vastly improved though it was, was still not ideal. It served, however, until the end of hostilities. In due course, permanent peacetime accommodation was constructed at Stanbridge and the Marley Tile site de-requisitioned.[2]

Re-design of Central Signals Centre Stanbridge for Far Eastern War

On 4 March 1945, the Air Ministry instructed Headquarters No. 26 Group to proceed with the re-design of the Central Signals Centre at Stanbridge to provide facilities to handle the increased traffic which was expected to result from the prosecution of the war in the Far East. Preliminary dis-

[1] A.M. File S.76607/II.
[2] A.M. File S.76607/II.

cussions had already been held to determine the accommodation requirements and general layout of offices, and detailed plans were prepared for the reorganisation of the Centre. Air Ministry policy was to substitute radio teleprinting for automatic morse, and this meant rack-mounted teleprinting equipment, with automatic reperforating facilities to enable traffic to be transferred from internal teleprinters to external radio teleprinters, and vice versa.[1]

Air Ministry Communications

The expansion of the Air Ministry, the overall increases in the R.A.F., the rising tempo of operations, and the increase in operational stations, caused steadily increasing rises in Air Ministry traffic as the war progressed, culminating in a rise of 20 per cent in April 1941. The Air Ministry Communications Section (A.M.C.S.) at Whitehall thus became overloaded; but instead of expanding this section it was decided in May 1941 to decentralise the signals and cypher staff and apparatus in Whitehall by establishing a new centre in the Kingsway area. The new centre handled all administrative traffic, which comprised some 60 per cent of the whole, while Whitehall was restricted to operational traffic only.

This proved a most convenient arrangement, beneficial to both types of traffic; the segregation of operational traffic made for improved security, and the location of the administrative traffic section in Kingsway resulted in a general speed-up of traffic in that area. The new centre was located temporarily in Adastral House, but protective accommodation was necessary and the centre subsequently moved to a permanent home in Bush House, where accommodation was sufficient to allow the Whitehall section to operate there as well in emergency.[2]

In March 1941, it was decided to establish communications facilities in new accommodation at Horseferry Road to provide a full duplicate of Air Ministry Whitehall in case its essential communications should be knocked out, and to provide also for the housing of certain important Air Ministry branches in the Kingsway area which had only the barest sheltered accommodation below ground. The Air Ministry informed the G.P.O. of the facilities required and the G.P.O. provided them. By May 1942, however, it was decided that the north and south rotundas at Horseferry Road should be occupied by the War Office Invasion Staff, Air Ministry moving to alternative accommodation constructed in a steel frame building.[3]

In April 1943, a Signals Centre known as the London Signals Centre was established to deal with signals traffic of units located in and around London, and to provide an emergency signals office for use in the event of damage to either A.M.C.S. Whitehall or A.M.C.S. Kingsway. The main purpose was to relieve these two sections of traffic not destined for the Air

[1] A.H.B./IIM/B26/1A.
[2] A.M. File CS.9348.
[3] A.M. File A.954359/47.

Ministry. Accommodation was provided at first in the Air Ministry building in King Charles Street, Whitehall, and later in the south rotunda in Monck Street, after its vacation by the War Office.[1]

Transmitting and Receiving Stations

The Air Ministry W/T Transmitting Station was established after the First World War at Kidbrooke, remotely controlled from the Air Ministry W/T Receiving Station on the top floor of the Air Ministry building in Kingsway. By 1929, however, the transmitting station had outgrown its accommodation at Kidbrooke and it was moved in that year to a new site at Greenford. Space at Greenford, however, was also limited, and some three years before the war the site was already becoming too small to accommodate the growing number of circuits. It was not possible to extend the site or to erect further aerials because of the surrounding buildings. A site of sufficient size to cater for all existing commitments was available on ground already owned by the Air Ministry at Halton; but here again there was little room for expansion, and the Air Ministry were determined not to repeat their previous mistake at Greenford. A new site was therefore found at Dagnall, in an ideal situation. Treasury approval for the acquiring of the land was obtained, and tests on the site began in June 1937. It was originally intended to dispose of the Greenford site after the opening of Dagnall, but in the event, due to the increased demands following the outbreak of war, the Greenford site was retained.[2]

Early plans for the new transmitting station at Dagnall were based on the simple reprovision of the existing services at Greenford, but in 1937 the scheme had to be very considerably extended. In addition to the commitments arising from expansion, experience during the Abyssinian campaign, when operational messages were taking as much as five days to handle, had underlined the need for high-speed transmitters on certain routes. Revised estimates for the W/T building and masts, for roads, water, drainage and electrical services and for barracks, quarters, offices and stores, were approved by the Treasury in April 1938.[3] Six 120-ft., seven 180-ft., and five 230-ft. masts were erected, and the transmitters installed included the SWB8B, the SWB11, and the M.15, besides the lower power T.1087 and T.77 and various amplifiers. It had been anticipated that the more concentrated radiation arising from the greater length of the aerials possible at Dagnall would overcome any interference, but trials proved that to overcome intentional jamming and to ensure clear and continued reception by stations abroad, it was necessary to increase the strength of transmitters. A three-phase 80 kW. amplifier was therefore provided to boost the power of any transmitter whose signals were affected. This increased the overall

[1] A.M. File CS.21917.
[2] A.M. File CS.14545.
[3] A.M. File 420378/35.

power requirements for W/T purposes and necessitated the provision of an additional stand-by generator.

At this time, some eighteen months before the war, the landlines scheme for the R.A.F. was developing quickly and the foundations of the D.T.N. system were being laid, based on the new main telephone and teleprinter centre to be established at Leighton Buzzard at a point convenient to the G.P.O. main trunk lines. Plans for the evacuation or partial evacuation of government buildings in London were taking shape. The original intention had been to maintain the main Air Ministry receiving station at Adastral House and to control the Dagnall transmitters remotely from there, but this idea was abandoned in 1937, when the decision was taken to build a new station some five miles north of Dagnall at Leighton Buzzard, the new station to act as both a central exchange and a W/T receiving station controlling the transmitters at Dagnall.[1]

Another projected move out of the London area was that of the Meteorological Office and Communications Centre, and since one of the main considerations in re-siting this centre was communications, Dunstable was chosen as giving immediate access to Leighton Buzzard and alternative access direct to the new transmitting station at Dagnall, and also to an existing transmitting station at Cardington. To give additional security, cables were laid and circuits set up so that, in the event of Leighton Buzzard being damaged, Cardington and Dunstable could control Dagnall and communicate direct with the Air Ministry.

It was intended that Cardington should in the future be used as a receiving station only, and the provision of an alternative transmitting station to Dagnall was decided upon, a site being chosen at Symington, where it was also convenient to house services to Canada and for Coastal Command long-range aircraft. Symington was chosen because it was within reach of the main inter-Service lines switching centre near Glasgow (Cambuslang). Neither the Dagnall nor the Symington stations came into operation until 1940, services continuing to be handled at Greenford and Cardington.[2]

Meanwhile, the exodus of government departments from London to the Gloucester area necessitated the erection of a small transmitting station, together with an associated receiving station, in that area. Considerations of security dictated a location at Hartlebury, where a considerable proportion of the line telegraph and telephone plant serving the Air Ministry emergency area was already located in a protected building. Hartlebury also housed the transmitters for the emergency meteorological centre located at Birmingham. The G.P.O. provided two remote control circuits between Hartlebury and Leighton Buzzard in October 1940 and also joined Hartlebury to Gloucester.[3] Three T.1087's were provided at Hartlebury to act as a standby to the landline system in the area. Subsequently various long

[1] A.M. File CS.14545.
[2] A.M. File 420378/35.
[3] A.M. File S.2055/I.

distance circuits, including circuits to Iceland, Gibraltar and Malta, and for trans-Atlantic services, were operated from this station.

A further need in the Gloucester area arose from the establishment there of an Overseas Air Movements Centre. The main circuits to be operated were the point-to-point and aircraft guard circuits for delivery flights between United Kingdom—Gibraltar, United Kingdom—Malta—Egypt, United Kingdom—West Africa, and United Kingdom—Bermuda—Montreal.[1] It was decided in June 1940 to build a new receiving station at Birdlip, with remote control lines being provided so that transmitters available at Bodmin could be keyed via Plymouth, or other transmitters keyed through Leighton Buzzard. (Bodmin was a station belonging to Cable and Wireless Ltd., which afforded certain facilities to the Air Ministry.) Birdlip was connected to the Air Ministry Signals Centre at Gloucester, and from there the outlets to Bodmin and Dagnall were provided by the D.T.N.[2]

However, this was not a satisfactory situation owing to the need for employing long landlines from Birdlip for the remote control of transmitters, and there were occasions when these lines were damaged by enemy action. In addition, Bodmin was a vulnerable site with poor communications, and was not intended to be used as a main station. The requirements for high power transmitters in this area continued to increase, particularly for the South Atlantic route and for Malta and Gibraltar, and it was decided in November 1940 to increase the facilities at Birdlip and to build a new transmitting station at Winstone.[3]

To save time, and because the drawings were suitable, the Symington transmitting station was used as the basic design for the new station at Winstone. Although the main associated receiving station controlling the transmitters was at Birdlip, connection to Leighton Buzzard was also required. Most of the major circuits were already operating from either Bodmin or Greenford, and these were closed down when Winstone opened. The transmitters erected at Winstone included the Marconi SWB8, with T.1087's for some of the shorter circuits. In addition to point-to-point and aircraft guard circuits for delivery flights, standby facilities were provided for certain main Air Ministry circuits.[4] A combined camp for the two stations, Winstone and Birdlip, to house 200 personnel, was constructed.[5]

It was some months before the new station at Winstone was ready for operation, and meanwhile, the requirement for point-to-point aircraft circuits for the North Atlantic and Iceland delivery flights increased. To meet this requirement, suitable transmitters and associated aerials were installed at Symington. To operate in conjunction with Symington, a new receiving

[1] A.M. File S.70239.
[2] A.M. File S.2055/I.
[3] A.M. Files CS.14545 and A.38673/50.
[4] A.M. File S.70239.
[5] A.M. File A.38673/50.

station was built at Redbrae, near Prestwick, in August 1941, to house some ten receivers required to operate North Atlantic point-to-point aircraft services, Iceland and local point-to-point services, and a meteorological reception watch. The necessary aerials were erected and remote control circuits with Symington and other local circuits arranged.[1] Winstone acted as a standby for the North Atlantic and Iceland delivery flight circuits operated from Symington.[2]

Communications with Bomber and Coastal Aircraft

The original policy was that medium power transmitters for Bomber groups should be sited at main Air Ministry W/T stations, but this was abandoned shortly after the outbreak of war owing to the lack of space at these stations and to the long and vulnerable remote control lines involved.[3] The policy became that Bomber and Coastal groups should control locally situated transmitters. In case of local facilities becoming ineffective, each group was given access to one other station where aerials for its main frequencies could be provided. Each group headquarters controlled one SWB8 transmitter.[4] Mobile stations, in which were mounted SWB8 transmitters, were allocated by Headquarters No. 26 Group for temporary use when group medium power transmitters were damaged or needed overhaul.[5]

Bomber Command groups were later provided with a T.1087 for short-range work, but the SWB8 met all the requirements of long-range work in this Command. In Coastal Command, however, the increasingly long range at which the group transmitting stations had to work their aircraft made the provision of high power transmitters essential. In May 1943, the only group in possession of such facilities was No. 18 Group, which controlled an SWB10 at Symington for all sorties beyond 900 miles. It had been found that the SWB8 was not capable of satisfactory direct working with aircraft over such distances. The need was for similar facilities at Nos. 15 and 19 Groups, mainly for working with aircraft engaged on anti-submarine patrols and convoy protection at distances beyond 900 miles, especially in areas where static was prevalent.

Headquarters No. 26 Group pointed out the many difficulties in the supply and installation of new transmitters, and suggested that the desired effect might be achieved by using higher gain aerial systems than the quarter-wave vertical aerials then in use; but it was eventually found possible to make a number of high power transmitters available. Two SWB11's were installed at Silloth for the use of Headquarters No. 15 Group, and were in use by the end of January 1944; and one SWB11 was made available at

1 A.H.B./IIE/27.
2 A.M. File S.70239.
3 A.M. File CS.14545.
4 A.M. File S.2955/I.
5 A.M. File S.4058.

Bodmin for use by Headquarters No. 19 Group. The installation at Silloth was a temporary one, prior to a permanent installation which was planned on a new site at Aston Hill; but by August 1944, the Aston Hill project was in abeyance pending a decision on post-war requirements and policy. Headquarters No. 15 Group were using two SWB8's at Aston Hill for aircraft and convoy frequencies, but their commitment for the North Atlantic point-to-point service and for very long range aircraft continued to be met by the two SWB11's at Silloth. The other main reconnaissance and convoy frequencies operated by Nos. 16, 18 and 19 Groups used SWB8B or E transmitters housed locally.[1]

The introduction of very long range aircraft for escort duties also raised reception problems, and a marked improvement in signal strength was achieved by combining the outputs of three receivers. The inputs to the receivers came in two cases from rhombic arrays directionally sited to Reykjavik and St. Johns and in the third case from a quarter-wave dipole, the three receivers being aligned and their output brought to a single pair of headphones. The fine tuning of all three receivers was mechanically coupled, and thus capable of being controlled by one operator. The scheme worked well but was rather cumbersome, and an additional unit was produced by No. 2 Signals Depot to which inputs of the three aerial systems were brought and from which the output was taken to an ordinary H.R.O. or R.1188 receiver. The improvement in signal strength was most marked.[2]

Headquarters Coastal Command operated a number of transmitters from Northwood but the site was an unsatisfactory one and the operating difficulties had always caused a good deal of concern. In November 1943, Headquarters No. 26 Group carried out a survey of the H.F. communications at Northwood and concluded that it was essential to provide better sites and aerial systems than existed there at that time. The known future requirements were H.F. W/T links to Iceland and the Azores, with one standby, and an H.F. W/T link to E.A.C. Halifax and No. 1 Group St. Johns. The Iceland and Azores services were already being operated from Northwood, but no standby was in existence, and the Halifax and St. Johns circuit was a future requirement.[3] In addition to these main circuits, Northwood provided a link in the Air Ministry and group standby point-to-point system, involving a total of nine T.1190's; these transmitters also provided standbys for the main circuits. The receiving station at Northwood provided receivers for all these services plus five additional receivers for monitoring watches.[4]

Plans for the transfer of the transmitter circuits to the main transmitting stations, and for the building of a new receiving station at Northwood in

[1] A.M. File S.4058.
[2] A.M. File S.4058.
[3] An M.F. circuit was in existence between Prestwick and Iceland which replaced the H.F. circuits during black-out conditions.
[4] A.M. File S.4058.

the old transmitting station, were laid;[1] but because of the decreasing W/T commitments of Coastal Command, evident in the first six months of 1944, the original plan was abandoned. The transmitters were transferred to Winstone and Greenford, and the transmitting station was dismantled, but the old receiving station at Northwood remained in use.[2]

Further requirements in the course of 1942-1943, including the need for short remote control lines, for adequate spares, and adequate provision for 'Overlord', made the erection of two further main W/T transmitting stations necessary. These were erected at Greatworth and Weyhill. Towards the end of 1943, it was also decided to provide certain facilities at Chicksands for various W/T point-to-point services, the new station to be known as Chicksands 'B'. It was subsequently enlarged and later became the Cross Channel Signals Centre.[3]

Review of Transmitting Station Requirements

In order to meet commitments in the post European war period, and to provide increased power on existing circuits, a number of high power transmitters and amplifiers were provisioned in 1944. The main requirements were the provision of transmitters of higher power than those already in use on the circuits to India, Ceylon and Australia, and the installation of similar transmitters for circuits to Singapore and the Far East when those areas were occupied.

Accommodation for these transmitters had to be found, and a review was carried out of R.A.F. transmitting stations with the idea of formulating some basis for future policy with regard to these stations. The main transmitting stations at this time were situated at Dagnall, Greatworth and Weyhill, with other stations (some carrying purely Transport or Coastal Command traffic) at Symington, Winstone, Silloth, Bodmin, Hartlebury, Aston Hill, Greenford and Galdenoch. The main receiving stations were at Leighton Buzzard, Stoke Hammond, Chicksands, Cardington, Birdlip and Redbrae. It was decided that the new accommodation could best be found by altering existing accommodation at Dagnall and providing additional accommodation at Greatworth. These two stations, with Weyhill, were expected to remain the main transmitting stations as a long-term policy. The target date for the completion of works services and the installation of some 40 additional transmitters was February 1945.[4]

Greatworth was a high-power station carrying operational and administrative traffic to India and the Far East. In 1944, it was operating eight SWB8's, one SWB10 and two SWB11's. It was employed for operating services of the highest operational priority delegated to the R.A.F. by

[1] A.M. File S.2065/II.
[2] A.M. File S.4058.
[3] A.M. Files CS.23930 and S.74858.
[4] A.M. File CS.22974.

the Chiefs of Staff. By the end of 1944, it was decided to operate an additional 20 services from Greatworth, including ten SWB11's. The station was not equipped to operate the additional circuits, and accommodation, equipment and power supplies had to be provided. Among the Air Ministry W/T stations scheduled for post-war employment, Greatworth was the only one with the ideal geographical position, being situated in the approximate centre of England. Daventry, chosen by the B.B.C. for identical reasons, was 15 miles to the north. Greatworth provided an ideal site from which to serve the United Kingdom with broadcast meteorological and aircraft safety reports.[1]

Up to April 1945, owing to the danger of destruction of Air Ministry W/T stations by enemy action, Headquarters No. 26 Group made arrangements for standby transmitters with associated aerial arrays to be provided at alternative stations for the more important services. Thus, if Dagnall were destroyed, the more important services carried on from there could be immediately replaced by the use of equipment at Winstone and Hartlebury. Although there was no Air Ministry ruling on this point, it was nevertheless a desirable and worthwhile precaution. But by April 1945, the danger of destruction by enemy action had passed, and some relief was afforded to the general congestion at transmitting stations by discontinuing these precautionary arrangements. From this point on, Air Ministry W/T stations were organised on a basis of one transmitter to a circuit, covered only by station spares. Any transmitting station which had its facilities damaged or destroyed could still have them replaced in a comparatively short time from the mobile SWB8 transmitters and power supplies held in reserve at the various depots.[2]

By this time it had become general policy, where conditions permitted, to endeavour to provide triple diversity reception, usually with two sets of rhombic aerials, one for the night and one for the day frequency. However, such an arrangement was expensive in terms of the land required, aerial masts and general upkeep, and where conditions justified it and the frequency was not too great, one set of rhombic aerials to cover both day and night reception was used. Day and night transmitting rhombic aerials were also provided on long and difficult circuits. It was the practice of Headquarters No. 26 Group to associate their designs with the frequencies that were to be employed and the route and range of the circuits.[3]

With the end of the war in Europe, neither Fighter nor Bomber Command required the provision of long-range facilities at any of the main Air Ministry transmitting and receiving stations under the control of Headquarters No. 26 Group. Coastal Command no longer required long-range transmitters for escort in the Atlantic, and they were ready to transfer an SWB8 they

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[1] A.M. File S.103136.
[2] A.M. File CS.22974.
[3] A.M. File CS.22974.

were using at Bodmin to Headquarters No. 19 Group at Mount Batten. The only long-range requirements likely to continue, other than those for the inter-command circuits, were those of Transport Command. The future plans of this Command were as yet uncertain, but a tentative plan was prepared in July 1945. The main stations envisaged for the combined post-war lay-out were:—

Inter-Command Communications

Main Signals Centre	Leighton Buzzard (now known as Stanbridge).
Receiving Stations	Stoke Hammond and Chicksands.
Transmitting Stations	Greatworth, Dagnall and Weyhill.

Transport Command Communications

North Atlantic Air Route	Receiving station: Prestwick. Transmitting Stations: Symington and Galdenoch.
For H.Q. No. 44 Group Overseas Traffic Control	Receiving Station: Birdlip. Transmitting Station: Winstone.
For H.Q. No. 46 Group and Continental Aircraft Control	Receiving Cabins: H.Q. No. 46 Group and C.A.C. Uxbridge. Transmitting Station: Greenford.

In pursuit of this plan, the Transport Command transmitting station at Uxbridge was closed and its transmitters transferred to Greenford. The other stations becoming redundant were : Silloth, Aston Hill, Bodmin and Hartlebury. Silloth was given up almost at once, while the closing down of Aston Hill, Bodmin and Hartlebury awaited the completion of extensions at Greatworth It was anticipated that subsequently Birdlip and Winstone might be transferred to civil aviation.[1]

By August 1945, the majority of the action required had already been taken. Dagnall was eventually to house some twelve SWB8's, six of which would drive SWB10 amplifiers, five SWB11's, and a small number of R.C.A. transmitters of varying power. Greatworth was to have seventeen SWB8's, four of which would drive SWB10 amplifiers, thirteen SWB11's, and a small number of R.C.A. type ET.4332 transmitters.[2]

W/T Traffic

Headquarters No. 26 Group controlled the operation, both technical and

[1] A.M. Files S.74858 and CS.22974.
[2] A.M. File S.103136.

traffic, of the Air Ministry W/T Receiving Stations in the United Kingdom—Leighton Buzzard, Birdlip, Prestwick etc.—together with their associated transmitting stations. Within the United Kingdom, very little traffic was passed over W/T circuits in normal circumstances because of the excellent teleprinter network which covered the country, but where widespread landline breakdown made normal and emergency teleprinter working impossible, operational and urgent priority administrative traffic was sent by means of the emergency standby point-to-point network set out in C.C.O.s. The control of these circuits was vested in the home commands, Headquarters No. 26 Group co-ordinating the traffic arrangements necessary and issuing re-routeing instructions to all signals offices concerned.[1] The control of W/T traffic fell under four major headings : handling by W/T signals offices, centralised day-to-day traffic control as exercised by Headquarters No. 26 Group (including routeing), traffic statistics, and procedure for the investigation and prevention of delays.[2]

There were two methods of W/T communication in use—hand-operated and automatic. The procedure in force for hand-operated traffic was that laid down in the R.A.F. Signals Manual. For automatic transmission and reception, the detailed traffic arrangements depended on the particular method of transmission and reception in use, of which the main were normal undulator reception and transcription, direct teleprinting from a gummed undulator slip, and direct reperforating and reprinting. Other methods were experimented with but these were the only methods regularly employed.

An Overseas Routeing Directory was compiled and distributed which covered all normal routeing. It was based on the Air Ministry W/T circuits listed in C.C.O.s and on the circuits in the individual signals organisations of overseas commands and other formations. The ideal overseas directory (without taking into account the question of security) would show the route to every R.A.F. unit outside the United Kingdom, but it was impracticable to produce and maintain such a document, and all that was really required by United Kingdom signals offices was to know the United Kingdom W/T terminal which handled the messages for any particular station and for the terminal to know the necessary circuits.

While R.A.F. units overseas remained comparatively regionalised and within the communications network of their own command headquarters only, this was a comparatively simple matter, and a very brief directory fulfilled the requirement, but when the units of one command moved into areas controlled jointly with another command—the joint operations of Headquarters R.A.F. Middle East and Headquarters N.A.A.F. were a case

[1] The 'K' W/T broadcasts from Leighton Buzzard to home W/T stations were reduced to one per day in 1943 owing to the urgent necessity for freeing W/T operators in the U.K. for employment elsewhere.

[2] A.H.B./IIM/B26/1A.

in point—and when more than one overseas W/T station in the same command was in regular direct communication with the United Kingdom, a more detailed directory had to be produced. A new directory was therefore drawn up showing all main W/T circuits existing in the R.A.F. communications network.[1]

The whole matter of routeing was further complicated by the fact that address-signs were not allocated to every overseas unit, and it was necessary in many cases not only to decide the correct circuits to be used but also the unit to which the message was to be routed for de-cyphering. An appendix was therefore included with the main directory to cover doubtful cases where there was more than one unit in the same area acting as cypher office for local units.

The policy of allocating new address-signs only to overseas units with cypher facilities of their own had the effect of transferring to the originating station the responsibility of ascertaining the cypher office responsible for an addressee. But the originating station often had great difficulty in doing this without knowledge of the local organisation existing in the overseas theatre. In the case of United Kingdom originating stations, the routeing of units at locations not shown in the overseas directory was referred to the duty traffic control office atHeadquarters No. 26 Group. Arrangements were made for the group to receive the internal signals routeing directories and location statements issued by overseas commands, and for overseas commands and certain main W/T stations to hold copies of the United Kingdom directory, so as to facilitate the interchange of routeing and cypher information.

The Overseas Routeing Directory indicated the primary route to an overseas W/T station only : whenever this primary route was not available for any reason—but W/T conditions, traffic congestion, equipment or remote control failure—the United Kingdom terminal W/T station was instructed by the traffic control duty officer at Headquarters No. 26 Group on the action to be taken. A comprehensive card index was prepared for use in bad W/T conditions or in traffic congestion, giving all the available routes known to stations in the overseas directory. This index included NOTWT cable routes, telegraphic addresses, and any other data which might assist the traffic control duty officer in disposing of traffic. It was based on the W/T and landline circuits indicated in overseas C.C.O.s and signals organisations. Before diverting traffic over alternative routes the duty officer estimated the probable duration of non-communication or congestion by referring to a series of charts in the War Room at Headquarters No. 26 Group which indicated normal hours of working and traffic capacities. These charts were prepared daily and gave a good picture of the working of circuits. The duty officer also referred to the last two-hourly situation reports on the alternative W/T link to ascertain the prob-

[1] A.H.B./IIM/B26/1A.

able delay if a proportion or the whole of the traffic affected was diverted. Traffic was not diverted unless delay threatened to be excessive for its precedence category. In normal circumstances alternative routes were less expeditious than primary routes, and before traffic of high precedence was diverted the duty officer invariably contacted the appropriate United Kingdom W/T terminal station to obtain up-to-the-minute information on W/T and traffic conditions and never relied solely on the two-hourly reports.

Cable and Wireless Ltd., and the Chief Telegraph Censor, kept the duty officer informed of all cable breaks, restorations and traffic congestion occurring on overseas civil routes. In certain cases, with poor quality circuits which involved regular and frequent diversions, the United Kingdom W/T terminal was supplied with standing diversion instructions for the different traffic precedence categories, enabling it to divert to the best alternative routes without undue delay. A large diagram was kept in the war room at Headquarters No. 26 Group showing all remote control circuits associated with the Air Ministry W/T stations, their terminations and private wire numbers; and details of all W/T transmitters and receivers at these stations, with their relevant standbys, were exhibited for easy reference, types of aerials and their orientations being included. The duty officer at Headquarters No. 26 Group was thus able to transfer the affected service immediately any remote control or equipment failure took place. No. 26 Group also kept a card index of unit locations, which gave the location of every R.A.F. and U.S.A.A.F. unit at home and overseas, and which was referred to where exceptional routeings were called for.[1]

In addition to all questions of routeing and traffic control, Headquarters No. 26 Group was also concerned with the general traffic organisation and inter-communication link-up of the United Kingdom W/T terminals, covering such points as the associated teleprinter circuits, establishments, layout of W/T stations and traffic offices, visiting officers, minimising traffic and use of code-words, concession telegrams, and matters of procedure. The landline teleprinter facilities at each W/T receiving station were kept constantly under review to ensure that they were adequate for the traffic handled, and when new W/T circuits were planned the Traffic Control section of Headquarters No. 26 Group were consulted on the teleprinter circuits to be installed. Although a large part of the teleprinter circuits in the United Kingdom were switchable and formed part of the D.T.N., the traffic passing over the overseas links was usually fairly closely related to a limited number of stations only, and was of such a volume that it permitted the frequent use of tied simplex or duplex circuits, with improved traffic handling capabilities and transit times. Advice on the personnel establishments of all wireless and teleprinter trades was given to the Air Ministry, thus co-ordinating commitments and staff. Up-to-date and complete records of W/T equipment and aerials at Air Ministry W/T

[1] A.H.B./IIM/B26/1A.

stations were held, to enable the resources available to be employed to the maximum advantage of all users. Frequent visits of Headquarters staff officers formed a valuable part of the Traffic Control section's activities, giving a close liaison with station signals officers. When it was necessary for 'Minimise' procedure to be instituted to any particular part of the world, Headquarters No. 26 Group undertook its control and enforcement so far as the home W/T stations were concerned. Under these conditions, arrangements were usually made for all non-precedence traffic originated in the United Kingdom to be referred back to originators, to be held pending removal of the restriction. The use of codewords for frequently recurring phrases or sentences in signals was organised in connection with traffic between the Air Ministry Accounts Sections and Overseas Accounts Offices to save signalling and cyphering time. The use and administration of the concession telegram service was supervised in conjunction with the Air Ministry; all concession telegrams to or from the United Kingdom passed through the Air Ministry Communications Section (a unit within No. 26 Group) and any verbose or irregular CSN telegrams were sorted out and checked with their originators. Advice was given to the Air Ministry on matters of W/T procedure, including recommendations for the amendment of existing procedure.

The Traffic Control Section of Headquarters No. 26 Group operated in a War Room in which was gathered all the available information relating to the operation of telephone, teleprinter and W/T circuits, together with accompanying traffic statistics and alternative and emergency routes that could be used. A duty officer was on continuous duty to advise and instruct Air Ministry W/T stations and any signals office in the country on traffic matters. So far as overseas traffic was concerned, the following additional information was available to assist the duty officer in maintaining maximum efficiency at all points :—[1]

(a) Daily circuit loading charts were kept for each W/T circuit terminating in the United Kingdom showing the normal loading capacity.

(b) Daily 'hours of availability' charts were kept for each circuit, indicating the times during which communication was maintained each day.

(c) Every two hours throughout the day and night the Air Ministry W/T stations telephoned, for each of their circuits, the number of immediate, important and ordinary messages on hand, together with the maximum delay in each category, and information on the quality of communication. Every 24 hours a signalled report giving similar details was received from the overseas terminals of the United Kingdom W/T channels.

(d) World-wide charts were kept indicating civil routes normally available with normal traffic loadings.

[1] A.H.B./IIM/B26/1A.

(e) Charts were kept showing the communication networks of the other Services.

As a guide to the direction and flow of traffic 'In' and 'Out', teleprinter check sheets for two days each month were forwarded by each W/T station. In addition, a periodical analysis of traffic was made to ascertain the average internal transit times at the United Kingdom W/T terminal stations of the various classes of precedence traffic on all the main wireless circuits. Information was also held indicating the average transit time, estimated from time of origin to time of receipt by addressee, of all precedence traffic circulating between Air Ministry and the main overseas command headquarters. A monitoring station was used to check the loading and flow of traffic on circuits shared by more than two stations, and this was of particular value where two overseas stations shared a circuit which also had a United Kingdom terminal; in such cases the home traffic returns were not a complete record of the total traffic passing.

Once a day the Traffic Control duty officer completed a communication situation report which was forwarded to the Air Ministry by special despatch rider, with the idea of giving the Air Ministry a daily picture of W/T communications between the United Kingdom and overseas in as brief a form compatible with the amount of detail required.

Regular surveys were made by the Traffic Control section of signals office transit times of priority traffic, and action taken whenever these times exceeded the permissible limits. Signals failures, breaches of procedure, and general signals discipline, were similarly investigated and checked, the monitoring section being used for this purpose. In all cases of traffic delay, the transit times were carefully checked between originator and cypher office, between cypher office and signals office, and between time of receipt and time of despatch from the signals office. Cypher sections were encouraged to consider themselves an integral part of the signals service.[1]

The Traffic Control duty officer had available in the War Room a complete set of signals publications, confidential communications orders, and similar instructions, which enabled him to advise any enquiring W/T station on the correct procedure to be followed in any given case. This service was particularly helpful where an out-station duty officer was in doubt on the correct action to be taken in unusual cases.

Whenever formations changed their location or title, a period generally ensued in which difficulty was experienced in effecting the delivery of communications.[2] This was mainly due to delayed information on changes, or to non-compliance with such information. The problem became especially urgent in 1944/45 in view of the many changes made to deal with fluctuat-

[1] A.H.B./IIM/B26/1A.
[2] A.M. File CS.17010/I.

ing situations and big advances, both in Europe and in South-East Asia.

The value of a central controlling authority, however, was repeatedly demonstrated. It was neither economic nor practicable for every W/T station to attempt to gather together on its own account the very comprehensive traffic information necessary to ensure maximum efficiency, but the organisation of the Traffic Control Section at Headquarters No. 26 Group enabled all relevant details to be collected by a skilled staff at a central point and distributed to all signals offices requiring them.

Administrative Telephone System

The problems of R.A.F. administrative telephone traffic, although similar to the problems of any telephone system, differed in two fundamental ways. On the G.P.O. network, exchanges were concentrated, either directly or through intermediate exchanges, on to a central exchange in the locality, known as the group centre. The group centres were then inter-connected with other group centres according to traffic needs, and all long-distance or trunk traffic originated at the minor exchanges was passed to the appropriate group centre for control. The community of interest between Service establishments, however, was functional rather than geographical, and the provision of routes was therefore mainly from lower to higher formations within each individual command, with the addition of certain lateral communications. The second factor, which emphasised the inevitability of the functional approach, was that many of the administrative speech circuits were in fact basically reserve operational circuits alternatively routed, but used for administrative purposes for reasons of economy, and to ensure continuity of service on vital operational communications.[1]

The principle of nominating a number of the more important exchanges as switching centres—equivalent to the G.P.O. group centres—was, however, still applicable. Such centres were known as terminal trunk centres (T.T.C.), and were selected with due regard to the size of the switchboard concerned, the variety of main outlets to other terminal trunk centres, and other like considerations. The T.T.C.s differed from the group centres of the G.P.O., however, in that there was no concentration of control of long-distance traffic, local control of all calls being adopted on the R.A.F. private-wire network. In connecting an establishment to this network, as much regard as possible was paid to the geographical aspect as its function would permit, however, since the acute shortage of line plant rendered the provision of long-distance circuits difficult.

Having selected the T.T.C., it was then possible to associate every unit on the network with one or more of these centres according to the circuits provided. This association was shown in the Telephone Routeing Master List, which was held by all R.A.F. establishments on the administrative

[1] A.H.B./IIM/B26/1A.

telephone network. The next and final stage towards affording complete inter-communication was to organise the flow of traffic from each T.T.C. to all the others. This was effected by using telephone routeing schedules, which were peculiar to each T.T.C., showing the primary and, in certain cases, the secondary route to be utilised as the initial link in the chain of connections to the distant T.T.C. The main principles adopted in compiling these routeing schedules were, briefly, that only one (primary) or two (primary and secondary) routes were normally authorised, but two additional (emergency) routes were given for use under breakdown conditions, and the most direct routeing with the least number of intermediate switchings was preferred, a secondary routeing being given only when this involved the same number of switchings as the primary or as an alternative to a direct route. Stations which possessed more than one outlet to other stations or T.T.C.s were supplied with telephone routeing instructions, which specified, on the same basis as for T.T.C.s, which calls should, primarily and secondarily, be circulated over the different routes. The procedure for connecting a call to a distant station therefore was :—[1]

(a) Refer to the Telephone Routeing Master List to ascertain the appropriate T.T.C. with which the required station was associated.

(b) Consult the routeing information (where applicable) to determine the authorised route or routes.

(c) Ask each intermediate switchboard for the distant T.T.C. required until this was obtained, when the required station was requested. It was always the distant T.T.C. which was demanded of the intermediate operator, who was then responsible for extending the call in accordance with local routeing information.

It was a prime necessity to have properly trained personnel to operate and supervise the switchboards, but unfortunately this was one of the main difficulties encountered when the R.A.F. Telephone Traffic Control section was formed at Headquarters No. 26 Group in 1942. After the new section had reorganised the method by which calls were circulated over the network, special attention was therefore given to the question of improving the standard of operating. The first essential was the preparation of a standard operating procedure, and this was compiled by a small inter-Service committee in co-operation with the G.P.O. A second essential was that all operators should be adequately schooled in standard procedure, but for various reasons any extensive system of training was impossible. Arrangements were made, however, to provide an improved short introductory course on switchboard manipulation, which was augmented by local training on posting. A third essential was adequate and efficient supervision; but it was found that due to rapid expansion many supervisors were unequal to their task and lacked the necessary knowledge, initiative and drive. In order to overcome this weakness, and in an

[1] A.H.B./IIM/B26/1A.

endeavour to improve the poor standard of operating generally, a course for telephone N.C.O.s was instituted at Headquarters No. 26 Group on the fundamental principles of telephone practice so far as switchboard operating and supervision and switchroom organisations were concerned. This course had excellent results.[1]

The ideal staffing system was to staff switchboards exactly according to traffic loads, and in order to achieve this, it was essential to obtain reliable information on these loads. The different types of calls concerned were all evaluated according to the operating time taken in dealing with them, which was initially determined by means of timed observations; and in view of the fact that an uneven flow of traffic was always experienced, due allowance was made for unoccupied time. When the traffic record had been taken and valued, and the load an individual should be able to handle calculated, it was then a comparatively simple matter to work out a duty chart covering the requirement and taking into account meal-reliefs etc. If a staffing review was carried out at regular intervals of six months or so, any material variation in conditions was quickly apparent, steady growth could be observed and anticipated, and difficulties due to overloading avoided. However, with the comparatively small staffs concerned at the majority of stations it was always difficult to cater for privilege and sick leave and similar contingencies solely within each unit.

Having ascertained the number of switchboard positions and the staff needed to handle traffic, the next problems to be decided were the type of switchboard available best suited to the requirement, and the provision of circuits. There were several different forms of record on which circuit provision could be based, the simplest of which was the engaged circuit count, allied, if necessary, to an overflow record. By counting the number of engaged circuits on a route at frequent intervals the amount of traffic passed over the route could be accurately determined in traffic units—occupied circuit hours per hour, or the average number of circuits occupied during each hour. Circuit provision was normally based on the busiest hour of the day (as was switchboard provision). If the number of calls connected during this hour was divided into the total duration, then the average circuit time per call was obtained. This was then added to the number of ineffective calls in order to obtain the total circuit time needed. The longer distance circuits, being the more difficult to provide, were generally less liberally installed, but in order to avoid wasting time on these circuits due to a distant short line being engaged, more liberal provision was allowed on the shorter distance circuits. Engaged circuit counts, however, left many factors out of consideration, their value lying in their simplicity. Such counts were therefore supplemented by a more detailed return at intervals, such as a traffic distribution analysis. When additional circuits were shown by these records to be needed, it was generally possible to afford relief either by building up existing routes or by providing new

[1] A.H.B./IIM/A26/1A.

routes between switchboards having a fair community of interest. The former method was generally preferable. The provision of direct circuits eliminated intermediate switchings, but small routes of one, two or three circuits were not comparable in efficiency, so far as call-carrying capacity per circuit was concerned, with the larger routes. It was a matter of deciding between these opposing considerations, and a compromise was often reached in providing direct circuits within reason but not up to full requirements, arranging by means of the routeing schedules for the overflow traffic to circulate over the larger backbone routes.[1]

Amongst other records maintained by the Traffic Control section of Headquarters No. 26 Group was a card index of all circuits—teleprinter, telephone, operational, administrative etc.—either provided or on order within the United Kingdom, and the Telephone Routeing Master List was based on the circuits shown as existing in this list. A daily amendment list was issued, from which changes in the routeing schedules and instructions were made. Unfortunately, considerable delay often occurred between the provision, cessation or alteration of a circuit and the date on which the change was reported. In addition, it was only possible to issue routine amendments to the Telephone Routeing Master List once a month.

There was an essential difference between the R.A.F. and G.P.O. systems of controlling long-distance traffic. On the public network, all trunk calls were controlled at the originating group centre, whereas on the R.A.F. private-wire network such calls were controlled at the originating switchboard whether or not this happened to be a Terminal Trunk Centre. (It was generally agreed that it was preferable to invest control of calls as near the originating point as economically possible.) The shorter-distance calls, local and toll, were handled in the same way as on the G.P.O. system. Another difference in the treatment of calls between the two networks was that on the G.P.O. network all trunk calls had to be timed for accounting purposes, wheareas this did not apply on the R.A.F. network.

The condition of ' trunk lines engaged ' was frequently encountered, to the extent that special provision to eliminate the numerous repeat attempts resulting became highly desirable. A restricted scope of concentration was therefore permitted. When both primary and secondary routeings proved ineffective owing to the ' lines engaged ' condition being encountered at the first intermediate switchboard, it was permitted to book at the primary intermediate centre for subequent completion. A free circuit on the required route—as well as back to the originating switchboards—was immediately apparent at this switchboard, whereas enquiry had to be made regarding this so far as the originating station was concerned, involving additional and otherwise unnecessary utilisation of operating and line time. Such booking after an initial attempt resulted in centralised control to a degree commensurate with the congestion pertaining on the individual

[1] A.H.B./IIM/B26/1A.

routes. If the procedure was properly and universally used, an analysis of booked calls became available and formed a useful guide to circuit provision.[1]

The varying degrees of importance attached to calls handled, and the fact that difficulties in the immediate completion of traffic were always present owing to line plant shortage, etc., necessitated the introduction of exceptional or favoured treatment for urgent calls. It was found that for most purposes two degrees of priority were adequate, priority I and priority II, although an overriding 'clear the line' priority existed for strictly limited use. The success of exceptional treatment of priority traffic depended on its application being rigidly restricted, and authority to make such calls was therefore strictly controlled.

An appreciable amount of intercommunication between establishments in different Services was necessary, and the need was met by nominating certain of the T.C.C.s as Inter-Service Switching Centres. Calls for other Services were normally routed to the nearest of these centres.

It was essential that information on the large number of establishments to which a call might be made, and the large number of people in an establishment for whom calls might be received, should be readily available to the telephone operator. The Telephone Routeing Master List covered routeing for all R.A.F. establishments, but individual incoming calls could only be quickly and efficiently connected if the local telephone directory was kept accessible and up-to-date and callers were educated to use their directories and not ask for a name or a department. Permanent and temporary changes and other similar information was made immediately apparent to all operators by placing different coloured pegs in their relative jacks.

When circulating calls over a switching network such as that provided in the R.A.F. it was highly desirable that circuits should be released for other calls immediately the current call was finished. Auto-signalling was desirable but often impracticable, and generator signalling circuits did not normally afford any indication of when a call finished. It was therefore necessary, especially at intermediate switchboards, to monitor connections involving generator signalling circuits at frequent intervals to ascertain whether a call was finished. A 'ring-off' unit was therefore developed and incorporated as a standard facility in certain types of switchboard, whereby ringing at the termination of a call in the forward direction—i.e. from originating to called station—gave a clearing supervisory to the next operator in the chain of connections. The advantages of this system were greatest at those switchboards dealing with an appreciable volume of traffic, and it was accordingly fitted on all generator signalling circuits at Terminal Trunk Centres.

[1] A.H.B./IIM/B26/1A.

Having obtained the distant station required, an extension user often found that the person or department wanted was engaged. The natural reaction of the caller was that he would wait until the extension cleared down, but this was not usually allowed, as line-time was wasted while he waited which could be used for other calls. If the call in progress was a local one, precedence was generally given to the trunk call and an interrupt procedure adopted. Another habit of callers was to ask for the station required and extract a promise from the operator that they would be rung back when the connection was made. The mere operation of recalling this subscriber wasted the time of the operators at both ends as well as adding to the time for which the lines were held for the call, while it frequently happened that when the call matured the originating subscriber could not be found. Delays of this sort were inevitable to some extent, but were kept to a minimum by encouraging extension users to hold on while their calls were attempted and educating them to advise the supervisor if they were likely to be away from their telephone for a while.[1]

The organisation of telephone exchanges was constantly being adjusted to give speed and efficiency in connecting calls and to eliminate unproductive line time, extension users being under a moral obligation to co-operate. Observation facilities were provided at the more important switchboards, not only to confirm adherence to instructions but also to discover weaknesses in order that these might be eliminated. A staff of travelling officers, although limited in number, was available amongst the Telephone Traffic Control Officers at Headquarters No. 26 Group, and since they were all ex-G.P.O. telephone traffic officials they were well suited to visiting and inspecting installations, determining deficiencies that might not be appreciated locally, advising on weaknesses and difficulties, and generally applying their wide knowledge and experience.

In March 1943, special arrangements for unrestricted calls on the public service were granted to important units in Maintenance Command. These units had only meagre connections to the R.A.F. private-wire network, sometimes even none at all, and they were compelled to rely on the public trunk network for most of their long-distance communications.[2]

The expansion of the trunk telephone service was unable to keep pace with the demand, owing to shortage of manpower and equipment, and early in 1943 a general drive was instituted to limit the use to which the public service was put. From the Services' point of view, the important thing was to use the public service for essential communications only and to make these in the most concise form. Use of the public service was confined almost entirely to administrative traffic. In an effort to reduce congestion, a six-minute limitation on trunk calls was introduced by the G.P.O. in March 1943. In passing this restriction to all commands, the Air Ministry directed

[1] A.H.B./IIM/B26/1A.
[2] A.M. File CS.18702.

that every effort was to be made to comply with it, particularly in the case of long distance calls. The facilities granted to Maintenance Command, however, were not affected.

Early in 1944, it became apparent that this direction was not being fully implemented, heavy waiting calls being caused throughout the private wire system through lines being held for considerably longer periods than six minutes. The traffic load was making it increasingly difficult to provide rapid telephone communications, and the enormous demands on lines planned for independent operational circuits prevented further expansion of the private wire system.

The Air Ministry issued a new directive on 9 March 1944, requesting that calls on the private wire system be restricted to six minutes. Only in the most exceptional circumstances were lines to be held for a longer period, and even for such cases calls must be terminated after 15 minutes.

Headquarters A.E.A.F. found difficulty in carrying out this directive, partly because no method existed of timing calls except by the preparation of individual dockets, which led to delays, but largely because operational considerations dictated the continuance of a call even beyond 15 minutes in some circumstances. However, a number of measures were introduced to encourage telephone users to be brief, and shortly before D-Day an order was issued barring certain nominated extensions from originating traffic, both at Headquarters A.E.A.F. and at subordinate formations.[1]

The system subsequently introduced was that memorandum slips were prepared only for those calls which could not be connected on demand. The booking officer inserted on this slip the time when the call was established and when disconnected. Subscribers requesting booked calls were reminded by operators of the need for brevity when the call was established, the operator saying, 'Your call to. . . . The line is very busy. Go ahead.' During a booked call the originating operator entered the circuit at the end of six minutes, 9, 12 and 15 minutes, the last time adding 'May I clear the line, please?' Supervisors examined booking slips daily and made regular reports.

Many difficulties involving wastage of line time were still common in 1944, caused mainly by difficulties in the operating standards at originating switchboards. In an effort to improve these standards, arrangements were made for switchboard supervisors to visit the switching centre to which they were connected so as to improve co-operation and give supervisors a wider appreciation of the system. Some telephone operators made no attempt to use secondary routeing when the primary routeing was engaged, and instructions were issued to encourage them to do so. G.P.O. liaison officers were established at R.A.F. and U.S.A.A.F. commands, groups and major and key formations, and by 1944 some 30 such officers were established. Consequent

[1] A.H.B./IIS/110/9/37.

upon the formation of the A.E.A.F. and the Ninth U.S.A.A.F., a review of the appointments and duties of these officers was made and a new establishment list issued.[1]

On 3 February 1944, the Air Ministry informed all Commands that the G.P.O. was fully engaged on a programme of construction and installation work of the highest priority (i.e., the 'Overlord' requirements), which was absorbing practically all the available manpower, and that applications for the alteration or provision of telephone facilities should be restricted until further notice to the minimum essential to maintain efficiency. Outstanding telephone requirements were reviewed and cancelled or postponed wherever possible.

Priorities

The abuse of priority markings was continuous and characteristic of all commands. In spite of repeated warnings and instructions, the whole of the Service lines of communication were loaded with messages bearing priority markings which showed a total disregard of the objects for which these markings were instituted. Surveys of signals traffic suggested that the bulk of messages should have no priority marking whatever, and should take their turn with other Service messages.[2]

Messages marked with priority markings were handled in accordance with such markings at all stages of transit, at the station of origin, in transmission, at the receiving station, and by the recipient.[3] For priority facilities on telephone calls a schedule was approved for use on Service and civil lines. Authority to originate priority calls varied according to local circumstances, but the number of officers so authorised was kept to a minimum.[4]

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[1] A.H.B./IIS/110/9/37
[2] A.H.B./IIM/A13/1D.
[3] A Table showing the use of priority prefixes is at Appendix No. 19.
[4] A schedule of priority indications on telephones is at Appendix No. 20.

CHAPTER 13

W/T AND R/T STANDBY ORGANISATIONS IN THE UNITED KINGDOM

W/T Standby Point-to-Point Organisation

Wireless Telegraphy provided the main system of point-to-point communications in the R.A.F. at home up to 1936. By this time, however, it had become apparent that the system was ill-suited to the needs of general expansion and lacked the elements of security necessary in time of war. With the development of the administrative landline scheme and the Defence Teleprinter Network, all R.A.F. units became well served by landline circuits and the W/T point-to-point organisation was relegated to a standby role. By March 1940 it had become possible to appreciate the scope and trend of landline development more fully, and with the settlement of units and formations at their war stations, a review was carried out of the standby point-to-point W/T organisation within the United Kingdom.[1]

It was realised that, in most instances, formation headquarters at either end of any one landline circuit had at least one alternative line connecting them via an independent route, and that a great number of lines would have to be destroyed before general communications in an area were seriously affected. However, the landline system unavoidably contained concentrations of landlines in the form of telecommunications centres etc., so that a direct hit on any one focal point might simultaneously destroy a number of landline channels. It was not always possible to protect these concentrations absolutely, and it was therefore regarded as still necessary to provide a standby W/T organisation.[2]

Since only a vast number of W/T channels could completely replace the landline system, considerations of economy dictated that the standby system could absorb only a small part of the total traffic. Thus the object of the organisation was to provide facilities for passing high priority traffic between R.A.F. formations cut off from landline communications; routine administrative or non-operational messages were not passed by this organisation but were sent in accordance with the emergency schedules set out in Confidential Communications Orders, or by the Despatch Rider Letter Service.[3] Signals officers were instructed to exercise the strictest supervision over all out-going traffic, which was kept down to a minimum to avoid congestion. To keep the system as flexible as possible, the working arrangements within commands were left in the hands of the C.S.O.s, although the Air Ministry was kept informed of any major changes. Watches were kept as required by C.S.O.s or as instructed by the Air Ministry, but stations had to be

[1] A.M. File S.3501.
[2] A.M. File S.3501.
[3] A.H.B./IIH/241/10/105(C).

capable of maintaining continuous watch on any or all sections to which they belonged in case of landline failure or other emergency. In the event of a station having to open up on W/T, the traffic control section at Headquarters No. 26 Group was informed immediately.

It was essential to put the majority of point-to-point W/T within the 3-4 megacycles band, owing to the short ranges involved, the necessity to use low-power transmission, the need to release T.1087/R.1084 equipment for the more urgent aircraft and mobile services, and to avoid the aircraft bands as far as possible. All closely-grouped stations in any one section used the T.1083/R.1082. Section control stations were given more power, with the T.1087/R.1084. Receiver and transmitter aerial systems were made directional wherever possible, for signal strength purposes and to divert propagation away from enemy territory. Control stations kept watch continuously, but other stations were required only to test with control not less than twice daily. Groups and stations constructed portable pack-sets comprising the T.1083/R.1082 and ancillary equipment, which was dispersed well away from main station buildings. Three mobile wireless stations were installed in St. James's Park for the Air Ministry terminals of the standby point-to-point services with Bomber, Fighter and Coastal Commands.[1] All messages were sent in cypher unless of the utmost operational urgency. Arrangements were made for the passing of meteorological reports by the standby organisation, although it was expressly ordered that the passage of weather information was not to interfere with urgent operational requirements. A section was opened for Flying Training, Technical and Maintenance Commands, and emergency equipment demand signals originated by operational units could, in the event of landline failure, be transmitted direct to the appropriate Universal Equipment Depot, the unit concerned being authorised to join the appropriate Maintenance Command standby section and transmit the signal.[2] The W/T standby organisation was also used in conjunction with the 'Panda' organisation.

In November 1940 the number of standby W/T sections in use by the various commands was as follows :—[3]

Air Ministry	7
Fighter Command	6
Bomber Command	9
Coastal Command	5
Other Commands	7

Provision was later made for standby point-to-point communication between the No. 44 Group control stations at Prestwick and Gloucester and their associated airfields.[4]

[1] A.M. File S.3501.
[2] A.H.B./IIH/241/10/105(C).
[3] A.M. File S.3501. For the full W/T Standby Point-to-Point Organisation as at November 1940, *see* Appendix No. 21.
[4] A.M. File CS.16664.

Curtailment

In view of the acute shortage of operators, and the fact that a large number of maintenance units were lodger units on parent stations in other commands, the point-to-point standby organisation for these units was reviewed in October 1942, when it was decided that, as maintenance units were provided with an adequate number of teleprinters for normal working, parent stations should be able to cope with the standby requirement during periods of landline breakdown. Some twenty maintenance units were affected. Three months later, in January 1943, consequent upon the pressing need to economise still further in personnel and equipment, it was decided that the standby point-to-point organisation in Bomber Command should be considerably curtailed. The command organisation consisted of two command-to-group sections and nine group-to-station sections, and of these only the two command-to-group sections were retained on the existing basis of 0800—2000 hours daily and 2000—0800 as required. The others were reduced to weekly exercises of one hour, with the proviso that a watch was to be opened as necessary when landlines were disrupted. The personnel and equipment made redundant by these decisions were withdrawn.[1]

By August 1943, it was generally realised that the conditions under which the standby organisation had been devised and brought into operation had changed fundamentally and that the whole organisation required review. The need for economy in wireless personnel, the increased security of landline communications, and the speed with which essential circuits were being re-routed by the G.P.O., suggested a reduction in all commands similar to that which had already taken place in Bomber Command. The standby organisation became a command-to-group organisation only, two sections in Bomber Command, two in Coastal, one in Fighter, and two in Maintenance Command. All other sections were closed and frequencies and personnel released, although in the majority of cases the equipment was retained for emergency use. These measures were agreed in September 1943. They did not apply to the Tactical Air Force, full W/T communications for which were still required.[2]

By November 1944, in view of the flexibility of traffic routeing provided by the landline system, and in view of the number of standby sections already suspended, consideration was given to the complete suspension of the whole organisation. Two Coastal sections and one Fighter section, all covering areas in northern Scotland and the Orkneys, where landline communications were sparse, were retained, but with these exceptions the entire organisation was suspended on 22 January 1945. The frequencies, however, were retained for training purposes, and were used to prevent deterioration in the operating ability of wireless operators.

[1] A.H.B./IIH/241/10/105(C).
[2] A.H.B./IIH/241/10/105(C).

' Beetle '

In May 1940 it became apparent that there was a likelihood of attack on the United Kingdom by parachute troops, troop carriers, or by sea invasion, and that such an attack might be accompanied by a breakdown in landline communications.[1] The ability to repel such an attack, it was thought, whether by sea or by airborne forces, depended largely on immediate and accurate warning being passed to such local defence formations as were in a position to take immediate offensive action. A variety of means existed for the collection of such information, but a rapid system independent of landlines was needed.[2] A W/T point-to-point system was therefore required, to disseminate information collected from Naval and R.A.F. sources to the Army Home Defence Formations responsible for despatching land forces to deal with such attacks; and a medium-power R/T system was required so that the Army formations thus alerted could broadcast instructions to their own and other subordinate formations. The W/T organisation comprised Headquarters Fighter Command (which acted as control), the Headquarters of Bomber and Coastal Commands, Headquarters Scottish, Northern, Eastern and Western Commands (Army), Nos. 11 and 12 Corps (Army), and Area Combined Headquarters Nos. 15, 16 and 18 Groups (R.N. and R.A.F.). The Admiralty operated a W/T routine embracing the three A.C. H.Q.s plus G.H.Q. Home Forces, and this routine was the means by which the new ' Beetle ' organisation was linked to G.H.Q. Home Forces.[3]

The organisation was originally intended to provide for a situation in which landlines were extensively damaged, but by June 1940 its use was contemplated as an additional means of passing information even when landlines remained intact.[4] The W/T part of the organisation was installed and working by 10 June 1940, by which time the R/T stations were in the process of erection. Certain stations in Bomber Command were issued with portable receivers to enable them to take the R/T broadcasts from the military commands, so as to enable forces on the spot to take immediate action for their own protection. Responsibility for the scheme was delegated to Headquarters No. 26 Group, and a satisfactory test of the whole organisation was carried out on 23 June.[5]

Instructions covering the implementation of the ' Beetle ' plan, first issued in full in July 1940, were revised in April 1941,[6] by which time the scheme had been extended to cover northern Scotland, Northern Ireland, and non-operational R.A.F. commands.[7] The purpose of the organisation remained to supplement, and if necessary to replace, other means of communication in order to ensure that the earliest possible warning was given of an enemy

[1] A.H.B./IIH/241/10/40(A).
[2] A.M. File S.8685/II.
[3] A.H.B./IIH/241/10/40(A).
[4] A.H.B./IIH/241/10/40(A).
[5] A.H.B./IIM/B26/I.
[6] A.M. File S.8685.
[7] A.M. File S.8685/II.

attack on the United Kingdom. The W/T system, now known as System 'A', remained centred on Fighter Command, and connected Army, R.A.F. and Naval command headquarters with each other and with G.H.Q. System 'B', the R/T organisation, enabled the Army commands and certain other headquarters to broadcast instructions and information to Naval, Army and R.A.F. formations and units in the areas affected, broadcast receivers being issued to the formations and units concerned to enable them to pick up these broadcasts. Areas were divided geographically, and units or formations in one R.A.F. command might come, for the purposes of 'Beetle', under another. All R.A.F. group headquarters were issued with lists of holders of 'Beetle' receivers, showing the geographical areas into which these units came. R.A.F. group headquarters were responsible through their commands for informing the Air Ministry of the moves of units in their groups, so that the list could be kept up to date and the Army commands notified.[1]

Equipment for System 'A' was provided, manned and maintained by the R.A.F. The equipment used was the T.1087/R.1084 at the R.A.F. command headquarters and the A.C. H.Q.s., the T.1087/R.1084 mobile ground W/T Station at the Army Commands, and the T.1083/R.1082 mobile pack set at the Army Corps. In System 'B', the transmitting equipment was provided in some instances by the R.A.F. and in others by the Army but in all cases the Army was responsible for operation and maintenance; R/T broadcast receivers for System 'B' were provided for all units capable of defending themselves, operation and maintenance being the responsibility of the unit or formation concerned. No special skill was required to operate these receivers and qualified wireless operators were not employed. The W/T stations in System 'A' were manned continuously whereas the R/T stations in System 'B' opened watch only according to the code-word received. Any unit or formation finding that normal means of communication had failed assumed watch for set periods without awaiting orders. Verification tables and a special inter-service code were employed.[2] Messages passed on 'Beetle' were subject to normal rules for cyphering and security.[3] When airfields were required by 'Panda' controls to keep watch on 'Panda One' they could be warned by 'Beetle' R/T. Lateral communications on 'Panda' between commands could be made on 'Beetle' W/T. 'Panda' warnings could be sent in clear to avoid delay.

With effect from 31 July 1943 the 'Beetle' organisation was declared in abeyance, and W/T and R/T practice transmission, which had been carried out regularly meanwhile, were discontinued. The organisation was, however, retained so that it could be re-introduced at any time subject to one month's notice. W/T equipment at commands was retained and tested monthly, and W/T frequencies were also retained; R/T equipment was returned to store.[4]

[1] A.M. File S.8685.
[2] A.M. File S.8685.
[3] A.H.B./II/54/40.
[4] A.H.B./IIE/25.

' Panda '

Up to mid-1941 there was no direct means of communication between Army formations and R.A.F. airfields for operational messages to be passed under invasion conditions when landline systems were dislocated. ' Beetle ' provided an R/T warning system, but something more than this was needed. The majority of operational R.A.F. airfields had a standby W/T link with their group headquarters for the passing of operational traffic when landlines could no longer be used, but this formed part of the group standby point-to-point network and was operationally and not geographically disposed; the R.A.F. airfields in a corps area might be in wireless communication with different group headquarters. It was therefore decided to provide direct wireless communications for emergency use between Army formation headquarters and the R.A.F. airfields within their areas.[1] The organisation was known as ' Panda ', and the links used were :—

(a) From Army Command or Corps H.Q. to R.A.F. airfields to warn the latter of impending attack.

(b) From R.A.F. airfields to Army Command or Corps H.Q. to give information of enemy attacks and to call for assistance.

(c) Between a mobile column detailed to the defence of an airfield and the airfield itself, for passing tactical information regarding the disposition of the forces engaged.

The organisation consisted of two systems, ' Panda One ', between airfields and Army formation headquarters responsible for providing their reinforcement, and ' Panda Two ', between airfields and Army units or formations detailed to reinforce them, for the passage of tactical information concerning the battle. Army formation headquarters concerned were known as Panda Controls, and the R.A.F. provided wireless equipment and personnel for them. The equipment used at airfields was left to local arrangements, but where no other local set was available, the standby point-to-point set was used.

The full organisation for the operation and testing of ' Panda ' was set out in combined signals instructions, and was revised from time to time. The orders for the organisation were rewritten by the Director of Signals, Air Ministry, in April 1942.[2]

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[1] A.M. File CS.10093.

[2] *See* Appendix No. 22 for the ' Panda ' Signals Organisation, April 1942.

CHAPTER 14

W/T GROUND EQUIPMENT

The W/T ground equipment in use early in the war included the SWB8 short-wave medium range transmitter, various other medium range transmitters, including the standard telephone M.7, 8 and 15, and the T.1807, which was a low power transmitter used for the shorter ranges. There was, in addition, the T.77 M.F. transmitter, and the T.1083 aircraft transmitter, which was also used for a variety of purposes on the ground. The R.1084 was the receiver used for general purpose work in conjunction with most of these transmitters, and the R.1082 aircraft receiver was also used on the ground. In the first year of the war, however, considerable difficulties were encountered in the supply of equipment.[1]

Long Term Estimates

As a result of long term estimates submitted in October 1940, the supply of W/T signals equipment improved generally during the latter half of 1941. The long term estimates had enabled the Director of Radio Production (D.R.P.) to organise production on a comprehensive basis. But there were still a number of items where production had not reached sufficient quantities to permit all requirements to be satisfied, and efforts were made to adjust this. In the course of 1941, substitutes for certain transmitters and receivers were introduced. A modified version of the T.1087 was built, which included a crystal adaptor, and was then styled the T.1190. An American transmitter, the R.C.A. Type R.T.4332 (R.A.F. Type T.1179) was found to be suitable as a replacement for either the T.1087 or the T.1190. The T.1204A and T.1223A were small crystal-controlled transmitters designed for use on point-to-point services up to a distance of 100 miles, and they were used to replace the T.1087 on this type of work. The T.1204A was mains operated and the T.1223A was designed for operation with a generator. Of the new receivers, the mains operated American receiver, the R.C.A. Type A.R.77 (R.A.F. Type R.1188) was used as a replacement for the R.1084 in permanent stations with their own power supply, and it could also be installed in vehicles incorporating a special power pack. A second replacement for the R.1084 was a new Marconi receiver Type C.R.100 (R.A.F. Type R.1297), mains operated, and unsuitable for installations in vehicles. A third new receiver was the R.1224A, the corresponding receiver to the transmitters T.1204A and T.1223A. This receiver was battery operated, and was capable of replacing the R.1084 for short distance work. In spite of these numerous replacement sets, the demand was so great that supplies of the R.1084 were still needed. The M.F. transmitter T.77 was still in use, and efforts to find a substitute, both in the U.K. and U.S.A., failed. A

[1] The organisation for Signals Equipment Provisioning is described in the R.A.F. Signals History, Volume I : ' Organisation and Development ', Chapter 4.

further 50 T.77's were ordered to cover requirements for the ensuing two-year period. Two new transmitter/receiver combinations, the T.1148 and TR.1150, were on order in large numbers, sufficient for all known requirements in the ensuing two years. The provision of D.F. and associated equipment was also included in the 1941 estimates, together with W/T masts and coaxial cable, production of the latter being estimated at not less than 20,000 yards per month.

It was also decided that production of the T.1190 (the T.1087 with crystal adaptor) should be discontinued. The T.1190 was primarily used for Army co-operation, and a new type of tender incorporating the T.1179/R.1188 was developed. The requirements for pack and transportable W/T stations, and a new Marconi T.1154/R.1084 or R.1082 field transportable equipment, were also planned, together with light mobile W/T ground stations, using the Marconi A.D.67 and its associated receivers: this equipment was primarily designed for use overseas where metalled roads were practically non-existent, and in view of the expansion of the war area to the Middle East and Far East, both actual and potential, the production of some 120 transmitters and receivers was planned. Vehicles, petrol/electric generators, accumulators, and associated equipment, were all included in the estimates.[1]

These plans for the provision of equipment, laid in 1941 and set in motion in 1942, took into account all ground station requirements up to the middle of 1943. Further plans had to be made early in 1942 for the latter half of 1943 and for the year 1944; a very large proportion of the equipment needed to meet this later requirement was ordered from the U.S.A.

American Equipment

The major types of American set ordered, all in large numbers, included the A.R.88 H.F. and M.F. receiver for point-to-point and aircraft services at fixed W/T stations; the H.R.O. H.F. and M.F. receiver for vehicle and mobile use; the E.T.4332 (R.A.F. type T.1179) H.F. ground local communications transmitter and its replacement the E.T.4336; the Collins 18Q H.F. transmitter/receiver for general transportable and light mobile working; and the SCR.522 V.H.F. transmitter/receiver for ground-to-air, point-to-point and mobile working. Other equipment ordered in smaller numbers included an H.F. intercept receiver styled S.27 D.U.; the R.C.A. triple diversity H.F. receiver for general use on important long distance high-speed automatic W/T circuits; and a variety of general W/T equipment, some in large numbers, including special equipment for balloon barrage communications and R.A.F. Regiment airfield and vehicle communications, a small number of M.F. radio range equipments and various ancillary equipment.[2]

[1] A.M. File CS.12200.
[2] A.M. File CS.18776.

The E.T.4331 transmitter was required because of the increase in the number of W/T stations whose working distance approximated to 1,000 miles. These were mostly small Transport Command stations. The need for a transmitter of this type had been foreseen some time earlier, and orders had already been placed, but very few of this type of transmitter were forthcoming up to the end of 1943. In consequence it was necessary to install medium power transmitters such as the SWB8 or the R.C.A. A.V.T.22, when lower power transmitters would have sufficed. However, Headquarters No. 26 Group used a modification to the E.T.4332 by means of which an output of some 600 W. was obtained, and while this was rather less than the ideal, it was nevertheless decided to provide a supply of these modified E.T.4332's until such time as sufficient quantities of the E.T.4331 became available. Details of the modifications necessary were given to overseas commands.[1]

In spite of these large orders for American equipment, the home market was not neglected. It was realised that the American tendency to concentrate on landline communications and to relegate wireless to a minor role, plus the tendency to employ a variety of types of equipment for different specialist purposes, was likely in time to move more into line with the British policy of having as far as possible only a few types of equipment with wide frequency coverage and a general application. This, it was foreseen, would inevitably mean that R.A.F. orders placed in America would be competing with a new American demand; and in case supplies from America should be held up, at least one production line for each type of equipment was kept going in the United Kingdom. In the event there were many breaks in U.S.A. production, and these, coupled with various Lease-Lend troubles, caused many difficulties.[2]

Requirements for the main lines of British ground wireless equipment for 1944 were tabulated in June 1942. The principal types of equipment for which manufacture was planned were the Marconi SWB8 and SWB11 transmitters and the SWB10 amplifier; the T.1190, which, although previously declared obsolescent, was now reinstated in production because of the uncertainty of supply of its replacement; the American E.T.4336; and the T.1154, for fixed and hutted stations, radio vehicles, medium transportables, and marine craft. Receivers in production were the Murphy R.1311 for high-speed automatic working at the main W/T stations; the Marconi C.R.100 (R.1297), which had not been entirely successful and whose production was eventually expected to lapse; the R.1084, which although regarded as obsolescent was not being replaced by any new equipment; the R.1155, large numbers of which were required for use with the T.1154; and various other transmitter/receiver combinations, including the TR.1196 and several transportable Army sets. Other transportable equipments in production, in addition to the T.1154/R.1155 and the

[1] A.H.B./IIE/48.
[2] A.M. File CS.18776.

TR.1196, included the TR.1143 and, from America, the Collins 18Q; a large number of these were built in 1944.

In view of the failure of supply of the American replacement to the T.1190, it became imperative to produce a British made successor, and this was designed in the shape of the T.1509. This equipment, however, was not in production until the middle of 1945, and was no help in relieving wartime pressures. The production of the T.1190 was therefore continued and increased; in any case it proved more satisfactory than the E.T.4336.

V.H.F.

Up to 1943, most of the V.H.F. equipment built for overseas use was in mobile form, but the stage was reached at which this mobile equipment had to be replaced by fixed installations, so as to free the mobile equipment for use elsewhere. The number of home fighter sectors was reduced in 1943/1944, but this was more than offset by a considerable increase in the use of V.H.F. R.T. overseas, and also by the introduction of V.H.F. equipment in Bomber and Coastal Commands. A rapid growth in the production of all kinds of V.H.F. equipment resulted. The equipment used was the T.1131/R.1132A for fixed ground stations and the TR.1143 for transportables. Six different types of mobile V.H.F. station were produced. Graded V.H.F. equipment was produced for the use of expeditionary forces in the rapid construction of temporary fixed installations to replace mobile equipment in rearward areas.[1]

The actual production of signals equipment to meet provisioning programmes was carried out by the radio industry; but the conversion of equipment for various types of task, and the prototyping of installations, such as in vehicles, was carried out by units of No. 26 Group. For this purpose, Headquarters No. 26 Group were given a forecast of the work they would be called upon to perform each year in the construction and provision of radio equipment and accessories. This enabled them to plan layouts and to adjust establishments. Instructions were issued by the Air Ministry for the requirements of line telecommunications and radio vehicles, transportable radio equipment, and the provision of main W/T stations. For instance, radio stations built in 1944 (in connection with 'Overlord') included two new main stations at Weyhill and Chicksands and other special stations at Uxbridge and Stanmore. Hutted W/T stations and radar vehicles were also produced by No. 26 Group. Mobile medium power stations were used in the early stages of operations on the Continent, but static stations of considerable size were required in the later stages, and allowance was made for the fitting out of four such stations in 1944. Other requirements dealt with by No. 26 Group included airfield telecommunications, V.H.F., 'Beechnut', and G.C.A.[2]

[1] A.M. File CS.18776.
[2] A.H.B./IIE/48.

CHAPTER 15

POST-WAR COMMUNICATIONS—DEVELOPMENT AND POLICY

With no firm Air Staff plan and no knowledge of the probable size of the post-war R.A.F., it was impossible to make detailed plans for post-war communication systems. However, broad assumptions were made which took into account the much reduced scale of the post-war R.A.F. in the United Kingdom and the giving up of many airfields. The result would be the relinquishing of many speech and telegraph landline circuits; but the D.T.N. system would remain.

During the war the R.A.F. had built up in the United Kingdom an extensive system of operational and administrative landline communications including:—

(a) An administrative speech and teleprinter network, based on four major switching centres and embracing all principal operational and administrative formations.

(b) Several networks of speech and telegraph circuits integral to and following the operational channels of the main functional commands.

(c) A meteorological broadcast teleprinter network.

(d) Remote control circuits for the wireless system and special circuits for such services as 'R.C.M.', aircraft safety, and movement liaison.

Scale of Peacetime Traffic at Home

To maintain this system complete in peace was out of the question, and plans were therefore formulated for an abbreviated R.A.F. peacetime landline communications system. The scale of communications would naturally be smaller, but the principle of a separate system under Service control was considered necessary, since it was the only method of ensuring smooth expansion in emergency. Most of the traffic handled in peacetime was expected to be administrative, so it was proposed to retain the framework of the administrative network as a basis, though except for an essential minimum direct operational circuits could be given up, with the proviso that the equivalent, wholly or in part, must be made available for re-connection within a definite time. Operational circuits retained would be routed as far as possible through administrative switching centres so that they could be used to augment the administrative system during non-operational periods. An arbitrary scale of communications to be retained was laid down. Remote control circuits were retained pending decisions on the ultimate employment of wireless. Terminal equipment, switchboards, and operations room equipment were to be retained at all stations remaining functional in peacetime, to allow a quick return to operations. Little general change was expected in the meteorological network. Some recovery could be effected as stations and formations closed down, but there would be expansion in other directions, notably in civil aviation.

Air Ministry's recommendations were:—

(a) that a line communications system, based on the existing administrative network, should be retained under R.A.F. control;

(b) that the administrative system should be augmented to the scale given by direct operational circuits, so routed as to share the administrative load over non-operational periods;

(c) that all line equipment now existing in places scheduled for peacetime use should be kept *in situ*.

A meeting was held at the Air Ministry on 5 June 1945 to discuss aspects of the post-war communications system of the R.A.F. The purpose of the meeting was to acquaint the signals liaison officers of the Dominion Air Forces with the progress made in planning the post-war system and obtain their reactions to various proposals, in order that planning, where it embraced the Dominions, could go forward on a realistic basis.

Inter-Command Network

The ultimate R.A.F. telecommunications system was dependent on many factors, political, strategic and technical, most of which were not readily assessable in June 1945. A preliminary study, however, favoured an exclusive world-wide Air Force system linking all the main spheres of operation of the R.A.F. in the form of a primary network, employing multi-channel teleprinting equipment. It was thought that such a network could not be complete without terminals in each of the Dominions.

The system envisaged would, it was thought, produce a balanced network which would reduce the existing severe congestion in the long-range carrier frequency band, and remove the vulnerable nerve-centre which had grown up in the United Kingdom consequent upon progressive demands for direct communication to numerous individual terminals abroad. It was based on the following principles:—

(a) A main terminal station in each main sphere of Air Force activity, having any or all of the following functions:

  (i) to act as a main focal point for internal communications within the theatre;

  (ii) to act as a local communications centre for the main theatre headquarters;

  (iii) to act as a transit station for through traffic between other theatres.

(b) A number of subsidiary stations established where necessary, for technical reasons (mainly automatic relays).

The main terminal stations were to be linked together in such a manner that:—

(a) The network would not be focused on any one point the failure of which would disrupt the communications between other areas.

(b) Communications between any two areas would involve relaying *en route* not more than once, and at the most, twice, under normal conditions.

(c) The length and direction of the primary links would be such that continuous communication was achieved.

(d) The links would have sufficient traffic-handling capacity to cater both for any diversionary loads occasioned by the failure of a direct link and for the anticipated initial traffic at the beginning of any further hostilities.

(e) The number of high-powered transmitters in any one geographical area would, for reasons of frequency congestion and interference with reception, be kept to a minimum.

Implementation of the plan was a long-term policy only, secondary to the requirements of the Far Eastern war, but every endeavour was made to guide development along post-war ideas where this was compatible with immediate operational requirements. In the technical field, development proceeded in the introduction of a multi-channel radio teletype system on all main links, leaving the existing auto high-speed equipment to remain in being and be used in a standby role until the new system had proved itself.[1]

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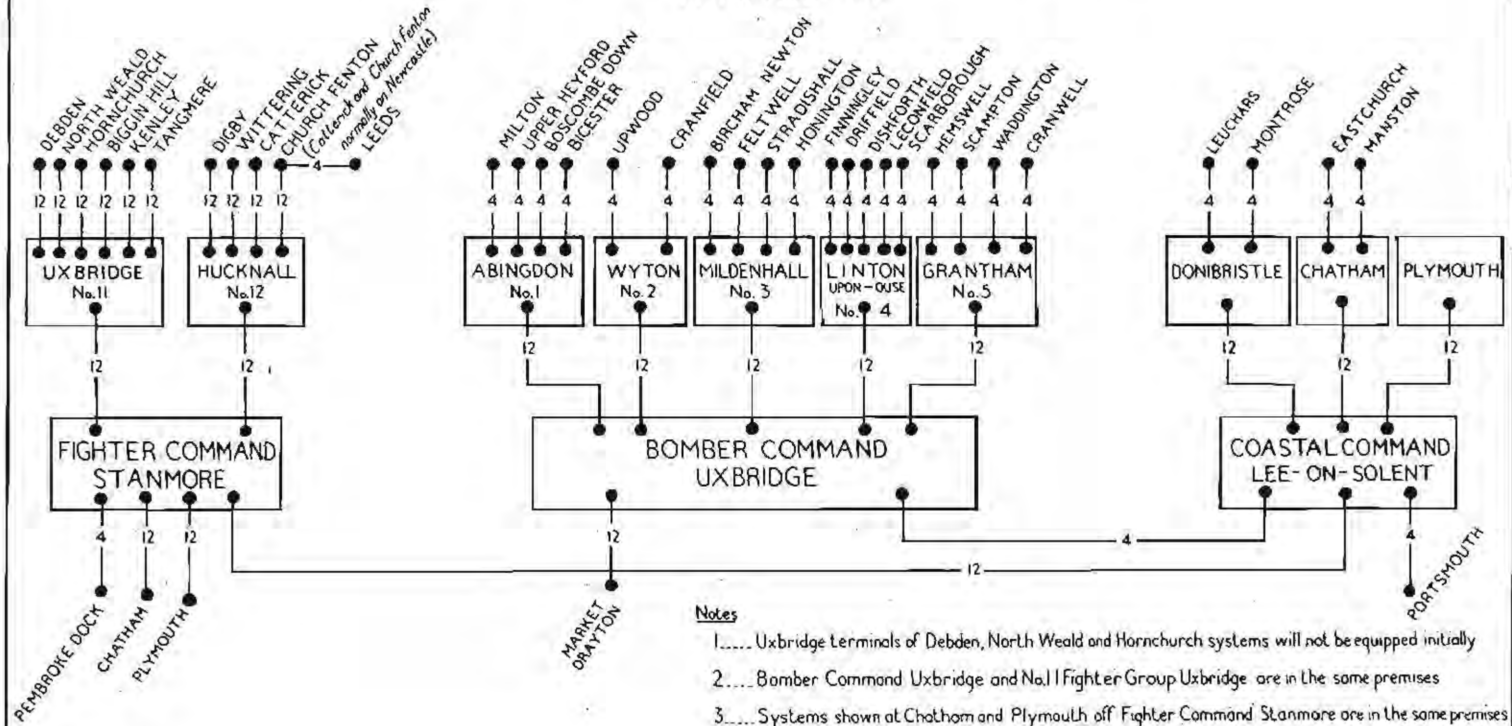
[1] A.M. File CS.22974.

DEFENCE TELEPRINTER NETWORK
(PHASE I)



Notes

1.... Uxbridge terminals of Debden, North Weald and Hornchurch systems will not be equipped initially

2.... Bomber Command Uxbridge and No.11 Fighter Group Uxbridge are in the same premises

3.... Systems shown at Chatham and Plymouth off Fighter Command Stanmore are in the same premises as Coastal Groups

APPENDIX No. 2

CONGESTION OF HOME TELEPRINTER SYSTEM WITH NON-URGENT MESSAGES[1]

(*C.S.* 22075/*Tels.* 4—8.6.44.)

1. Serious delays are occurring in the transmission of urgent messages owing to the overloading of teleprinter channels with non-urgent traffic. This congestion is adversely affecting the conduct of the war and must cease.

2. C.O.s are to ensure that the attention of all persons authorised to originate signals messages is directed to the necessity for conducting all non-urgent business by postagram or letter. As a further measure, C.Os. are to arrange that all messages before being handed in to the signals office, are scrutinised, and such messages as do not fall in the urgent category are to be diverted to the Despatch Rider Letter Service or postal service.

3. Examples of correspondeno which must not be sent by signals channels are as follows:—

   (i) Requests for officers', airmen's or airwomen's documents, except when required for overseas drafting, courts-martial, courts of inquiry, or in cases of serious or dangerous illness; in all such circumstances, the signal is to state the purpose for which the documents are required.

   (ii) Messages dealing with accounts, mail, laundry, etc.

   (iii) Notification of changes in prices of fuel, straw and other commodities.

   (iv) Congratulatory messages which have appeared, or will appear, in the press and which will be included later in command or other orders.

   (v) Normal replies to correspondence.

   (vi) All non-operational returns.

   (vii) All acknowledgments (unless of operational character).

   (viii) Notification, over 48 hours in advance, of posting of R.A.F. and W.A.A.F. personnel.

   (ix) Reports of movements of individual officers, airmen and airwomen.

4. C.Os. of main signals centres at home are to arrange that teleprinter traffic is scrutinised after transmission, and that copies of all messages for which the Despatch Rider Letter Service or post would seem to have provided adequate means of transit are forwarded to the Air Ministry (Tels.4) through the usual channels.

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[1] A.M.O. A.520/44.

APPENDIX No. 3

SIGNALS TRAFFIC—' MINIMIZE '[1]

In the event of serious congestion of signals channels at Home or Overseas, during operations or in any special emergency, the code word ' Minimize ', followed by an estimated period of effect, will be promulgated to all concerned.

2. The code word will have the following signification:—

(i) It is now essential that W/T, teleprinter and telephone traffic be reduced to that contributing directly to the conduct of the immediate operations in progress.

(ii) It is essential that the originator of any W/T or teleprinter message or telephone call (either internal or external) satisfies himself that immediate operations will be adversely affected if the message is not despatched, or the telephone call not made. A message or call which does not pass this test must not be made.

(iii) Messages to units overseas not connected with immediate operations or special emergency are:

(a) to be despatched by Air Mail where this facility exists;

(b) to be held up until ' Minimize ' is cancelled, or until the duration of the holding period renders it essential that they should be despatched.

Messages of a similar character to units in the United Kingdom must be despatched by D.R.L.S. or postal service.

3. In view of the dislocation of normal work when these restrictions are imposed, ' Minimize ' will not be introduced until congestion is really serious, and in these circumstances the time factor will not permit promulgation by means of an Office Instruction. The Director of Telecommunications is authorised, therefore, to introduce ' Minimize ' by circulating an appropriate message through A.M.C.S. to all Divisions and Directorates of Air Ministry. The cancellation of ' Minimize ' will be effected in a similar manner.

4. The severe restriction of the use of the telephone, particularly as regards internal calls, will inevitably result in a considerable increase in the number of written communications, which will throw an additonal burden on the messenger services. Provided that the ordinary transit service is used wherever possible, or in more urgent matters messages are conveyed by the ' Important ' service, the Registry Circulation Services should prove adequate. It is essential, however, that the ' Immediate ' service should only be used in cases of extreme urgency if congestion and a consequent breakdown of the messenger service is to be avoided.

5. Heads of Branches and Sections should ensure that this Instruction is fully understood by all members of their staff and, by personal supervision, must enforce the ' Minimize ' procedure when it becomes necessary to introduce it.

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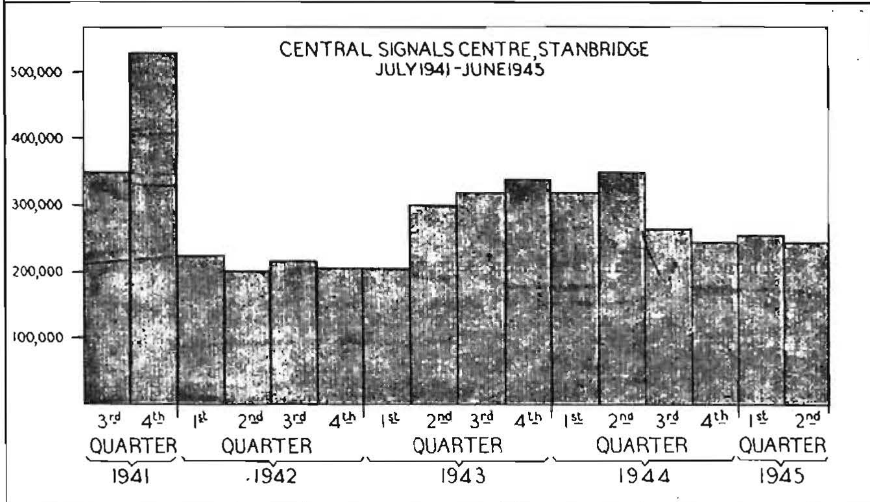
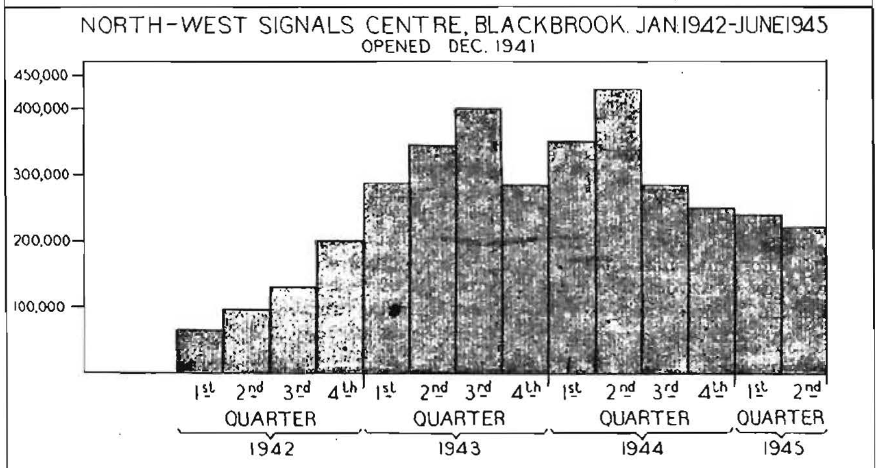
[1] Office Instruction No. 128/44.

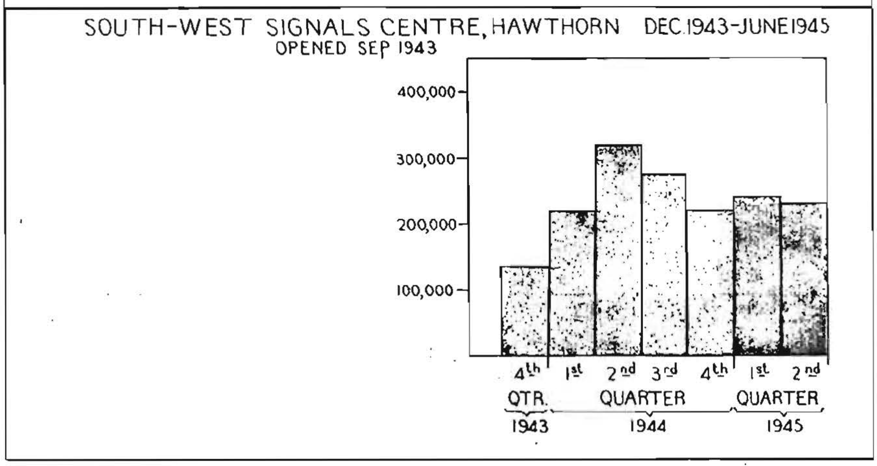
APPENDIX No. 4

DEFENCE TELEPRINTER NETWORK

QUARTERLY TOTALS OF MESSAGES DEALT WITH







APPENDIX No. 5

TELECOMMUNICATION ARRANGEMENTS—BOMBER COMMAND[1]

This instruction supersedes Tels. 3 Engineering Instruction No. 13, which is to be destroyed.

Information

1. Bomber Command are in process of reorganisation by which a Group Headquarters will control Bases which in turn will control three stations.
2. There will be in British Bomber Command :—
   - (i) Seven Operational Groups.
   - (ii) Five Bases to each Group giving a total of 35 Bases.
   - (iii) Three Stations to each Base giving total of 105 Stations, including the Stations at which Bases are located.
3. Group Headquarters will be much as they are at present. Bases will be quite a considerable organisation and will be located on what are now Parent Stations. Stations which are at present Satellite airfields will be increased to full Station status.
4. The increases in establishment of personnel and aircraft will be very considerable, and in consequence the weight of signals traffic will be much greater.
5. The chain of Operational and Administrative Control will be as follows :—
   - (i) Groups will exercise operational control over Bases, and each Base over its three Stations.
   - (ii) Administrative control will be direct between Groups and Stations. It is intended to centralise a large portion of the administrative work of Stations at the Base and consequently it is estimated that administrative traffic in and out of Stations will average 50 per cent between Stations and Group, and 50 per cent between Stations and Base.
6. Meteorological information as at present received at Parent Stations will be required at all Stations.
7. This organisation is now coming into force but is unlikely to be fully completed before the Spring of 1944.

Intention

8. To provide increased landline communications as Bases are formed and as existing Satellite Airfields are brought up to Station status.
9. (i) To retain W/T Operational Control at Group Headquarters as at present.
   - (ii) To give each Base W/T facilities, as at present provided at ' Parent Stations '.
   - (iii) To provide Pack-Sets at Bases and Stations to be used as a last resort for maintaining W/T Contact.

Execution

10. Since the Base will be located at one of its three Stations one Administrative P.B.X. is to serve both Base and that Station, and a three position PMBXIA board is to be provided at each Base.

    Total requirement 35 type PMBXIA 3-position switchboards.
11. Each Station, other than Stations at which Bases are located, is to be provided with two positions of 10 + 50 line switchboard

[1] Tels. 3 Engineering Instruction No. 14 as amended on 30 January 1943.

12. For operational circuits each Base is to be provided with a one-position switchboard which will cover the requirements of the Base and the Station on which it is located.
The circuits to be terminated on this P.B.X. are as follows:—

(i) *Private Wires*

Operational speech circuits to Group Headquarters.
Flying Control speech circuit to Group Headquarters.
One Admin. circuit to Group H.Q. to be earmarked for switching at C.O.P. to provide the Flying Control line as required.
Operational speech circuit to No. 1 Sub-station keyboard. (Sub-stations are those other than the ones at which Bases are situated).
Operational speech circuit to No. 2 Sub-station keyboard.
Flying Control speech circuit to No. 1 Sub-station keyboard.
Flying Control speech circuit to No. 2 Sub-station keyboard.

(ii) *External Extensions*

4 to Admin. P.B.X.
2 to Flying Control Base Station Watch Office keyboard.
Met. Officer.
Officer Commanding Base Station.
D/F Station No. 1.
D/F Station No. 2 (where installed).
Base Commander's Residence (if on station).

(iii) *Internal Extensions*

Base Commander's Office.
Base Commander (in Operations Room).
Controller 1.
Controller 2.
Intelligence Officer.
Signals Traffic Office.
A.A. Defence Room (Switchboard to B.H.Q.).
Base Flying Control Officer.
Bunching jacks or keys to be provided on Ops. P.B.X. to give simultaneous connection of Watch Office F/C keyboards.
Total requirement thirty-five P.M.B.X.I.A. switchboards.
For circuits peculiar to the Watch Office a 10-line Flying Control keyboard is to be provided in each Base Station Watch Office Control Room.
It will have the following circuits terminated on it:—
2 circuits from Ops. P.B.X.
Station Commander.
Flare path (Airfield Controller).
Look-out.
Total requirement thirty-five 10-line keyboards.

13. At each sub-station a 10-line keyboard is to be provided in the Watch Office Control Room to take all operational circuits as follows:—

Operational speech circuit from Base Ops. P.B.X.
Flying Control speech circuit from Base Ops. P.B.X.
Station Commander.
Operations Room 2.
Flare-path (Airfield Controller).
Intelligence Officer.
Controller.
Look-out.

14. To give necessary Speech facilities the following circuits are to be provided :—

(i) *Group to Base*

(a) One Operational Speech.

(b) Four Administrative Speech (one being reserve D.T.N. main).

Note: This is an increase of two speech circuits on the present Group/Parent Station facilities, one is to be provided when the three Stations are formed under a Base, and the second at a later date when Stations and Bases are brought up to strength in aircraft and personnel.

(ii) *Base to Station*

(a) One Operational Speech.

(b) One Flying Control Speech.

(c) Two Administrative Speech.

Note: This is an increase of one circuit on the present Parent/Satellite facilities. Flying Control Circuit is particularly necessary since only W/T aircraft channel is at the Base, which will co-ordinate control of aircraft of all three Stations.

15. To provide necessary teleprinter facilities the following channels are required :—

(i) *Group to Bases*

(a) Meteorological Broadcast channel.

(b) Operations and Administrative Broadcast channel.

(c) Three Administrative channels.

(d) Air raid warning channel.

(e) Intelligence channel.

(f) One spare channel.

Note: Under Phase 6 of the D.T.N. provision scheme, arrangements have already been made for the addition of a four-channel equipment between Group and Base. This four-channel equipment is to be arranged to work 'Back to Back' with the existing four-channel equipment between present Group and Parent Station, and thus use the same physical circuit. The new equipment is scheduled to come off contract between March 1943 and March 1944, and will thus meet the scheme.

(ii) *Base to Stations*

The Station at which the Base is located is to share the signals office of that Base. Provision of teleprinter circuits for the remaining two stations are to be as follows :—

(a) One Meteorological channel.

(b) One Administrative channel.

(c) One Broadcast channel.

16. To provide the necessary broadcast and switching facilities for teleprinter working the following are to be provided :—

(i) At the Group a Teleprinter Switchboard No. 16 to be provided in addition to the present Administrative Teleprinter switchboard. This will have the Ops and the Intelligence teleprinter circuit from individual teleprinters at each Base terminated on it.

(ii) At each Base a ten-line teleprinter switchboard with broadcast facilities up to five lines simultaneous transmission and a combined unit for Meteorological Broadcast from Group to Base and the two distant Stations.

17. The following teleprinters are to be provided :—

(i) *At each Base*

(a) One Meteorological.

(b) One Operational.

(c) Three Administrative.

(d) One Intelligence.

(e) One Air Raid Warning (if scheme is agreed).

Total requirements 245 for 35 Bases.

(ii) *At each of distant Stations*

(a) One Meteorological.

(b) One Administrative.

(c) One for broadcast of Operational or Administrative traffic principally from Group.

Total requirement 210 for 70 Stations.

18. A diagram showing circuits is attached to this instruction.[1]

19. Main Ground to Air W/T Communication for Operational Control of Aircraft is to be provided by Medium-Power Transmitter at Groups as at present.

20. Each Base is to be provided with W/T and R/T Installation as at present installed at Parent Stations i.e. :—

(i) H.F. D/F Station.

(ii) Point-to-point.

(iii) Air Ministry ' K ' Broadcast.

(iv) ' Panda ' W/T Channel.

(v) ' Beetle ' Broadcast Receiver.

(vi) ' Darky ' and Local Aircraft Control R/T.

(vii) Emergency W/T Pack Set.

21. Each of the distant Stations is to be provided with :—

(i) ' Darky ' and Local Aircraft Control R/T.

(ii) Emergency W/T Pack Set.

22. Many of the line requirements already exist, and a number of the two-position switchboards are to be provided by those recovered from Bases when PMBXIA is installed.

23. It was hoped that Bomber Command would be able to supply a list of priorities for fitting and provision of new lines together with approximate dates, but uncertainty of allocation of aircraft between Home and Overseas commitments and of manpower make long-term planning of opening dates impossible.

24. Bomber Command and the Directorate of Organisation are requested to give the earliest possible warning of opening dates or increases to this new organisation.

25. Following is a summary of circuit and apparatus requirements to be provided by the General Post Office.

(i) Increase of 2 Speech Circuits Group to Base.

(ii) Increase of 4 Teleprinter Channels Group to Base.

(iii) Increase of 1 Speech Circuit Base to Station.

(iv) Increase of 2 Teleprinter Circuits Base to Station.

Note: These increases are over and above circuits existing or ordered for present Parent and Satellite arrangement.

[1] Not reproduced.

(v) Provision of thirty-five 3-Position Switchboards for Bases.

(vi) Provision of thirty-five Single Position Ops. P.B.X. for Bases.

(vii) Provision of seventy 2-Position P.B.X. for Stations.

(viii) Provision of seventy 10-line Ops. Keyboards for Stations.

(ix) Provision of thirty-five 10-line D.T.N. Switchboards with Broadcast facilities for Bases.

(x) Provision of thirty-five Met. Channel combine units for Bases.

(xi) Provision of 245 Teleprinters for Bases.

(xii) Provision of 210 Teleprinters for Stations.

26. A map showing location of each Group Headquarters together with associated Bases and Stations has already been issued to The Director of Telecommunications, General Post Office.

27. A further Engineering Instruction on the American Bomber Organisation will follow.

28. Acknowledge.

for Air Commodore
Director of Telecommunications

Issued at 1200 hours, 7 December 1942.

APPENDIX No. 6
PROVISIONAL TELEPHONE ESTABLISHMENTS[1]
Fighter Sector Station

Cables

1. *Incoming cable.* Special scheme to serve off-site Operations Room etc.

2. *Perimeter cable.* 38 pair.
Exchange lines. 3 circuits to main P.B.X. at Airfield.
3 circuits to Ops. P.B.X.
P.B.X. Two $\frac{10 + 50}{65}$ switchboards, one in special protected building at airfield (possibly 2 later); one in off-site Operations Block.

Extensions

P.B.X. in Operations Block
Commanding Officer
Controller's Office
'B' Board
Signals Officer
Intelligence Officer
Met.
Cypher office
A/A and S/L office
Guard Room

Main P.B.X. at Airfield	*No. of Extensions*
Aircraft Shed	1
Watch Office	5 (suggest 14 pair cable to this building)
Squadron Office	5
Armoury	1

[1] CS.12488.

Main P.B.X. at Airfield	*No. of Extensions*	
Main Stores	2	
Main Workshops	1	
Link Trainer	1	
Gas Defence Centre	1	
M/T Office	1	
Station H.Q.	11	Maximum
Battle H.Q. (Defence Officer)	1	
Guard House	1	
Officers' Mess	2	(1 on repayment basis)
Sergeants' Mess	1	
Decontamination Centre	1	
Standby Set House	1	parallel from picket post
Sick Quarters	1	with plan 7 to M.O.
Picket Post	1	each but extensions to be paralleled wherever possible
W/T Transmitting Station	1	
Bomb Stores	1	cab rank type with loud ringing bell

Additional requirements

5 circuits between Ops. and Station P.B.X.s.
4 circuits from dispersal points to be terminated on Ops. ' B ' keyboard.
1 circuit from Defence Officers switchboard in Battle H.Q. terminated on Ops. ' B ' Keyboard.
4 circuits from Tannoy broadcast system between Ops. Room and Battle H.Q.
1 circuit from Watch Office to Ops. Room.
A schedule of special requirements was provided for airfields requiring night-fighter facilities.

Bomber Operational Station

Cables

1. *Incoming cable.* Two cables one of 20 pairs and one of 14 pairs by alternative routes or one cable of 28 pairs if the alternative should prove impracticable.
2. *Perimeter cable.* 38 pairs.

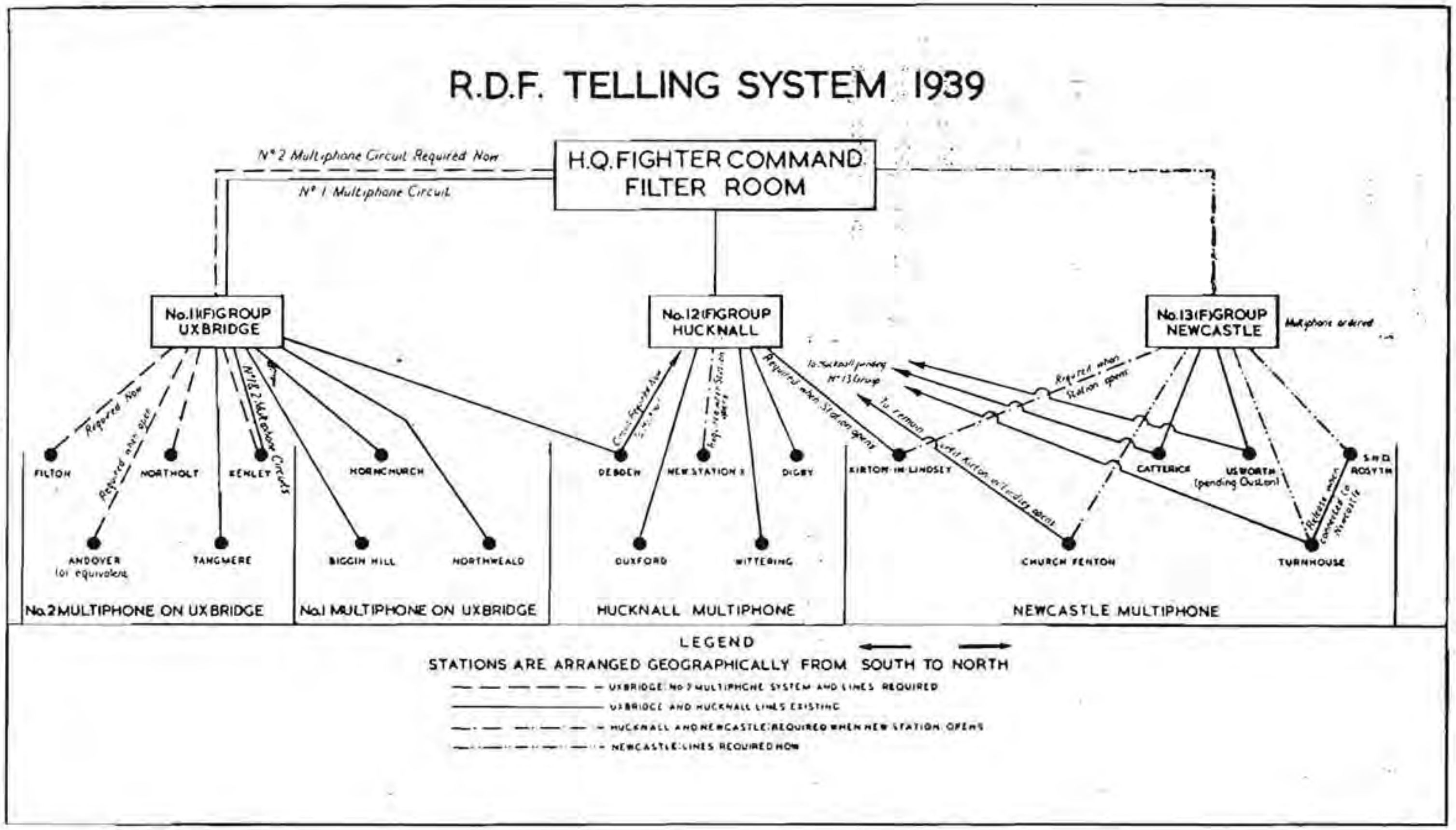
Exchange lines. Two initially, one to be routed by an alternative route through a suitable point, a protected building if possible, for interception in the event of damage to the P.B.X. At least one of these circuits must be provided to a manual or an attended auto exchange. The first of these lines will be provided with up to two extensions, to the office of the Resident Engineer in advance of the general station requirements. When the station opens the circuit should be switched to the station P.B.X. and an extension provided in lieu.

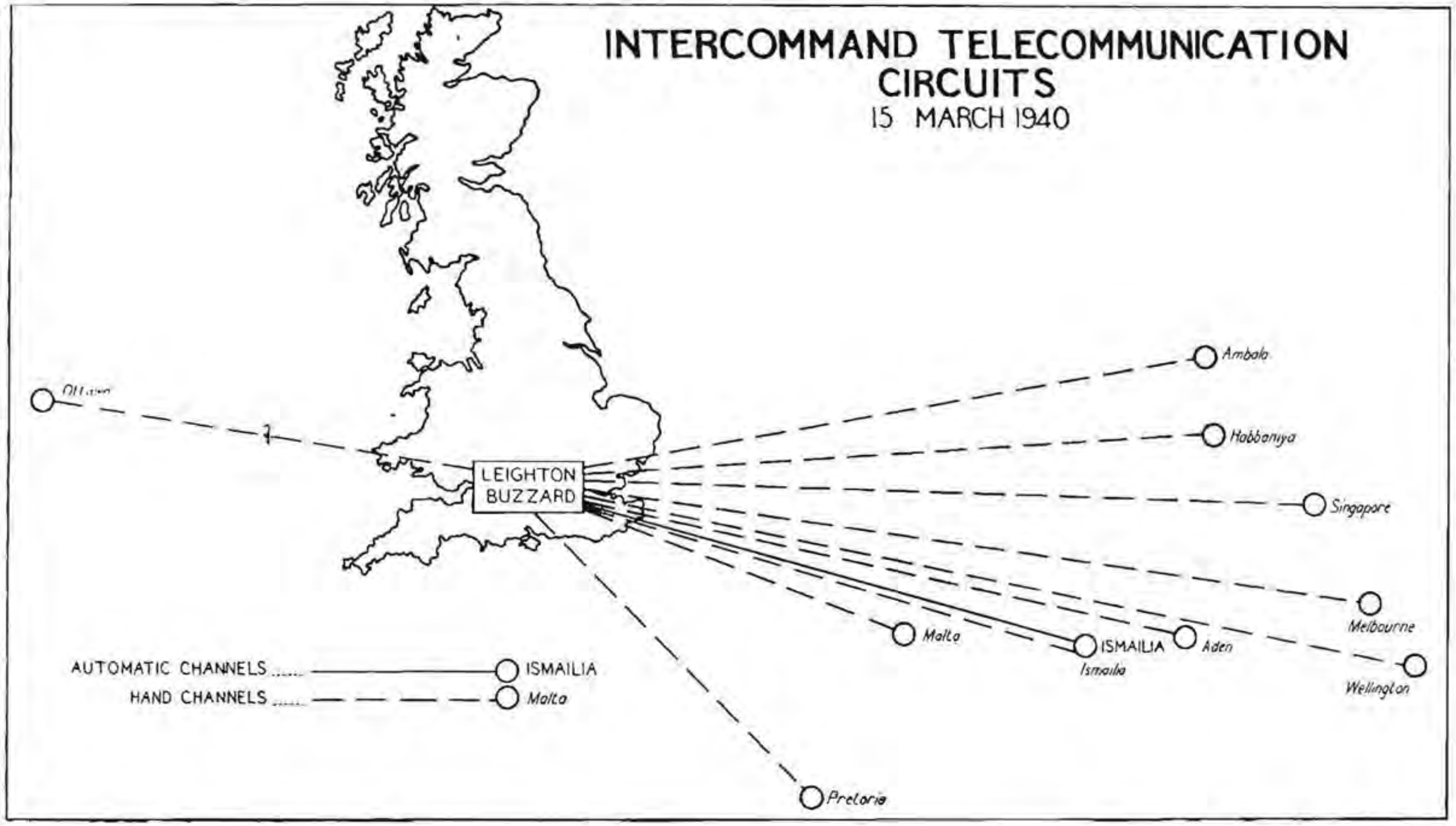
P.B.X. two 10 + 50 switchboards in Operations Block.

Extensions

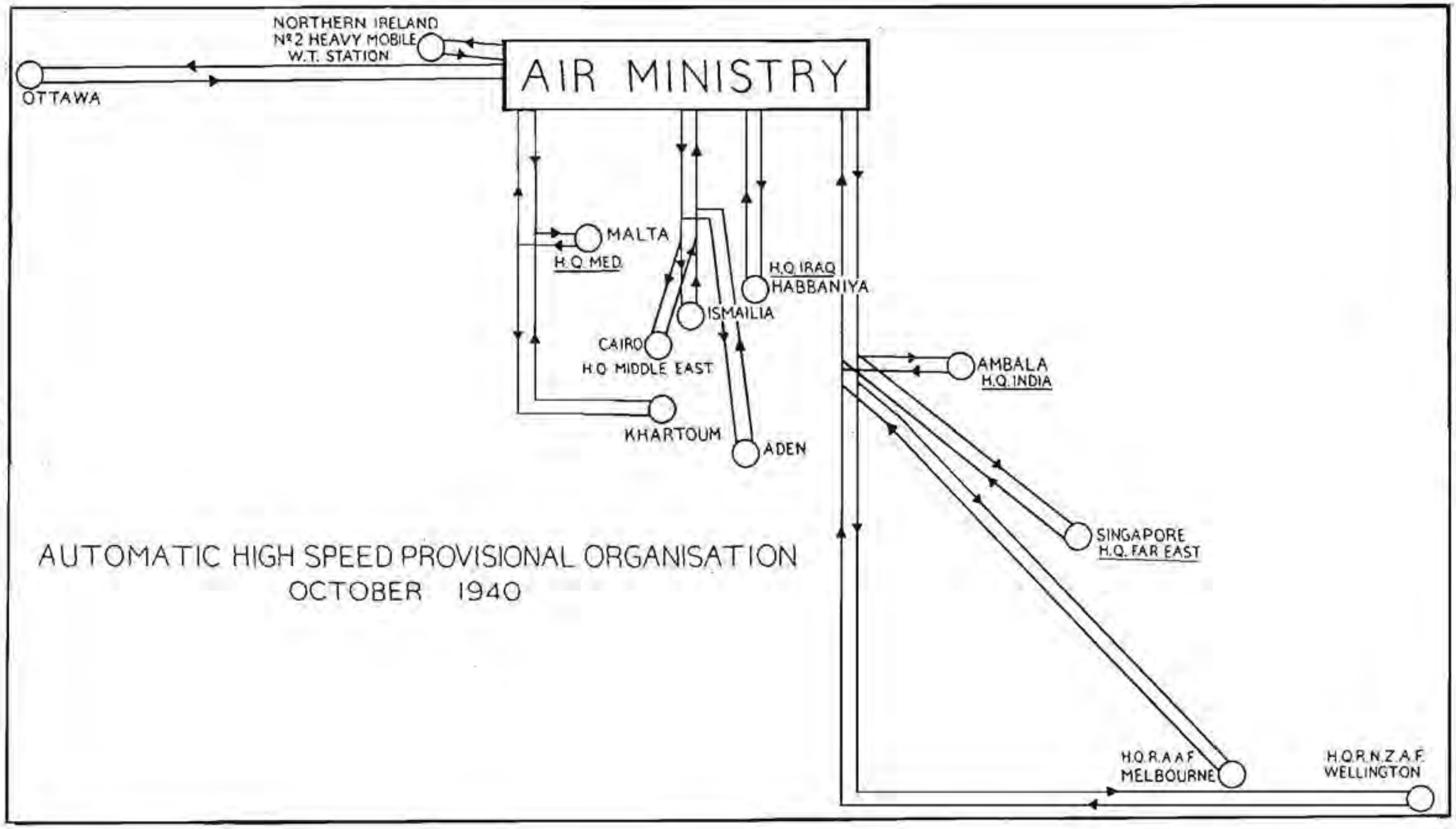
	No. of Extensions	*Remarks*
Aircraft shed	1 each	Maximum 2
Watch Office	3 initially	Suggest 14 pair cable to this building.
Armoury	1	
Main stores	2	
Main workshops	1	

	No. of Extensions
Gas Defence Centre	1
Station H.Q.	9 with 2 parallels
Ops. Block	10
Guard House	1
M/T Office	1
Sub. Stn.	1
Works Services Hut	1
Sqdn. and Flight Office	4 with 2 parallels
Crew Rest Room	1
Maintenance Unit	2 each
,, and Armoury unit	1
Photographic Block	1
Link Trainer Bldg.	1
Picket Post	1 each
Bomb stores	1 cab rank type with loud ringing bell
Battle H.Q. (Defence Officer)	1
Officers' Mess	2 (1 on repayment basis)
Sergeants' Mess	1
C.O.'s Quarters	1
Standby Set House	1 parallel from picket post
Sick Quarters	1 with plan 7 to M.O. Maximum 2
W.A.A.F. Officers' Mess and Quarters	1 parallel from picket post
,, ,, Sick Quarters	1
,, ,, Decontamination Centre	1 parallel from picket post
Look-out Post	1
W/T Transmitting Station	1

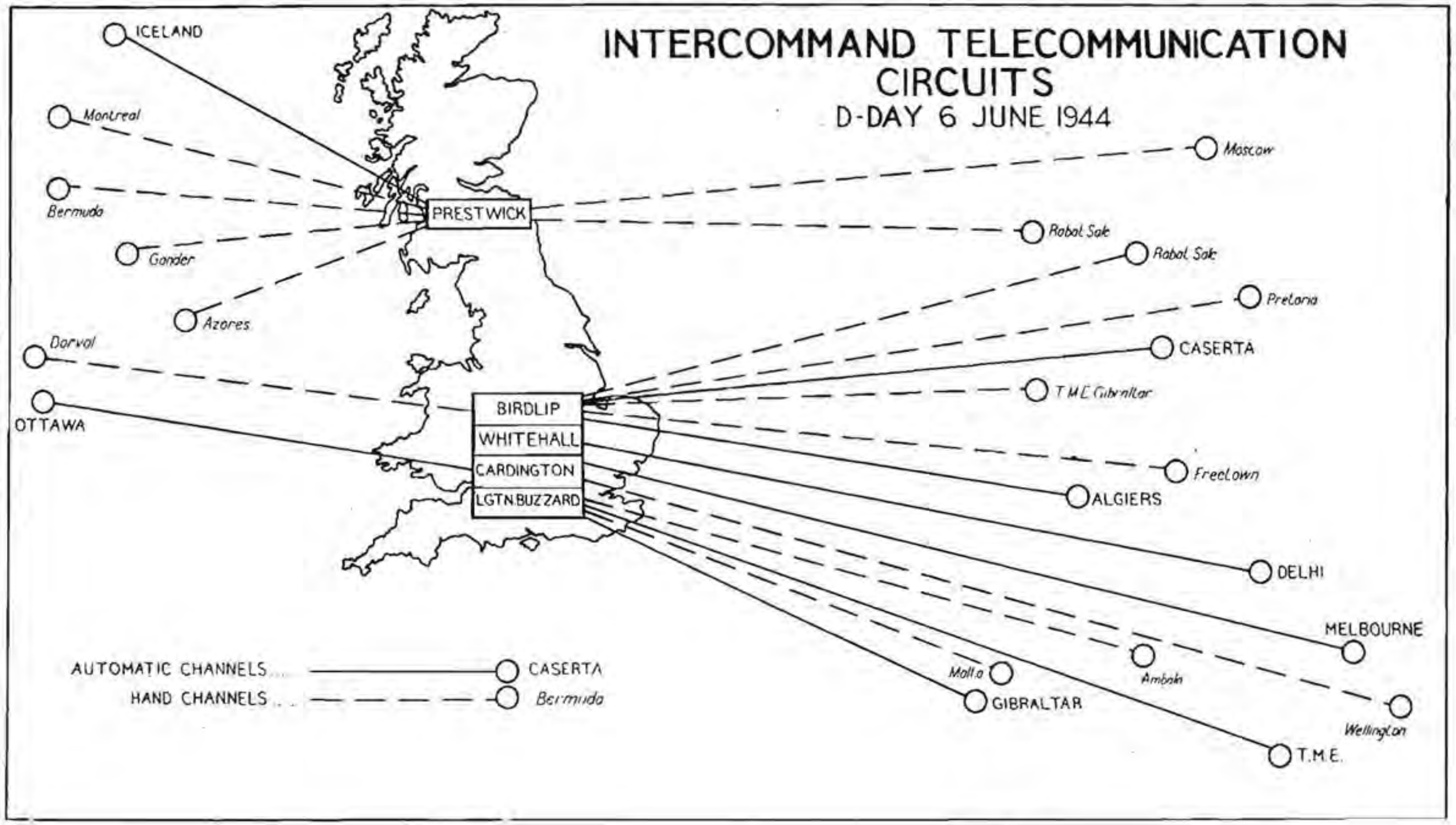

R.D.F. TELLING SYSTEM 1939
H.Q. FIGHTER COMMAND FILTER ROOM
N° 2 Multiphone Circuit Required Now
N° 1 Multiphone Circuit
No. 11 (F) GROUP UXBRIDGE
No. 12 (F) GROUP HUCKNALL
No. 13 (F) GROUP NEWCASTLE
Multiphone ordered
Required Now
Required when open
N° 1 & 2 Multiphone Circuits
Required when Station opens
To Hucknall pending N° 13 Group
Required when Station opens
To remain until Kirton-in-Lindsey opens
Release when connected to Newcastle
FILTON
NORTHOLT
KENLEY
HORNCHURCH
ANDOVER (or equivalent)
TANGMERE
BIGGIN HILL
NORTHWEALD
DEBDEN
NEW STATION X
DIGBY
DUXFORD
WITTERING
KIRTON-IN-LINDSEY
CATTERICK
USWORTH (pending Ouston)
S.H.D. ROSYTH
CHURCH FENTON
TURNHOUSE
No. 2 MULTIPHONE ON UXBRIDGE
No. 1 MULTIPHONE ON UXBRIDGE
HUCKNALL MULTIPHONE
NEWCASTLE MULTIPHONE
LEGEND
STATIONS ARE ARRANGED GEOGRAPHICALLY FROM SOUTH TO NORTH
= UXBRIDGE No. 2 MULTIPHONE SYSTEM AND LINES REQUIRED
UXBRIDGE AND HUCKNALL LINES EXISTING
= HUCKNALL AND NEWCASTLE REQUIRED WHEN NEW STATION OPENS
= NEWCASTLE LINES REQUIRED NOW

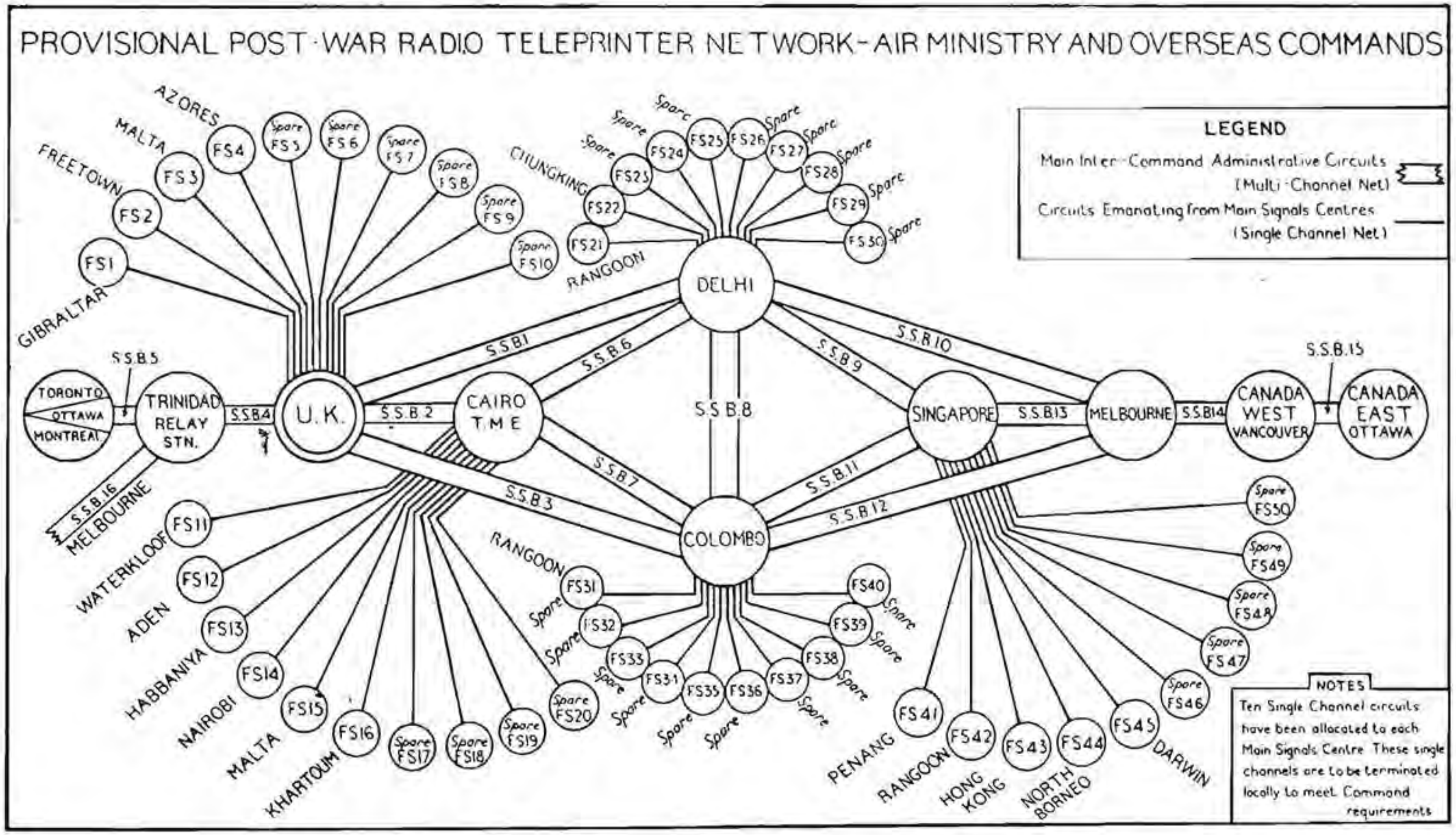

INTERCOMMAND TELECOMMUNICATION
CIRCUITS
15 MARCH 1940
LEIGHTON
BUZZARD
Ambala
Habbaniya
Singapore
Melbourne
Aden
ISMAILIA
Ismailia
Malta
Wellington
Pretoria
AUTOMATIC CHANNELS ...... ISMAILIA
HAND CHANNELS ...... Malta

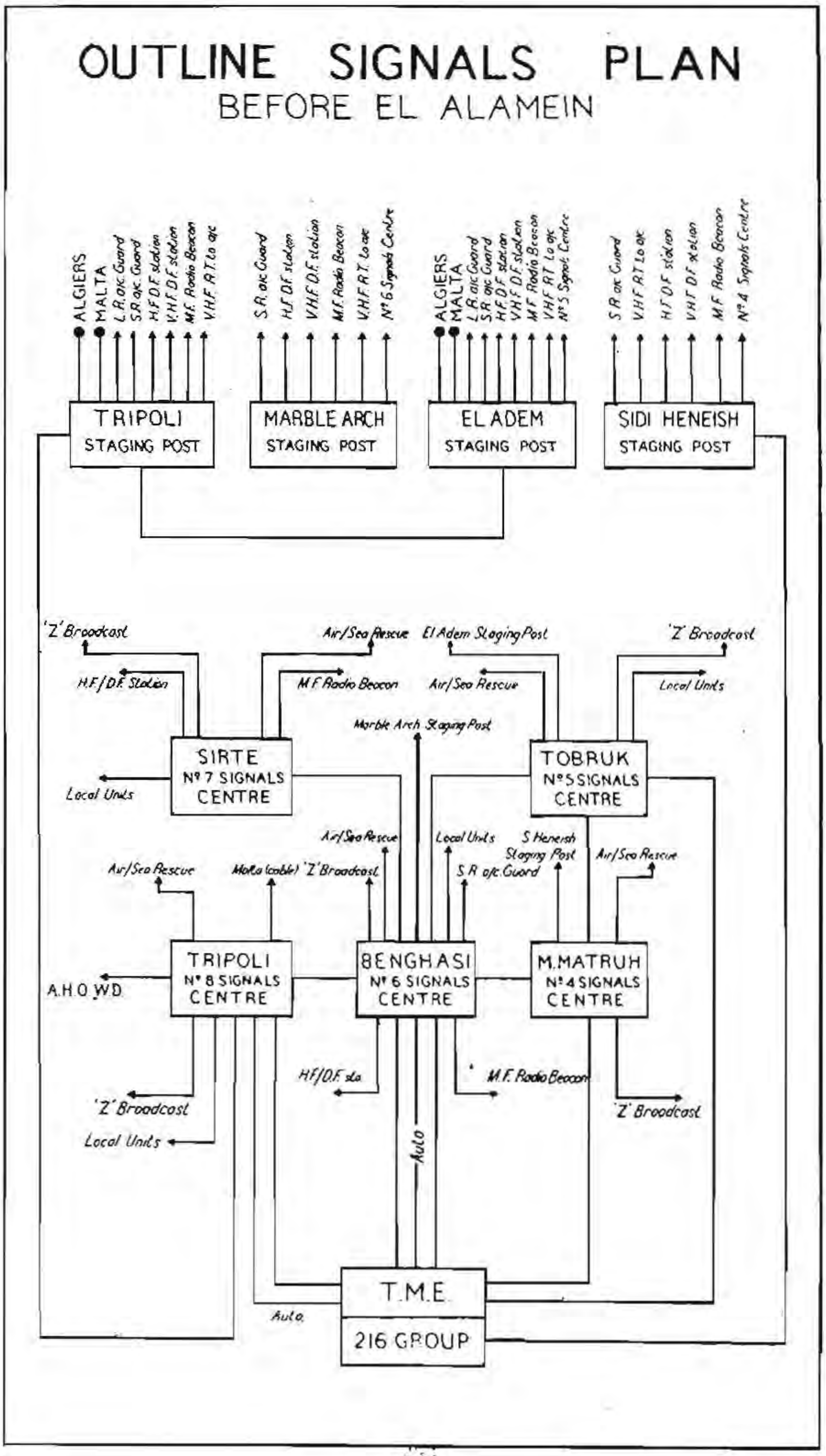
APPENDIX No. 9



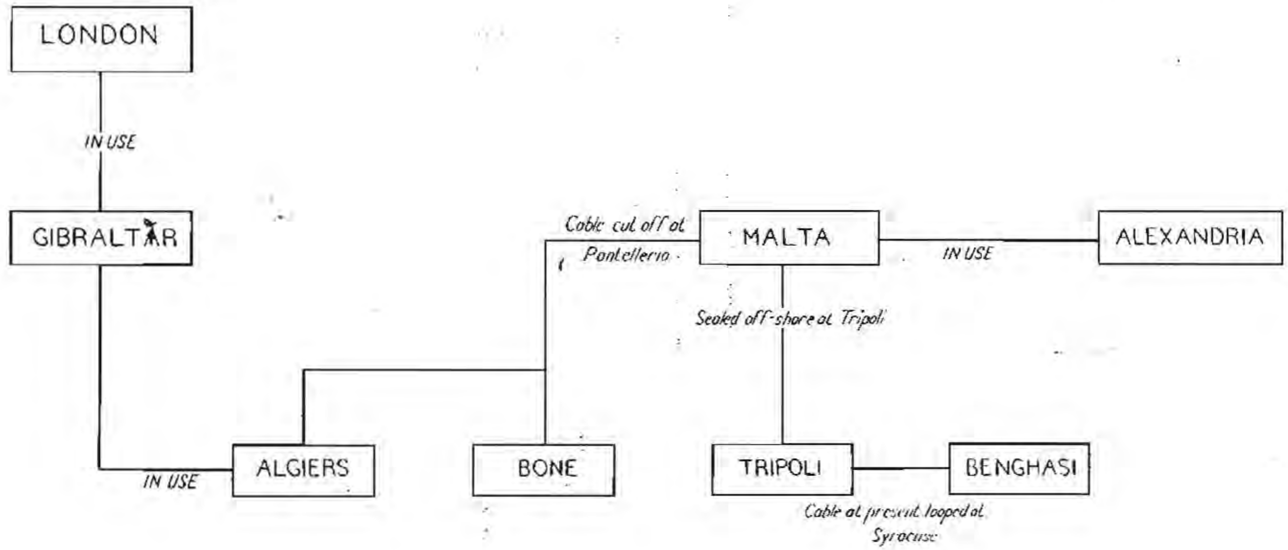
AUTOMATIC HIGH SPEED PROVISIONAL ORGANISATION
OCTOBER 1940


INTERCOMMAND TELECOMMUNICATION
CIRCUITS
D-DAY 6 JUNE 1944
ICELAND
Montreal
Bermuda
Gander
Azores
Dorval
OTTAWA
PRESTWICK
Moscow
Rabat Sale
Rabat Sale
Pretoria
CASERTA
T.M.E. Gibraltar
BIRDLIP
WHITEHALL
CARDINGTON
LGTN.BUZZARD
Freetown
ALGIERS
DELHI
MELBOURNE
Malta
Ambala
GIBRALTAR
Wellington
T.M.E.
AUTOMATIC CHANNELS
CASERTA
HAND CHANNELS
Bermuda


PROVISIONAL POST-WAR RADIO TELEPRINTER NETWORK - AIR MINISTRY AND OVERSEAS COMMANDS
LEGEND
Main Inter-Command Administrative Circuits (Multi-Channel Net)
Circuits Emanating from Main Signals Centres (Single Channel Net)
NOTES
Ten Single Channel circuits have been allocated to each Main Signals Centre. These single channels are to be terminated locally to meet Command requirements.
U.K.
CAIRO T.M.E.
DELHI
COLOMBO
SINGAPORE
MELBOURNE
CANADA WEST VANCOUVER
CANADA EAST OTTAWA
TRINIDAD RELAY STN.
TORONTO
OTTAWA
MONTREAL
S.S.B.1
S.S.B.2
S.S.B.3
S.S.B.4
S.S.B.5
S.S.B.6
S.S.B.7
S.S.B.8
S.S.B.9
S.S.B.10
S.S.B.11
S.S.B.12
S.S.B.13
S.S.B.14
S.S.B.15
S.S.B.16 MELBOURNE
GIBRALTAR FS1
FREETOWN FS2
MALTA FS3
AZORES FS4
Spare FS5
Spare FS6
Spare FS7
Spare FS8
Spare FS9
Spare FS10
WATERKLOOF FS11
ADEN FS12
HABBANIYA FS13
NAIROBI FS14
MALTA FS15
KHARTOUM FS16
Spare FS17
Spare FS18
Spare FS19
Spare FS20
RANGOON FS21
CHUNGKING FS22
Spare FS23
Spare FS24
Spare FS25
Spare FS26
Spare FS27
Spare FS28
Spare FS29
Spare FS30
RANGOON FS31
Spare FS32
Spare FS33
Spare FS34
Spare FS35
Spare FS36
Spare FS37
Spare FS38
Spare FS39
Spare FS40
PENANG FS41
RANGOON FS42
HONG KONG FS43
NORTH BORNEO FS44
DARWIN FS45
Spare FS46
Spare FS47
Spare FS48
Spare FS49
Spare FS50


OUTLINE SIGNALS PLAN
BEFORE EL ALAMEIN
ALGIERS
MALTA
L.R. a/c Guard
S.R. a/c Guard
H.F. D.F. station
V.H.F. D.F. station
M.F. Radio Beacon
V.H.F. R.T. Lo a/c
TRIPOLI
STAGING POST
S.R. a/c Guard
H.F. D.F. station
V.H.F. D.F. station
M.F. Radio Beacon
V.H.F. R.T. Lo a/c
Nº 6 Signals Centre
MARBLE ARCH
STAGING POST
ALGIERS
MALTA
L.R. a/c Guard
S.R. a/c Guard
H.F. D.F. station
V.H.F. D.F. station
M.F. Radio Beacon
V.H.F. R.T. Lo a/c
Nº 5 Signals Centre
EL ADEM
STAGING POST
S.R. a/c Guard
V.H.F. R.T. Lo a/c
H.F. D.F. station
V.H.F. D.F. station
M.F. Radio Beacon
Nº 4 Signals Centre
SIDI HENEISH
STAGING POST
'Z' Broadcast
H.F./D.F. Station
Local Units
SIRTE
Nº 7 SIGNALS
CENTRE
Air/Sea Rescue
M.F. Radio Beacon
El Adem Staging Post
Air/Sea Rescue
Marble Arch Staging Post
'Z' Broadcast
Local Units
TOBRUK
Nº 5 SIGNALS
CENTRE
Air/Sea Rescue
Malta (cable)
'Z' Broadcast
Air/Sea Rescue
Local Units
S. Heneish Staging Post
S.R. a/c Guard
Air/Sea Rescue
A.H.Q. W.D.
TRIPOLI
Nº 8 SIGNALS
CENTRE
BENGHASI
Nº 6 SIGNALS
CENTRE
M. MATRUH
Nº 4 SIGNALS
CENTRE
'Z' Broadcast
Local Units
H.F./D.F. sta.
M.F. Radio Beacon
'Z' Broadcast
Auto
Auto
T.M.E.
216 GROUP

EXISTING AND PROPOSED MEDITERRANEAN CABLE COMMUNICATIONS
DECEMBER 1942



APPENDIX No. 14

ORGANISATION OF AIR FORMATION SIGNALS THROUGHOUT THE MIDDLE EAST COMMAND

(a) This order is promulgated to clarify the relationship in the Middle East between the Chief Signals Officer, Royal Air Force, Middle East, Chief Signals Officers of Royal Air Force subordinate commands, the Chief Signals Officer Air Formation Signals, and Officers Commanding, Air Formation Signals units. It is based on the directive ' The Organisation and Employment of Air Formation Signals in the Field ', issued conjointly by the War Office and Air Ministry in February 1944.

(b) The Chief Signals Officer, Royal Air Force, Middle East, is the supreme co-ordinating authority for all R.A.F. communications within the Middle East Command. He will be responsible for formulating the requirements of the R.A.F. in respect of landline and despatch rider communications to meet the plans of the Air Officer Commanding-in-Chief, Royal Air Force, Middle East. These requirements will be notified to the Chief Signals Officer Air Formation Signals, Middle East.

(c) The Chief Signals Officers at Air Headquarters, Egypt, Levant and East Africa, will be similarly the supreme co-ordinating authorities for all R.A.F. communications within their respective areas. Their requirements will be notified to the Officers Commanding No. 3 Air Formation Signals, No. 5 Air Formation Signals and the Officer Commanding Air Formation Signals, East Africa, respectively.

(d) The Chief Signals Officers at H.Q. B.F., Aden and A.H.Q., Iraq and Persia, will be similarly the supreme co-ordinating authorities for all R.A.F. communications within their respective commands. Their requirements will be notified direct to the appropriate Army Chief Signals Officer.

(e) The Chief Signals Officers at Air Headquarters, Eastern Mediterranean, H.Q. 203 Group, H.Q. 206 Group and H.Q. 216 Group are the supreme co-ordinating authorities for all functional communications within their respective formations. Their requirements in respect of landline and despatch rider communications will be notified to the Chief Signals Officer of the Air Headquarters responsible for the area concerned who, in turn, will make these requirements known to the appropriate Officer Commanding Air Formation Signals or Army Chief Signals Officer.

(f) The Senior R.A.F. Signals Officers in Tripolitania and the Sudan will be responsible for notifying Royal Air Force landline and despatch rider requirements direct to the appropriate Army Chief Signals Officer.

(g) The Chief Signals Officer Air Formation Signals, Middle East, has a triple responsibility. Having received from the A.O.C.-in-C. Middle East, through the medium of the Chief Signals Officer, R.A.F., the A.O.C.-in-C's requirements in respect of landline and despatch rider communications, he will be responsible to the A.O.C.-in-C. for the operation of the communications provided by the various Air Formation Signals under his control. He will also be responsible to the Signal Officer-in-Chief, G.H.Q., M.E., for the technical efficiency of the communications and of the Air Formation Signals units under his control. He will also be responsible to the Chief Air Formation Signals Officer, M.A.A.F., for conforming with the general signals plan of the Air Signals Officer-in-Chief, M.A.A.F., as far as it affects the resources at his disposal.

(h) The Air Officer Commanding No. 3 Air Formation Signals will bear a similar responsibility to the A.O.C. Egypt, for landline and despatch rider communications in Egypt and Cyrenaica, to that of the Chief Signals Officer Air Formation Signals, to the A.O.C.-in-C., Middle East, for such communications in the Middle East. He will also be responsible to the Chief Signals Officer Air Formation Signals, Middle East, for the technical efficiency of the communications and of his Air Formation Signals unit.

(i) The Officer Commanding No. 5 Air Formation Signals will bear a similar responsibility to the A.O.C., Levant, for landline and despatch rider communications in Palestine, Syria and Cyprus, to that of the Chief Signals Officer Air Formation Signals, to the A.O.C.-in-C., Middle East, for such communications in the Middle East. He will also be responsible to the Chief Signals Officer Air Formation Signals, Middle East, for the technical efficiency of the communications and of his Air Formation Signals unit.

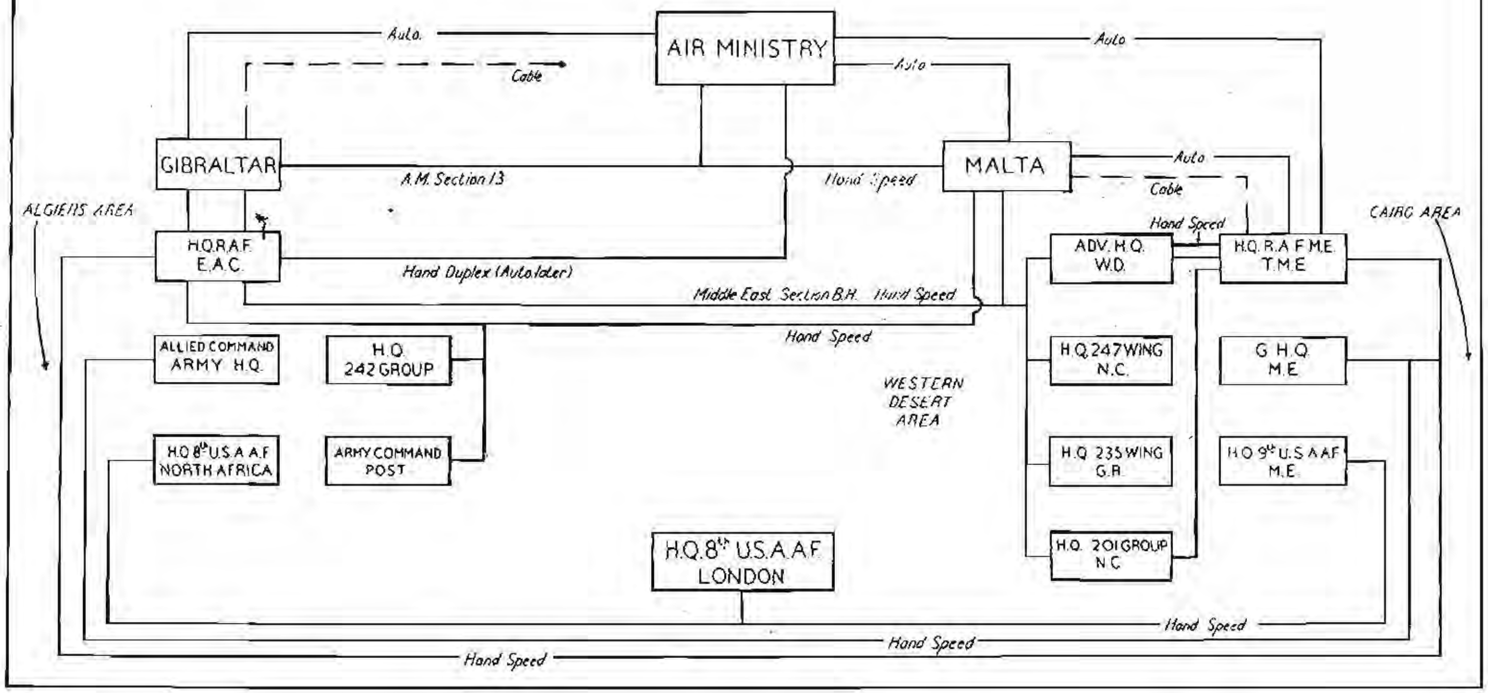
(j) The Officer Commanding, Air Formation Signals, East Africa, will bear a similar responsibility to the A.O.C., East Africa, for landline and despatch rider communications in East Africa, to that of the Chief Signals Officer Air Formation Signals, to the A.O.C.-in-C., Middle East, for such communications in the Middle East. He will also be responsible to the Chief Signals Officer Air Formation Signals, Middle East, for the technical efficiency of the communications and of the Air Formation Signals under his control.

(k) The action by Air Formation Signals after receipt of requirements prepared by the appropriate R.A.F. Chief Signals Officer is as laid down in the Signal Officer-in-Chief's Memorandum No. 18 of 9 May 1944.

(l) In cases where it is not possible for Air Formation Signals or the local Army G.S.C. to meet the landline or despatch rider requirements of subordinate commands, and when it is the opinion of the R.A.F. Chief Signals Officer or Senior Signals Officer concerned that such requirements are essential, it is the responsibility of the Chief Signals Officer or Senior Signals Officer to re-submit his demands to Headquarters, Royal Air Force, Middle East.

(m) Nothing in the foregoing order is to be construed as cancelling any arrangements which may at present exist for the provision of local minor landline or despatch rider requirements by local Air Formation Signals detachments at the request of the R.A.F. Signals Officer concerned.

CHANNELS OF COMMUNICATION H.Q. EASTERN AIR COMMAND TO H.Q. R.A.F. MIDDLE EAST DECEMBER 1942



APPENDIX No. 16

COMMUNICATIONS CHANNELS ON HEADQUARTERS SHIPS, FIGHTER DIRECTOR SHIPS AND G.C.I./L.S.T.s IN OPERATION NEPTUNE[1]

Communications Channels on Headquarters Ships

H.F. W/T — 2 to Tactical Air Force
2 to 87 Fighter Wing
1 to 87 Fighter Wing and Fighter Director Ships
1 to 63 Fighter Wing
1 to 63 Fighter Wing (Aircraft Movements)
1 to Carrier Flagships
1 A.L.O. circuit to Carriers
1 Air Support Control Forward Link
1 Track Broadcast from BORGO Sector (Rx only)

H.F. R/T — 1 to Carrier Flagships
1 to A.A. Units (standby for FM channel)
1 to G.C.I./L.S.T. (standby for VHF channel)
1 Track Broadcast

V.H.F. — 5 to aircraft (1 Fighter Control: 1 Fighter Bomber:
1 XII T.A.C.: Common and Tac/R:
1 World Guard and 1 A/S.R.)
1 Inter-controller channel
3 G.C.I. reporting
FM — 1 Command
1 to A.A. Units
Receivers — 1 Track Broadcast from BORGO Sector

Communications Channels on Fighter Director Ships

H.F. W/T — 1 to Carrier Flagships
1 to Headquarters Ship and No. 87 Fighter Wing
1 to 63 Fighter Wing (Aircraft Movements)
1 to 63 Fighter Wing (A/S.R. Flash)
1 to S.O.R. and L.W.
1 to G.O.s (standby)
1 to G.C.I./L.S.T.

H.F. R/T — 1 Inter-F.D.O.
1 to N.R.G.S. (standby)
1 Track Broadcast
1 to A.A. Units (standby)

FN R/T — 1 to A.A. Units
1 to G.O.s
1 to Command
1 to N.R.G.S.

V.H.F. — 5 to aircraft
1 Inter-controller
3 G.C.I./L.S.T. plotting

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[1] A.H.B./IIJ1/90/34.

Receivers — 1 Track Broadcast from BORGO Sector
1 Track Broadcast from Ops. 2 ashore

1 T.R.S.

Communications Channels on G.C.I./L.S.T.s

V.H.F. — 2 to aircraft
1 Plotting

H.F. W/T — 1 to Fighter Director Ship

APPENDIX No. 17

TELECOMMUNICATIONS DEVELOPMENT SCHEME—PROGRESS OF INSTALLATION ETC. OF TELEPHONE CARRIER AND V.F. TELEGRAPH SYSTEMS, INDIA, 15 OCTOBER 1944

1. Carrier Systems — 3 Channel

(A) *Systems installed and working — 42*

Delhi	—	Calcutta	Manipur Road	—	Jorhat
Delhi	—	Bombay	Manipur Road	—	Imphal
Delhi	—	Bombay 2nd	Manipur Road	—	Gauhati
Delhi	—	Agra	Manipur Road	—	Gauhati 2nd
Delhi	—	Lahore	Silchar	—	Imphal
Lahore	—	Karachi	Gauhati	—	Shillong
Lahore	—	Rawalpindi	Shillong	—	Silchar
Rawalpindi	—	Peshawar	Kharagpur	—	Cuttack
Calcutta	—	Gauhati	Cuttack	—	Vizagapatam
Calcutta	—	Gauhati 2nd	Cuttack	—	Vizagapatam 2nd
Calcutta	—	Comilla	Vizagapatam	—	Madras
Calcutta	—	Comilla 2nd	Vizagapatam	—	Madras 2nd
Calcutta	—	Kharagpur	Madras	—	Trinchinopoly
Calcutta	—	Asansol	Trinchinopoly	—	Bangalore
Calcutta	—	Cuttack	Trinchinopoly	—	Coimbatore
Calcutta	—	Bombay	Trinchinopoly	—	Colombo
Asansol	—	Ranchi	Bangalore	—	Madras
Comilla	—	Chittagong	Bangalore	—	Madras 2nd
Comilla	—	Silchar	Bangalore	—	Poona (via Belgaum
Manipur Road	—	Tinsukia	Bombay	—	Poona
Manipur Road	—	Silchar	Bombay	—	Bangalore

(B) *Systems being installed — 12*

Calcutta	—	Asansol 2nd	Cochin	—	Coimbatore
Kharagpur	—	Asansol	Allahabad	—	New Delhi
Nagpur	—	Calcutta	Bombay	—	Nagpur
Kandy	—	Trinchinopoly	Calcutta	—	Comilla 3rd
Trinchinopoly	—	Madras 2nd	Comilla	—	Imphal
Trinchinopoly	—	Bangalore 2nd	Delhi	—	Lahore 2nd

(C) *Equipment en route to site — 2*

Jubbulpore	—	Allahabad	Nagpur	—	Jubbulpore

(D) *New allocations — 2*

Patna	— Allahabad	Allahabad	—	Asansol

2. V.F. Telegraph Systems

(A) *Working — 17*

Delhi	—	Bombay	—	4 Channel
Delhi	—	Calcutta	—	4 Channel
Delhi	—	Calcutta	—	18 Channel
Delhi	—	Bombay	—	18 Channel
Delhi	—	Agra	—	6 Channel
Bombay	—	Bangalore	—	12 Channel
Bombay	—	Calcutta	—	18 Channel
Bangalore	—	Madras	—	6 Channel
Madras	—	Colombo	—	18 Channel
Calcutta	—	Comilla	—	6 Channel
Calcutta	—	Gauhati	—	6 Channel
Trinchinopoly	—	Madras	—	18 Channel
Madras	—	Vizagapatam	—	12 Channel
Vizagapatam	—	Calcutta	—	12 Channel
Gauhati	—	Manipur Road	—	6 Channel
Gauhati	—	Shillong	—	3 Channel
Shillong	—	Silchar	—	3 Channel

(B) *Installations in progress — 7*

Bangalore	—	Madras	—	18 Channel
Delhi	—	Lahore	—	18 Channel
Manipur Road	—	Tinsukia	—	3 Channel
Comilla	—	Silchar	—	6 Channel
Imphal	—	Manipur Road	—	3 Channel
Chittagong	—	Comilla	—	6 Channel
Imphal	—	Silchar	—	6 Channel

(C) *New Allocations* 4

Kharagpur	—	Calcutta	—	6 Channel
Trinchinopoly	—	Bangalore	—	6 Channel
Cochin	—	Coimbatore	—	6 Channel
Coimbatore	—	Trinchinopoly	—	6 Channel

APPENDIX No. 18

BUILDING PROGRAMME FOR CONSTRUCTION OF TRANSPORTABLE W/T AND R/T STATIONS FOR 1943[1]

Reference Number	Type No.	Nomenclature	1943 Total including Wastage	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Responsibility for Construction	Remarks
10D/382	—	Animal Pack W/T Station T.1083/R.1082	135	Delivery rate in accordance with Air Ministry Contract									Air Ministry	
10D/1774	18	Station W/T and R/T H.F. Light Transportable Army Type 22	60							20	20	20	No. 26 Group	
10D/1775	19	Station W/T and R/T H.F. Light Transportable Army Type 22 in Handcart	50	20						10	10	10	No. 26 Group	
10D/1776	20	Station W/T and R/T H.F. Medium Transportable American Collins 18Q	150							50	50	50	No. 26 Group	
10D/1777	21	Station W/T and R/T H.F. Medium Transportable T.1154K/H.R.O.	20							10	10		No. 26 Group	
10D/1716	15	Station W/T and R/T H.F. Medium Transportable T.1154K/R.1155L	150							50	50	50	No. 26 Group	No. 26 Group to modify R.1155 as substitute for R.1155L.
10D/1778	22	Station R/T V.H.F. Medium Transportable T.R.1143	40							20	10	10	No. 26 Group	Required for Airborne Transportables
10D/1779	23	Station R/T V.H.F. Medium Transportable T.R.1143 in Handcart	12							4	4	4	No. 26 Group	
10D/1780	24	Station R/T H.F. Medium Transportable T.R.1196	20								10	10	No. 26 Group	This production will be dependent upon completion of prototype by R.A.E. which is held up for Type 50 Mast
10D/1805	26	Station R/T V.H.F. Medium Transportable SCR.522	These reference and type numbers are issued to cover instances where American equipment is installed in the basic types 22 and 23 above.											
10D/1806	27	Station R/T V.H.F. Medium Transportable SCR.522 in Handcart												
10D/NIV	—	Station R/T V.H.F. Medium Transportable T.R.1143	275	No. 2 S.D. No. 30 M.U. No. 1 M.U.		20 —	20 —	20 20 To complete existing order as necessary to meet immediate requirements.	20 20	20 20	— 20	— 20	No. 26 Group DDRM (Radio) DDRM (Radio)	This equipment is as designed by No. 1 M.U. and will be replaced by H.Q., No. 26 Group prototype of Type 22 when available. Construction of these quantities is not affected by this new type.

[1] Telecommunications Engineering Instruction No. 31.

APPENDIX No. 19

USE OF PRIORITY PREFIXES

SERVICE	ROYAL NAVY	ARMY	ROYAL AIR FORCE	U.S.A.A.F.
Priority marking	MOST IMMEDIATE	MOST IMMEDIATE	MOST IMMEDIATE	MOST IMMEDIATE
Nature of text	Messages of vital importance	Messages of vital importance	Messages of vital importance	Messages of vital importance
Officers entitled to sign	C.-in-C. Senior naval officer present	C.-in-C. C.G.S. L.G.A. at Army Commander B.G.S. Commander Independent Corps	A.Os.C.-in-C. at Commands and their deputies, S.A.S.Os., A.Os.C. at air headquarters and independent groups. (This entitlement was not delegated)	Commanding General Air Force Command General Air Service Command
Priority marking	EMERGENCY AIR ATTACK	EMERGENCY AIR ATTACK	EMERGENCY AIR ATTACK	
Nature of text	Reports of formation of enemy aircraft	To be used by commanders of outlying detachments in districts where no adequate air-raid warning system existed	Reports of imminent air attack by enemy aircraft	
Officers entitled to sign	Flag and commanding officers	To be decided by army commanders in consultation with the R.A.F.	Authority for use could be delegated to anyone whose duty it was to report the presence of enemy aircraft	

SERVICE	ROYAL NAVY	ARMY	ROYAL AIR FORCE	U.S.A.A.F.
Priority marking	EMERGENCY	EMERGENCY OPERATIONS	EMERGENCY	EMERGENCY (x URGENT)
Nature of text	Certain enemy reports and messages of vital operational importance	To be used on messages of the utmost importance which had a direct bearing on operations	Operational messages of vital importance, and not coming under 'EMERGENCY AIR ATTACK'	Messages of vital operational importance
Officer entitled to sign	Flag and Commanding Officers	As for 'MOST IMMEDIATE' and :— D.C.G.S. D.A.G. D.Q.M.G. D.M.I. D.D.O. S.O.-in-C. A.Q.M.G., C.S.O. } at Army Commander, D.G.S., D.A. & Q.M.G. } at Corps Commander, G.S.O.I } at Division Commander, Brigade Major } at Brigade	Staff Officers at Headquarters not below the rank of Group Captain, Station Commanders and Commanding Officers of Units operating independently. Could be delegated for operational purposes to the captain of an aircraft operating singly or the Duty Operations Officer, but no further delegation of the authority was to be granted	Group Commanders

SERVICE	ROYAL NAVY	ARMY	ROYAL AIR FORCE	U.S.A.A.F.
Priority marking	IMMEDIATE	IMMEDIATE	IMMEDIATE	IMMEDIATE (* OPERATIONAL PRIORITY)
Nature of text	Certain enemy reports and messages of vital operational importance	To be used only on messages of special importance	(i) Messages of extreme importance and for operational messages of less importance than emergency categories. (ii) Messages regarding the movements of aircraft on which Very Important Personages (V.I.Ps) were passengers. *N.B.* Messages franked 'RESCUE AIRCRAFT' or 'FLYING CONTROL' were to be given priority over all other 'IMMEDIATE' messages which might be on hand.	Messages of extreme importance or operational messages of less importance than emergency
Officers entitled to sign	Flag and Commanding Officers Senior Staff Officers	1st grade Staff Officers Actual Commanders of Lieutenant - Colonel's Commands (and the Adjutants in their absence)	Staff Officers of Headquarters not below the rank of Group Captain, Commanding Officer of a Unit and Adjutant (in the absence of the Commanding Officer). The authority could be delegated to a Formation Leader, Section or Half-Section Commander, captain of an aircraft operating singly, Meteorological Officer and Duty Operations Officer. Duty Pilots (in respect of V.I.P. movements messages only—see (ii) above). Signals Officers and Signals Masters of key W/T Stations for signals service messages.	Organisation Commander or his authorised representative

SERVICE	ROYAL NAVY	ARMY	ROYAL AIR FORCE	U.S.A.A.F.
Priority marking	IMPORTANT	IMPORTANT	IMPORTANT	IMPORTANT (* PRIORITY)
Nature of text	Messages which required priority above the ordinary	To be used only on messages which required priority above the ordinary	To be used only on messages which required priority above the ordinary. This priority was employed for routine messages relating to aircraft movements, weather reports and requests for weather reports, when necessary.	Messages which required priority above the ordinary. Certain routine messages.
Officers entitled to sign	Flag and Commanding Officers, who could delegate this responsibility to appropriate subordinates	All Staff Officers not below the rank of major. All Commanding Officers of Units and Adjutants. All Signals Officers, but only on signals matters. Officers Commanding detached troops.	Staff Officers not below the rank of Squadron Leader. Commanding Officer of a Unit and Adjutant. Duty Pilot for aircraft movements. Officers Commanding detachments. Captain of an aircraft operating singly.	Any Officer authorised by the Organisation Commander

SERVICE	ROYAL NAVY	ARMY	ROYAL AIR FORCE	U.S.A.A.F.
Priority marking	ORDINARY	ORDINARY	ORDINARY	ORDINARY (* ROUTINE)
Nature of text			All normal signals	All normal signals
Officers entitled to sign			Any Officer	Any Officer
Priority marking	DEFERRED	DEFERRED	DEFERRED	DEFERRED
Nature of text			Messages on which a delay of forty-eight hours could be tolerated	Messages were cleared as soon as possible, but were, as indicated, last priority
Officers entitled to sign			Any Officer	Any Officer

APPENDIX No. 20

PRIORITY INDICATIONS—TELEPHONES

Importance	Priority Prefix	Over Telephone	Authority to use	Remarks
(1)	Most Immediate	Gave 'Clear the line authority'	Ambassadors, Ministers of the Crown, Governors of Colonies and Protectorates, Commanders-in-Chief.	Took precedence over all other calls and messages. Must be despatched at once and delivered at once to addressee. If delayed addressor must be informed immediately.
(2)	Emergency Air Attack	Gave 'Clear the line authority'	Any officer reporting the presence of enemy aircraft.	Must be despatched at once by one or more means, e.g. Landline and Wireless. Delay must be reported to addressor. Must be delivered at once to addressee.
(3)	Emergency Operations (for Military or Air operations only)	Gave 'Clear the line authority'	A.Os.C.-in-C. or Commanders of formations or their principal staff officers in the Army. A.O.C-in-C., Air Officers Commanding Commands or Groups or their S.A.S.Os. and Os.C. operational units specially authorised by A.O.C.-in-C. in the case of the R.A.F.	Must be despatched by quickest means. Any delay must be reported to addressor. Must be delivered at once to addressee.
(4)	Immediate	Gave priority facilities	Officers of Government or Embassy officials authorised to despatch immediate messages.	Must be despatched by quickest means. Receiving station should deliver at once.
(5)	Important	Gave no priority	Officers of Government or Embassy officials authorised to despatch important messages.	Should be given priority of treatment over ordinary landline traffic.

Regarding priority indication (3), authority to originate an Emergency Operational Telephone call was delegated to Officers Commanding Operational Units not smaller than Wings or Groups.

APPENDIX No. 21

W/T STANDBY POINT-TO-POINT ORGANISATION

NOVEMBER 1940

Section	Command	Group	Stations	Freq.	Remarks
A	Air Ministry		Whitehall		
			Leighton Buzzard		
			Hartlebury		
	Bomber		Southdown	3165	
	Fighter		Stanmore		
	Coastal		Northwood		
	Maintenance		Andover		
	Training Cmd.		Reading		
	Training Cmd.		Market Drayton		
AB	A.M./Bomber		Whitehall	3905	
			H.Q. Bomber Cmd.		
AC	A.M./Coastal		Whitehall		
			H.Q. Coastal Cmd.	3055	
			26 (Sigs) Group		
			No. 1 (Sigs) Depot		
AF	A.M./Fighter		Whitehall		V.H.F. Link ready shortly
			Fighter Command		
Y			Cheadle (C)		
			Lydford		
			Sutton Valence		
			Ingoldmells		
			Montrose		
			Wick		
			2 Mobile Stations		
F	Fighter		Stanmore (C)		
		No. 9	Preston		
		No. 10	Rudloe Farm		
		No. 11	Uxbridge	6330	
		No. 12	Watnall		
		No. 13	Newcastle		
		No. 14	Inverness		
F9		No. 9	Preston		
			Bagington	5990	
			Jurby		
			Speke		
			Tern Hill		

APPENDIX No. 20
PRIORITY INDICATIONS—TELEPHONES

Importance	Priority Prefix	Over Telephone	Authority to use	Remarks
(1)	Most Immediate	Gave 'Clear the line authority'	Ambassadors, Ministers of the Crown, Governors of Colonies and Protectorates, Commanders-in-Chief.	Took precedence over all other calls and messages. Must be despatched at once and delivered at once to addressee. If delayed addressor must be informed immediately.
(2)	Emergency Air Attack	Gave 'Clear the line authority'	Any officer reporting the presence of enemy aircraft.	Must be despatched at once by one or more means, e.g. Landline and Wireless. Delay must be reported to addressor. Must be delivered at once to addressee.
(3)	Emergency Operations (for Military or Air operations only)	Gave 'Clear the line authority'	A.Os.C.-in-C. or Commanders of formations or their principal staff officers in the Army. A.O.C-in-C., Air Officers Commanding Commands or Groups or their S.A.S.Os. and Os.C. operational units specially authorised by A.O.C.-in-C. in the case of the R.A.F.	Must be despatched by quickest means. Any delay must be reported to addressor. Must be delivered at once to addressee.
(4)	Immediate	Gave priority facilities	Officers of Government or Embassy officials authorised to despatch immediate messages.	Must be despatched by quickest means. Receiving station should deliver at once.
(5)	Important	Gave no priority	Officers of Government or Embassy officials authorised to despatch important messages.	Should be given priority of treatment over ordinary landline traffic.

Regarding priority indication (3), authority to originate an Emergency Operational Telephone call was delegated to Officers Commanding Operational Units not smaller than Wings or Groups.

APPENDIX No. 21

W/T STANDBY POINT-TO-POINT ORGANISATION

NOVEMBER 1940

Section	Command	Group	Stations	Freq.	Remarks
A	Air Ministry		Whitehall		
			Leighton Buzzard		
			Hartlebury		
	Bomber		Southdown	3165	
	Fighter		Stanmore		
	Coastal		Northwood		
	Maintenance		Andover		
	Training Cmd.		Reading		
	Training Cmd.		Market Drayton		
AB	A.M./Bomber		Whitehall	3905	
			H.Q. Bomber Cmd.		
AC	A.M./Coastal		Whitehall		
			H.Q. Coastal Cmd.	3055	
			26 (Sigs) Group		
			No. 1 (Sigs) Depot		
AF	A.M./Fighter		Whitehall		V.H.F. Link
			Fighter Command		ready shortly
Y			Cheadle (C)		
			Lydford		
			Sutton Valence		
			Ingoldmells		
			Montrose		
			Wick		
			2 Mobile Stations		
F	Fighter		Stanmore (C)		
		No. 9	Preston		
		No. 10	Rudloe Farm		
		No. 11	Uxbridge	6330	
		No. 12	Watnall		
		No. 13	Newcastle		
		No. 14	Inverness		
F9		No. 9	Preston		
			Bagington	5990	
			Jurby		
			Speke		
			Tern Hill		

Section	Command	Group	Stations	Freq.	Remarks
F10		No. 10	Rudloe Farm (C)		
			Filton		(M)
			Middle Wallop	5000	
			St. Eval		
			Pembrey		
F11		No. 11	Uxbridge (C)		
			North Weald		(M)
			Hornchurch	5910	(M)
			Manston	6190	(M)
			Hawkinge		
			Biggin Hill		(M)
			Kenley		(M)
			Tangmere		(M)
			Hendon		(M)
			Northolt		(M)
			Croydon		(M)
F12		No. 12	Watnall (C)		
			Digby		(M)
			Wittering		(M)
			Duxford		(M)
			Debden	5970	(M)
			Sutton Bridge	6130	
			Martlesham		
			Kirton-in-Lindsay		
			Coltishall		
			Church Fenton		
			Leconfield		
F13		No. 13	Newcastle (C)		
			Turnhouse		(M)
			Acklington		
			Usworth	4625	(M)
			Catterick	5950	(M)
			Drem		
			Grangemouth		
F14		No. 14	Inverness		
			Dyce	6510	
			Kirkwall		
			Wick		
BA	Bomber	—	Southdown (C)		
		No. 1	Hucknall		
		No. 2	Huntingdon	3204	
		No. 5	St. Vincents		
		No. 7	Brampton		
BB		—	Southdown (C)		
		No. 3	Exning	3980	
		No. 4	Heslington		
		No. 6	Abingdon		
B1		No. 1	Hucknall (C)		(M)
			Newton	3280	
			Binbrook		
			Swinderby		

(M)—Stations at which Meteorological reports are prepared.

Section	Command	Group	Stations	Freq.		Remarks
B2		No. 2	Huntingdon (C)		(N)	(N) Stations marked thus work on 3030 kc/s. at night only and use 6900 kc/s. during day-light hours.
			Wyton		(M)	
			Wattisham	3030	(M)	
			Watton		(M)	
			W. Raynham		(M)	
			Horsham St. Faith			
			Oakington			
			Kinloss		(N) (M)	
			Lossiemouth		(N) (M)	
B3		No. 3	Exning (C)			
			Mildenhall		(M)	
			Feltwell	3584	(M)	
			Honington		(M)	
			Marham		(M)	
			Stradishall		(M)	
			Waterbeach			
B4		No. 4	Heslington (C)			
			Linton		(M)	
			Driffield	3134	(M)	
			Dishforth			
			Leeming			
			Topcliffe			
B5		No. 5	St. Vincents (C)			
			Finningley		(M)	
			Hemswell		(M)	
			Scampton	3890	(M)	
			Waddington		(M)	
			Syerston			
			Lindholme			
			Doncaster			
B6		No. 6	Abingdon (C)		(M)	
			Benson		(M)	
			Harwell	3234		
			Hucknall			
			Bassingbourn		(M)	
			Bramcote			
B7		No. 7	Brampton Grange (C)		(M)	
			Upper Heyford		(M)	
			Bicester		(M)	
			Cottesmore		(M)	
			Upwood		(M)	

Section	Command	Group	Stations	Freq.	Remarks
C	Coastal	—	Northwood (C)	5020	Two channels used at same time if necessary
		No. 15	Plymouth		
		No. 16	Chatham		
		No. 17	Gosport	7500	
		No. 18	Rosyth		
C15		No. 15	Plymouth (C)		(M)
			Aldergrove	3815	(M)
			Hooton Park	7380	
			St. Eval		(M)
			Pembroke Dock		(M)
			Mount Batten		
			Port Ellen		
			Stranraer		
			Oban		
C16		No. 16	Chatham (C)		(M)
			Bircham Newton		(M)
			Detling	4625	(M)
			North Coates		(M)
			Thorney Island		
C17		No. 17	Gosport (C)		
			Calshot	4170	(M)
			Squires Gate		
			Abbotsinch		(M)
			Silloth		
			Catfoss		
C18		No. 18	Rosyth (C)		
			Dyce		
			Invergordon		(M)
			Leuchars	4960	(M)
			Stornaway		(M)
			Wick	6480	(M)
			Sullom Voe		(M)
			Sumburgh		(M)
			Thornaby		
			Helensburgh		

Section	Command	Group	Stations	Freq.	Remarks
T.M.1	Flying Training		Market Drayton (C)		See below
	Technical Tng.		Cranwell (S—C)		(M)
	Maintenance		Altrincham		
			Carlisle		
			Evanton		
			Heywood	4660	
			Jurby		
			Montrose		(M)
			Morecambe		
			Padgate		
			Ronaldsway		
			Weeton		
			West Freugh		(M)
			West Kirby		
			Blackpool		
			Prestwick		
			Kirkham		
			Brough		
			Perth		
			Leeds		
			Dalcross*		*Stations not yet open
T.M.2			Market Drayton (C)		See below
			Sealand (S—C)		(M)
			Derby		
			Fauld		
			Grantham		
			Harpur Hill	4285	
			Hednesford		
			Llanberis		
			Meir		
			Penrhos		(M)
			Peterborough		(M)
			Stafford		
			Manby		
			Elmdon		
			Desford		
			Sywell		
			Anstey		
			Cranage		
			Church Lawford*		
T.M.3			Market Drayton (C)		Control and Sub-Control maintain continuous guard watch on 4170 Kc. All stations (M) Sections T.M.1 to 4 will open up on this frequency when it is necessary to use W/T and revert to their own section frequency when instructed by the control station.
			South Cerney (S—C)		
			Bagington		
			Bridgnorth		
			Cardington		
			Cranfield		
			Gloucester		
			Henlow	4170	
			Hereford		
			Kidlington		
			Luton		
			Melksham		
			Milton		
			Ruislip		
			Watchfield		
			Worcester		
			Staverton		
			Hatfield		
			Cambridge		
			Bobbingdon*		
			Honiley*		

Section	Command	Group	Stations	Freq.	Remarks
T.M.4			South Cerney (C) Reading (S—C) Boscombe Down Chilmark Hartlebury Kidbrooke Langley Netheravon Porthcawl Quedgeley Rollestone St. Eval Weston-s-Mare (Locking) Yatesbury Compton Bassett Halton Uxbridge Fairoaks Woodley White Waltham Torquay	4225	See T.M.3 (M)
T.M.5			Kemble (C) Aston Down Brize Norton Colerne Hullavington Llandow L/Rissington Lyneham St. Athan Wroughton	3380	
T.M.6			Hawarden (C) Tern Hill Shawbury Cosford High Ercall Burtonwood Lichfield	3380	
T.M.7			Kirkbride (C) Silloth Dumfries Edzell Kinloss Lossiemouth Aldergrove	3380	(3767.5 kc. alternative frequency)

APPENDIX No. 22

SIGNALS ORGANISATION ' PANDA '

General

This instruction cancels Combined Signals Instruction No. 5, dated 29 October, 1941, and will take effect from 13 April, 1942, when Combined Signals Instruction No. 5 and all Appendices will be destroyed.

2. The provisions of this instruction will be implemented strictly in accordance with the text. Instructions passed to lower formations will *only* be in the form of extracts from these instructions.

Information and Intention

3. (i) The reinforcement of aerodrome garrisons in the United Kingdom against attack by enemy land forces is the responsibility of the Army. Aerodrome garrisons, in calling for such reinforcement, are to make use of all available means of communication (e.g. landline, despatch rider, pigeon, etc.). Direct wireless communication is not normally provided between Army formations/units and aerodromes. It is the intention of this instruction to provide an emergency wireless organisation for use in the event of the absence or failure of the normal methods of communication.

(ii) The R.A.F. is to assist in the provision of such an emergency organisation by :—

- (a) making full use of the wireless facilities already existing at aerodromes.
- (b) the provision of special wireless facilities at certain specified aerodromes.
- (c) the provision of control sets and necessary personnel at headquarters of specified Army formations. These sets will be mobile where the Army formation is mobile.

(iii) The organisation is intended to provide communication between :—

- (a) aerodromes and Army formations or unit headquarters to enable defence garrisons established at the former to call for reinforcement, should they deem it necessary.
- (b) aerodromes and the military forces sent to reinforce them.

(iv) Although this emergency organisation is to apply primarily to the defence of R.A.F. aerodromes, it is intended that it should embrace R.N. air stations, and M.A.P. and other civil aerodromes where facilities for wireless communication can be arranged.

(v) It is emphasised that the lack of continuity in the operational use of this emergency wireless organisation militates against its reliability, and therefore full use must be made of every other means of communication available. There will, however, be occasions when this organisation can provide the only means of communication and at such times the successful and rapid establishment of communication will be vital. Therefore all possible action must be taken to promote the efficiency of the organisation.

Method

4. (i) The organisation will be known as ' Panda ' and will consist of two systems :—

- (a) ' Panda One ': between aerodromes and Army formation headquarters responsible for providing their reinforcement.
- (b) ' Panda Two ': between aerodromes and Army units or formations detailed to reinforce them, for the passage of tactical information concerning the battle.

(ii) For the purpose of this instruction, the Army formation headquarters detailed in (a) above will be referred to as ' Panda Controls ', and an Army unit specifically detailed for the reinforcement of an aerodrome, or despatched in response to a call for assistance, will be referred to as a ' Panda Unit '.

Panda One

5. (i) The R.A.F. will provide a wireless set and the necessary personnel at each Panda Control detailed in Appendix A.

(ii) Where facilities are available, aerodromes are to arrange to have a transmitter and receiver ready calibrated to operate on the appropriate Panda One frequency at very short notice.

(iii) The set to be used at the aerodrome is left to local arrangements, according to the W/T facilities at, and the operational and defence requirements of, the station or satellite concerned.

(iv) If no other set is available at the aerodrome, the stand-by point-to-point set is to be used, and the station will have to leave its command, group or wing point-to-point system for the period during which it is operating on the 'Panda' system.

(v) Where special Panda W/T facilities exist, close attention should be paid to the erection of a suitable aerial system, particularly in respect of its orientation, having regard to the geographical relationship between the aerodrome and its Panda Control.

(vi) A 24-hours' watch will be maintained by all Panda Controls shown in Appendix A on receipt of the Army order 'Stand-To'.

(vii) Each Panda Control will keep watch on the frequency and use the callsign allotted to it in Appendix A.

(viii) The aerodromes which are affiliated to each Panda Control are shown in Appendix A.

(ix) Panda Controls will be responsible for finding out from aerodromes whether R/T or W/T is to be used by the Panda Unit when communicating under Panda Two. Appendix C will be annotated accordingly by Panda Controls and appropriate instructions sent to Panda Units.

(x) The R.A.F. will provide a wireless set and the necessary personnel to establish a Panda W/T Guard at each Army Command H.Q. If a mobile Army formation acting as a Panda control is ordered to move out of its area, the Army Command H.Q. concerned will order watch to be kept by the W/T guard on the frequency of the Panda Control which has been ordered to move. The R.A.F. personnel of the Panda Control will then be informed through the W/T Guard whether they will

(a) rendezvous with any incoming or adjacent Army formation,

(b) proceed to a static Army formation Headquarters.

When the R.A.F. personnel are established with the formation deputed to take over the duties of the outgoing Panda Control it will resume its own watch and the W/T Guard will be relieved of the watch which it has kept in the interim period.

Panda Two

6. (i) When a Panda Unit is despatched to reinforce an aerodrome with which it has had no previous practice, communications will be established on one of the six frequencies shown in Appendix B and the aerodrome will be informed of the Panda Units frequency and callsign by the Panda Control. Where, however, practices are possible, a suitable frequency will be selected from the current Army allotment by the Panda Unit in consultation with the signals officer of the aerodrome concerned. The Panda Control will be notified of such arrangements.

(ii) Where Panda Units have to be despatched by Panda Controls to reinforce an aerodrome, the aerodrome should if possible, provide a standby set for use on Panda Two. If no standby set is available arrangements are to be made to use the point-to-point set on this system. This set should be situated if possible at Battle H.Q. but where this is not possible rapid and reliable communication is to be provided between the terminal and Battle Headquarters.

Note: R.A.F. TR.9 or G.P. Sets may be used for the above purpose. If a TR.9 is to be used Panda Controls are to be informed in advance so that R/T may be used on Panda Two in accordance with the provision made in para. 5 (ix) above.

(iii) Where Panda Units are located near an aerodrome with the primary role of reinforcing that aerodrome they will by arrangement with the R.A.F. Station Commander on receipt of the Army order 'Stand-To', provide and man a terminal set at the aerodrome. The frequency and callsign for this purpose will be prearranged by Panda Units and will be taken from the current Army allotment.

(iv) The provision of a terminal set for Panda Two as in sub-para. (iii) above, does not absolve the R.A.F. Station from the responsibility of providing a set for use on Panda One in accordance with para. 5 (ii) above, since occasions may arise when further assistance may have to be called for from a Panda Control.

(v) Where Panda Units have been given the primary role of reinforcing an aerodrome and where arrangements for wireless communications have been arranged as in sub-para. (iii) above the aerodrome is, in case of necessity, to call for assistance on Panda Two direct, where possible informing Panda Control of the action taken.

Satellite Aerodromes

7. (i) Where satellite aerodromes have wireless facilities they are to communicate direct with their Panda Control on Panda One as laid down in para. 5 above.

(ii) Where satellite aerodromes have no wireless facilities but have made arrangements with Panda Units as laid down in para. 6 (iii) above, they will communicate with the Panda Unit on Panda Two.

(iii) Where satellite aerodromes have no wireless facilities and are in the same military area as their parent aerodrome they are to communicate by any means available requests for assistance through the parent aerodrome.

(iv) Where satellite aerodromes have no wireless facilities and are not in the same military area as their parent aerodrome, they are to get in touch by any means available direct with the Panda Control of the military area in which they are situated. A call for assistance to the parent aerodrome should only be sent if no means of communication is available with the Panda Control in their area, or if doubt exists as to whether the call for assistance has reached the control.

Warning of Impending Attack

8. In the event of an Army H.Q. receiving information of an attack which threatens an aerodrome, such information will be passed to the aerodrome by each of the following methods:—

(i) to the appropriate Army Command H.Q. for transmission on the Beetle R/T system.
This warning will be given as the text of a normal Beetle R/T operational message by the words 'Panda One' followed by the name or names of the aerodromes concerned.

(ii) to the aerodrome via the R.A.F. Group H.Q. (or R.A.N.A.S. for Southern Naval Air Stations and Commodore Donibristle for Northern Naval Stations) through the normal signal channels and franked Emergency Operations. Where direct links are not available between Army Command H.Q. and the R.A.F. Group H.Q. concerned, the warning will be sent via R.A.F. Command H.Q. using the Beetle W/T system or such other means as may be available.

The aerodrome on receipt of such a warning is immediately to call its appropriate Panda Control on Panda One.

Practice

9. (i) The efficiency of the Panda organisation depends on constant practice. The importance of close and constant liaison between R.A.F. and Army authorities concerned in connection with the practising of both Panda One and Panda Two cannot be over-emphasised. It is only by personal contact between the Army and R.A.F.

Officers immediately concerned that full advantage can be taken of the lessons learnt during practices. Where failures have been experienced, it is the responsibility of the Signals Officer of the aerodrome concerned to establish contact with the Signal Officer of the Panda Control concerned, to discuss the causes of failure with him, with a view to finding a remedy. Personal contact between officers is the keynote of successful co-operation between the Services.

(ii) *Panda One*

Panda Control will maintain a 24-hour watch on their appropriate Panda One frequency from 0900 hours on Tuesday to 0900 hours on Wednesday every week. During this period, R.A.F. aerodromes are responsible for initiating two calls, one during daylight hours and one during hours of darkness. The Signal Officer of Panda Controls should also make local arrangements for aerodromes to carry out practices during the very critical dawn and dusk periods. Normal R.A.F. procedure is to be used, and communications are to be confined to the passing of procedure signals.

(iii) Immediately after the practice period each week, Panda Control will report to their respective Army Command H.Q. (copy to G.H.Q. Home Forces) the names of those aerodromes which failed to make two transmissions. The Officers Commanding the R.A.F. Army Co-operation Wings attached to the respective Army Commands are to ensure that such failures are brought to the notice of the R.A.F. Command or Group H.Q.s concerned, for investigations to be made. They are to encourage direct liaison between Panda Controls and R.A.F. Stations during such investigations. Failures regarding communications with M.A.P., Civil, or Naval aerodromes should be brought to the attention of Headquarters, No. 26 Group.

(iv) *Panda Two*

The responsibility for practising Panda Two rests with the Panda Control. Where arrangements have been made as in para. 6 (iii) above, practices will be carried out at least once weekly. In all other cases Panda Controls will arrange direct with the aerodromes concerned for such practices as normal Army training will permit. The practising of Panda Two by W/T will be confined to the exchange of operating and procedure signals. Where R/T is used, no reference is to be made to anything which might disclose the operational role of the forces engaged.

(v) Officers Commanding R.A.F. Wings attached to Army Commands are to assist the Signals Officers of Panda Control and Units in smoothing out any difficulties which may arise in the operation of Panda Two. It is again emphasised that personal contact between the Army and R.A.F. Signals Officers concerned can go a long way to ensuring the smooth running of the whole organisation.

Daily Tests After ' Stand-To '

10. When an Army order ' Stand-To ' has been issued, weekly practices as in para. 9 (ii) will be cancelled. ALL R.A.F. Stations are to make at least one test daily to their Panda Controls. *Procedure Signals Only Are To Be Used.* Stations will listen out before making such test calls to ensure that they are not interfering with operational communications.

Administration and Discipline

11. R.A.F. personnel, attached to Army formation headquarters for duty with Panda Controls, will be administered by those Headquarters and will come under the O.C. Army formation H.Q. Signals for discipline, except at Army Command Headquarters where they will come under the Army Co-operation Wing for administration and discipline. Until Army ' Stand-To ' is issued, however, these personnel will normally be attached to nearest R.A.F. unit for administration, rations and accommodations;

duties, including weekly practices and maintenance of equipment.
concerned, but subject to immediate release at any time for their Panda Control
during this period they may be employed on other signals duties by the R.A.F. unit

Director of Signals.
Air Commodore
O. G. Lywood
Signals Officer in Chief.
Major General
(Sgd.) E. Phillips