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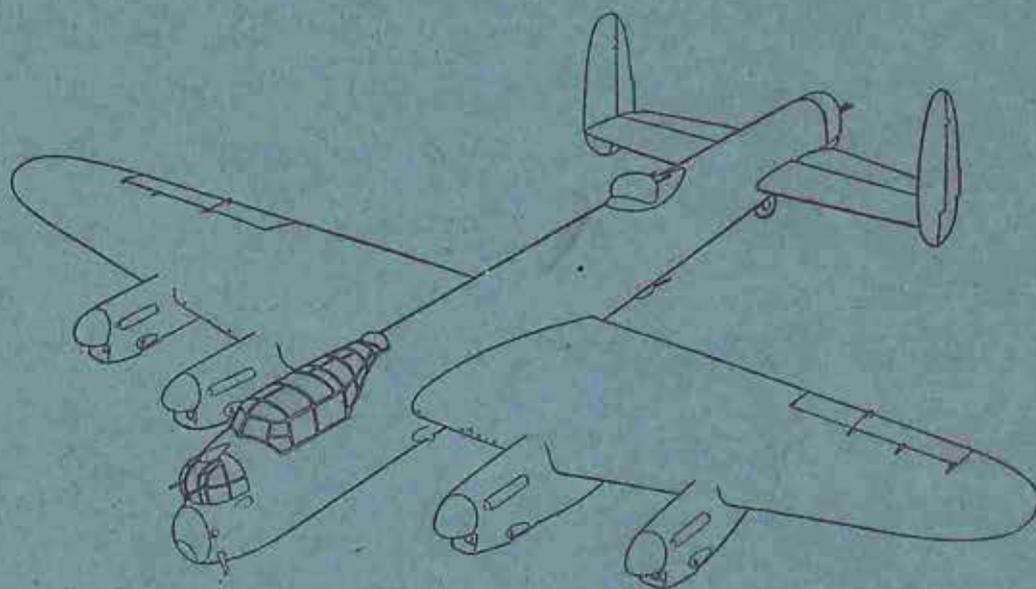
BOMBER COMMAND QUARTERLY REVIEW

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April — May — June, 1943

10th June 17 Feb 81.

No. 5



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HEADQUARTERS
BOMBER COMMAND
ROYAL AIR FORCE

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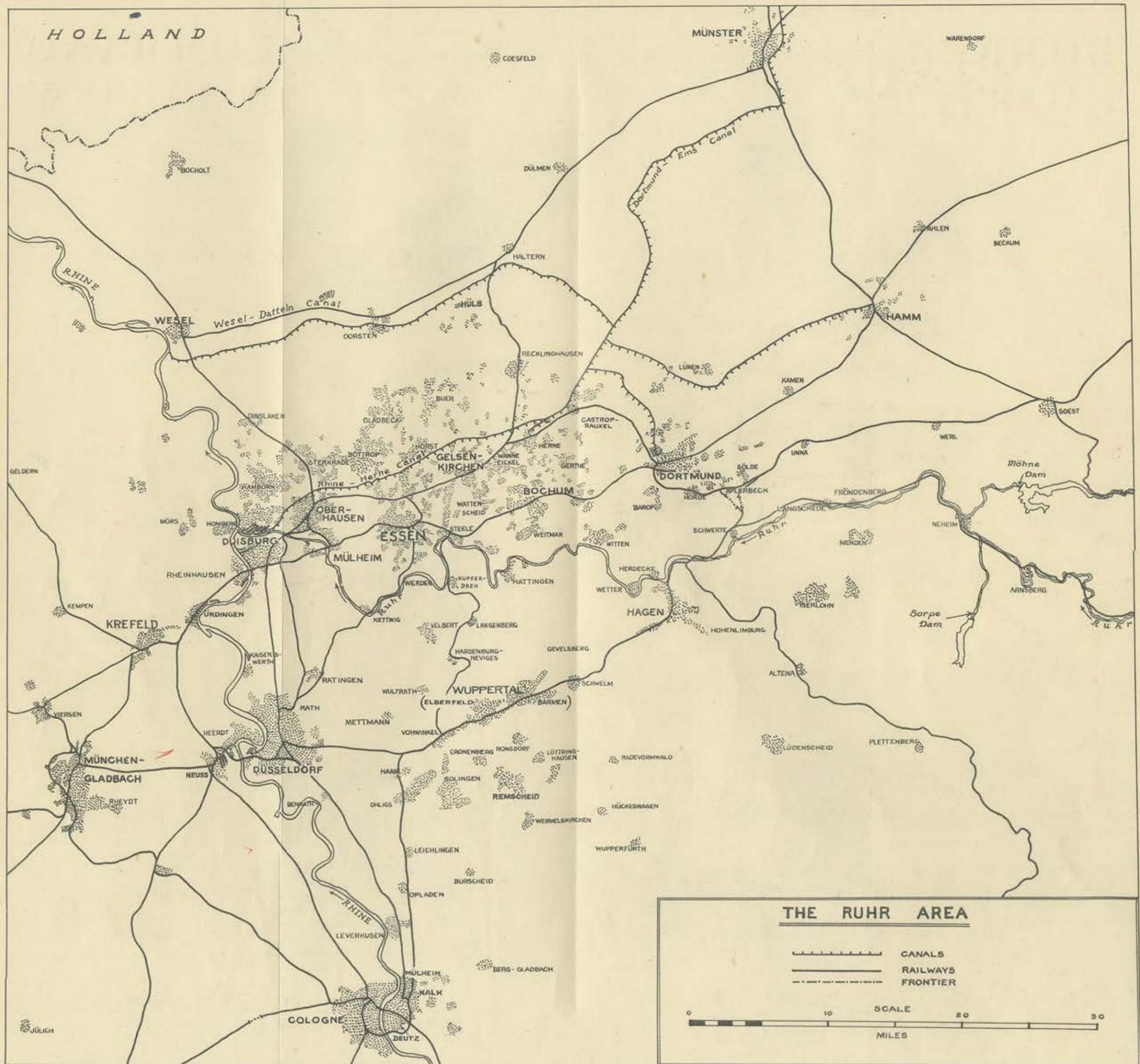
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BOMBER COMMAND QUARTERLY REVIEW

No. 5

I. REVIEW OF OPERATIONS

April—June, 1943

Introduction

The intensity of effort expended against the Ruhr and Rhineland industrial area in the second quarter of 1943 is entirely without precedent in air warfare. The scope of it can best be gauged by comparison with the corresponding quarter of 1942, which itself marked a new level of achievement and included the 1,000 raid on Cologne with its record bomb load of 1,500 tons.

<i>April-June Quarter.</i>	<i>Total Night Bombing Sorties.</i>	<i>Total Tonnage of Bombs Dropped.</i>
1942	9,751	14,057
1943	14,723	39,113

The increase in sorties is less striking than that in bomb tonnage, because of the very different proportion which heavy bombers bear to the force as a whole in 1943. This proportion has, indeed, almost doubled. The average strength of heavies in the second quarter of 1942 was about 40 per cent. of the total. In 1943, this figure has risen to about 70 per cent., and at the end of June, 1943, no less than 80 per cent. of the operational aircraft in Bomber Command were heavies.

Contrary to the hopes of German propagandists, this great expansion of effort has been made at a relatively smaller cost than the effort of 1942. Last year from May to June we lost 3.5 aircraft for every 100 tons of bombs dropped by night. In 1943, only two aircraft were lost for the same result. The number of personnel killed or missing per 100 tons dropped has also fallen from 18 in 1942 to 13 in 1943.

In addition, the accuracy of attacks in 1943 is vastly greater than that of 1942. This is attributable largely to the efficiency of the new navigational aids which render our bombing to a great extent independent of weather conditions over the target, and to the evolution of the Pathfinder technique. We are thus able not only to hit objectives under weather conditions which would previously have made night bombing a fruitless task, but we are able to operate on nights when night fighters find it difficult to leave and return to their aerodromes, and are otherwise impeded by the weather conditions. Also, by operating on such nights, we are able to avoid full-scale attacks against the most heavily defended targets during the full moon period, in which night fighters can operate most successfully.

It is thus true to say that 1943 has so far been the year of achievement for Bomber Command. It had long been expected that success on a decisive scale would be realised when a force of the order of 1,000 heavy bombers could be operated against Germany fairly frequently without cutting into the training organisation. We have not yet reached that stage. But the effects produced by attacks on the 600-800 aircraft scale show that the belief was well founded.

(a) The Battle of the Ruhr

After the successes gained at Essen in March, it was to be expected that the ensuing months would see a concentrated attack on the industrial heart of Germany—the Ruhr and Rhineland cities. That this was inevitable could not have possibly escaped the notice of the German High Command. The radius of action set by the short nights of May and June made it a certainty. Hence, nothing but tactical surprise could ever be hoped for, and the battle resolved itself into an all-out effort by the German defences to keep the bombers from smashing the Ruhr. They failed. It is in the light of this that the attacks delivered during this quarter on objectives other than the Ruhr and Rhineland must be viewed. Their purpose was not merely to damage important targets but also to keep the German flak and fighter defences spread out as widely and as long as possible by preventing the rest of Germany from sitting back and watching the battle of the Ruhr in comfortable detachment.

The offensive against the whole industrial system based on the Ruhr and Rhineland involved attacks on three groups of objectives:—

- (i) The industrial centres of the Ruhr valley—Essen, Dortmund, Bochum, Duisburg and their satellites, of which the most important are Mülheim, Oberhausen and Gelsenkirchen.
- (ii) The great Rhineland centres of commerce—Düsseldorf and Cologne.
- (iii) Subsidiary targets not primarily concerned with heavy industry but important for the production and transport of other badly needed war materials. Münster, Barmen, Elberfeld and Krefeld are all in this category, as is also the important synthetic-rubber works at Hüls, which was the target of the U.S. 8th Bomber Command.

During April, assaults on the Ruhr were limited to three attacks on Duisburg and two on Essen. These did quite a lot of damage but it was not highly concentrated. They served rather to interrupt and disorganise production than to further directly the primary object of putting the Ruhr as a whole out of action and making it a liability rather than an asset to Germany at the most critical period of the war on land. May and June, however, were a period of unparalleled concentration in a relatively small area, and achieved far-reaching success against the enemy's war industry. Only twice during the whole period did any considerable bomber force attack targets outside the industrial orbit of the Ruhr and Rhineland. For the rest, the industrial areas of the Ruhr and Rhineland, in spite of their reinforced defences, received a bombardment on an entirely different level of accuracy, persistence and duration from anything which they, or for that matter anybody else, had previously experienced. It is still much too early to estimate the total results of this campaign. Bombing victories do not produce spoils in the shape of captured troops, guns and tanks—and the photographic records can do no more than indicate the scope of the disaster the enemy has suffered.

The battle, of which the destruction of Essen in March was the first phase, recommenced on 3/4 April. The second phase which is covered in this *Review* closed with the attack on the Deutz and Kalk districts of Cologne on 3/4 July. A summary of the major attacks delivered during this period shows the volume of the offensive.

APRIL

Date.	Target.	A/C Despatched.
3/4	Essen	348
8/9	Duisburg	392
9/10	Duisburg	109
26/27	Duisburg	561
30/1	Essen	305

MAY

Date.	Target.	A/C Despatched.
4/5	Dortmund	596
12/13	Duisburg	572
13/14	Bochum	442
16/17	Möhne and Eder Dams	19
23/24	Dortmund	826
25/26	Düsseldorf	759
27/28	Essen	518
29/30	Wuppertal (Barmen)	719

JUNE

Date.	Target.	A/C Despatched.
11/12	Düsseldorf	783
11/12	Münster	72
12/13	Bochum	503
14/15	Oberhausen	203
16/17	Cologne	212
21/22	Krefeld	705
22/23	Mülheim	557
24/25	Wuppertal (Elberfeld)	630
25/26	Gelsenkirchen	473
28/29	Cologne	608

JULY

Date.	Target.	A/C Despatched.
3/4	Cologne	653
Total		<u>11,565</u>

By way of comparison it may be mentioned that the total number of heavy bomber sorties on night bombing raids during the whole of 1942 was 11,336.

The full consequences of this almost continuous pounding are probably known only to a small number of high German authorities. Stories told by refugees to other parts of the Reich are partial and naturally concern themselves rather with the general terror produced than with any concrete facts. They have, however, given rise to such a flood of alarming rumours as to constitute a serious threat to morale in unbombed Germany. It is apparently forbidden to neutrals and even to other Germans to visit the devastated areas without the strongest reason, so that stories emanating from Sweden and Switzerland may be highly coloured rather than authentic. Similarly, no clear idea of the state of things prevailing at the end of the assault can be constructed by reference to earlier British experience. In the first place, there is no compact area in this country which corresponds at all closely to the highly concentrated heavy industry and coal producing area of the Ruhr and Rhineland. Secondly, and more important, nothing remotely approaching this onslaught in intensity has been experienced here. To put it shortly, it is practically impossible to imagine what 1,000 acres of closely built-up area devastated by fire and H.E. is like. Yet this and more is what Cologne, Düsseldorf, Barmen, Elberfeld and Krefeld have all experienced within a few weeks. Essen, Dortmund, Bochum and Duisburg, though less completely ravaged, have also suffered devastation on a catastrophic scale. It is impossible to doubt that this in itself has been sufficient to disorganise communications, break down public utility services and provide the authorities with fearful problems in the housing, feeding and evacuation of hundreds of thousands of bombed-out workers. To make matters much worse, the successful attack on the Möhne and Eder Dams on 16/17 May let loose floods on a disastrous scale. Here again, detailed results are unknown and part of the consequences will in any case not be apparent until a spell of dry weather sets in. It is certain, however, both from photographic and German sources that railway tracks and bridges were carried away and undermined, filter beds polluted and the supply of water for domestic purposes drastically reduced over a large area. Perhaps the best index of what is happening in the Ruhr is given by German propaganda on the bomber offensive. Up to the end of April, this was exasperated and slightly patronising. The general line was that the destruction of "cultural monuments" was deplorable and the loss of life and property caused to a small section of the population was something which had to be taken seriously. But the Luftwaffe was tied down on the Eastern Front and air raids would simply have to be tolerated for the time being. They were regarded as a major nuisance and rather an insult to the German nation. But they were not a major threat.

In two months, this has completely changed. The population of the Ruhr and Rhineland are now national heroes. Their continued resistance in the face of a savage and admittedly successful attack is compared to that of the VI Army at Stalingrad. Front line reporters and Siegfried's Funeral March are lavishly provided to raise emotional sympathy with them to the highest pitch. In fact, there is open recognition of the fact that this is a decisive battle and one which can be lost only with disastrous consequences for the whole Reich. It is recognised that all who are not essential to maintain production in the coal mines and blast furnaces, which are immobile, must be got away and sent to other parts of Europe as quickly as possible. But to do this without panic and indiscriminate evacuation and to reorganise production under battle conditions is in itself an administrative problem of very great difficulty. It is complicated in Germany as it has been elsewhere by the universal tendency of refugees to regard themselves as heroes, whereas the receiving areas consider them nuisances. The Germans, too, unlike their victims all over Europe, have so far had no experience of this kind of thing, and indeed have been frequently and authoritatively told that it could never happen to them.

However, they are a highly efficient and tractable race and the destruction of the Ruhr and Rhineland alone will probably not give rise to immediate disaster. But it is reasonable to suppose that, as devastation on a comparable scale spreads across Germany with the lengthening nights, the problems of reorganisation, evacuation and rehousing will become cumulatively worse. There will be less intact areas from which help can be got and less consumer goods with which to provide the millions of bombed-out refugees with the minimum necessary to support existence.

But, although our information is imperfect, we know enough to claim that the industrial production of this entire area—enormously the most important in all Europe—has been injured beyond recovery. This does not imply that no habitable houses or undamaged factories remain. Undoubtedly there are considerable numbers of both, and, since the heavy industrial output of the Ruhr and Rhineland simply cannot be given up by the enemy without the certainty of complete military disaster, there is no doubt that some production must and will go on. Probably attempts at reconstruction and rehousing will be made as they were last year in order to increase output to the limit now considered possible. Hence it will very likely be necessary to discourage such endeavours by further attacks. The fact remains, however, that the back of the Ruhr and Rhineland is broken. This has been done not primarily by destroying war factories themselves. Many of them have been badly hit, but coal mines and coke ovens, though not indestructible, are difficult to wreck completely for any length of time. They can, however, be immobilised by other methods. The key to the problem is housing. As the enemy himself has stated—"A person without a roof over his head has been liquidated just as effectively as one who is starving." But even housing is not the whole story. There were approximately 3,000,000 inhabitants in the 250 square miles of the Ruhr valley. This number has been considerably reduced by evacuation, but the minimum number of essential workers cannot be kept going, even on a bare subsistence basis, without local transport and supplies of gas, light, water and food. A highly efficient administrative organisation is also needed to procure orderly evacuation and see that the living space which remains intact is used to the best advantage.

Heavy attacks on the commercial, residential and administrative centres of all the large cities in the area have made the efficient provision of these indispensable necessities impossible. It is not, of course, suggested that they have disappeared altogether. Life goes on, but it is crippled.

To complete the picture, it must be remembered that industry on a large scale is impossible without adequate and reliable transport facilities. Raw materials must be got to the factories and finished goods must be taken away from them. Hence, the railway network of the Ruhr is one of the most complicated in the world. Theoretically, railway damage is easy to repair if labour and materials are available. The Ruhr system, however, has been badly hit at so many vital points and has, in addition been undermined at many places by the Möhne and Eder floods, that traffic could not conceivably be adequate to meet the requirements of evacuation, relief and reconstruction unless, as may well be the case, the demand for rolling stock to meet normal industrial requirements is now negligible.

The general picture is thus that of destruction, dislocation and distress on a scale never previously experienced. To this must be added disillusionment and despair. The inhabitants of Germany have been so often told by their leaders that this kind of disaster was reserved for their victims—not for themselves—and the promise of adequate reprisals or successful defence is now no longer plausible enough to be handed out except in a perfunctory way as an inducement to them to hold out. Strength through fear is all they are offered, and they must surely wonder whether occupation by the British or even the Russians would really be less attractive than what they have had already and see in prospect.

To fill in even those details of this picture which are known to us completely would be a very lengthy business. The attacks have been too numerous and the damage too extensive to be catalogued in detail. The final analysis of what has happened in Düsseldorf alone takes twenty pages to set out. Hence, it is possible only to summarise the attacks on the chief Ruhr and Rhineland objectives with a few of their outstanding results. Reference to the map facing page 1 will show how thorough and methodical has been the reduction to impotence of the whole area.

THE RUHR VALLEY

Essen

Date.	A/C Despatched.	A/C Attacking.	Bomb Tonnage.			A/C Missing.
			H.E.	Incendiaries.	Total.	
3/4 April	348	317	513	470	983	21
30 April/1 May	305	251	423	417	840	12
27/28 May	518	493	762	680	1,442	23

These attacks were intended to finish off the destruction done in March, which has been described in *Bomber Command Quarterly*, No. 4, and to discourage attempts at rehabilitation. The first was highly successful. Fifteen more buildings, including three main workshops, in Krupps, were damaged by fire and H.E., railways were again hit and 300 buildings, mostly workers' dwellings in the immediate vicinity of Krupps, were destroyed. The other two attacks both employed deliberate blind bombing technique and were not expected to achieve any high degree of concentration. Both added to the destruction in Krupps and did further useful housing damage. Essen, however, had already reached a stage of disintegration at which new housing damage was very difficult to identify with certainty in many parts of the city. The final state of Krupps is as follows:—

“ Not counting the large number of small and unidentified sheds which have been destroyed within the area of the works, nearly 100 workshops or administrative buildings have now been damaged in the recent raids. Of these about 60 are large and important workshops and over 40 of them have been at least partly destroyed. As yet only the beginnings of roof repairs are visible. The fact that smoke or steam is seen issuing from chimneys or vents at seven or eight points, however, may be taken as some indication that production has not been altogether interrupted.”

It has been reported that Krupps are no longer interested in supplies of raw materials.

Dortmund

Date.	A/C Despatched.	A/C Attacking.	Bomb Tonnage.			A/C Missing.
			H.E.	Incendiaries.	Total.	
4/5 May	596	534	842	728	1,570	31
23/24 May	826	764	1,167	1,081	2,248	38

Dortmund is one of the chief centres of the German heavy industry. It is also the great transport centre at the East end of the Ruhr, corresponding to Duisburg in the West. In addition to handling railway traffic to and from the Ruhr industries, it deals with a vast quantity of through traffic to Central, North and East Germany, and is the terminus of the Dortmund-Ems canal. Traffic on this canal has recently gained in importance from the considerable transfer of German sea-traffic from Rotterdam to Emden. The population is estimated at about half a million.

EDER DAM: THE FLOODS, AND TWO MONTHS AFTER



FIG. 1 (A).—17 May, 1943: the waters of the reservoir flood through the breached dam.



FIG. 1 (B).—17 July, 1943: The reservoir completely empty, apart from the water of the Eder River which had reverted to its original course. As a first step towards its eventual repair a light railway has been constructed up to the foot of the ruined dam. The breach measures 245 ft. across the crown and 123 ft. along the base. Its depth is estimated as 96 ft. and further damage can be seen below.

THE NORTHERN SECTION OF KRUPP'S WORKS, ESSEN



FIG. 2.—This photograph, taken more than three months after the March raids, shows all the buildings still largely in ruins. At a few points roofing repairs have begun. Several of the many workers' camps destroyed in March are also outlined and the hut foundations can be clearly seen (H). Compare this figure with the photograph of part of the same area still burning after the attack on 12/13 March. (*B.C.Q.R.* No. 4, Fig. 3.)

FRESH DAMAGE IN THE CENTRAL SECTION OF KRUPPS



FIG. 3.—In addition to considerable areas of destruction caused here in the two March raids, much fresh damage resulted from the April and May attacks (see outlined incidents). This has since been greatly augmented.

- A and B.—Heavy damage to large machine shops, built since 1939.
- C.—The notorious Machine-shop No. 9 (long-range guns, etc.).
- D.—Administrative offices.
- E.—Electro steel foundry shop.
- F.—Heavy lorry manufacture.
- G.—Permanent way assembly.



FIG. 4.—This photograph, taken on 4 July, 1943, shows nearly two miles hardly an undamaged building to be seen. Most of the reconstruction attack on 28/29 June. The Main Railway Station, the Geron Goods of damaged buildings in

THE CENTRE OF COLOGNE



of water-front from the Deutscher Ring to the Rheinau docks with which followed the "Thousand Raid" was nullified in the "blind" Depot, the City Hall, and the Post Office are among the hundreds the area shown above.

AN INDUSTRIAL DISTRICT OF DÜSSELDORF

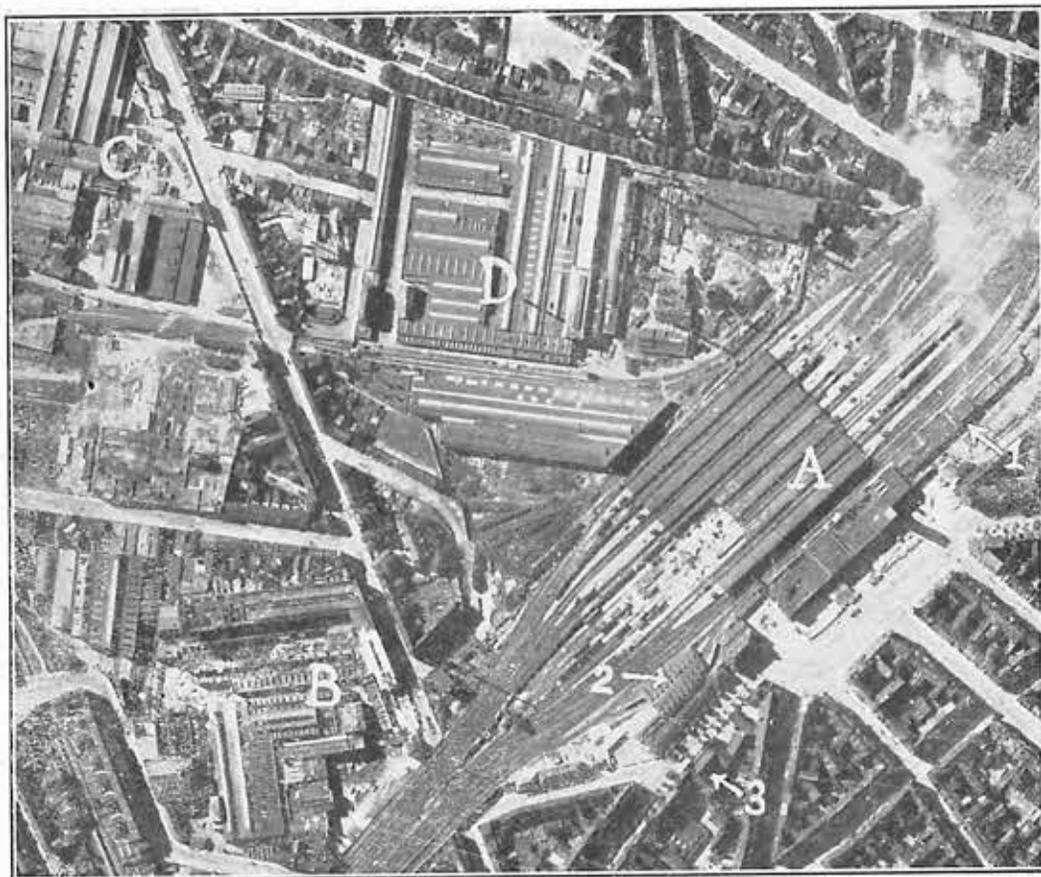


FIG. 5.—1 August, 1942: The Main Railway Station (A), the heavily damaged first-priority works of Schiess A.G. (B), part of Deutsche-Röhrenwerke (C), and Press & Walzwerk A.G. (D). Compare with Fig. 6, below.

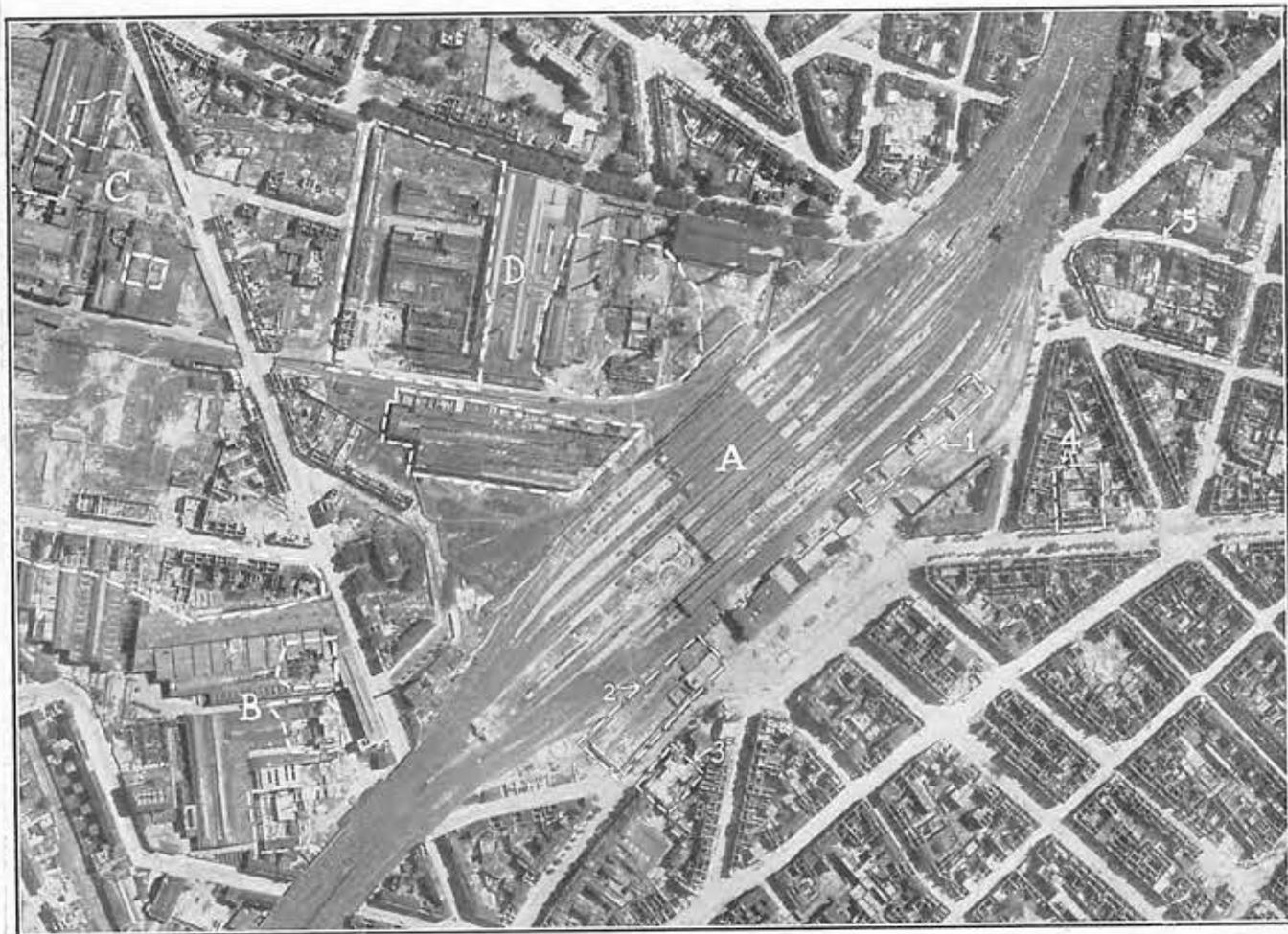


FIG. 6.—The same area of south-east DÜSSELDORF after the raid of 11/12 June, 1943, which destroyed or severely damaged more than a third of the whole area of the city and probably unhoused over 26,000 families. Beside fresh incidents of major damage to all three engineering plants the following are indicated:—

- (1) and (2) The gutted Express Goods and Parcels Offices flanking the already shattered Main Railway Station.
- (3) The Post Office damaged by fire.
- (4) The Chamber of Commerce building gutted.
- (5) Railway Administrative Offices and adjoining buildings burnt out.

The virtual elimination of this industrial centre in two attacks at a total cost of 69 aircraft missing is in some ways the most remarkable achievement of Bomber Command, up to date. The attack on 23/24 May delivered what was up to that time the greatest tonnage dropped on a single target in one night and also brought the total tonnage dropped on Germany since the outbreak of war above the 100,000 mark.

The havoc caused was very great. Not only was the centre of the town largely burnt out, but direct damage to factories and transportation was widespread. In particular, the damage to Hoesch A.G., one of the largest steel-producing undertakings in Germany, was so severe as to make production impossible for a considerable time, even without reference to the simultaneous destruction to houses, utilities and transport. Indeed, for a short time these two attacks probably made Dortmund the most heavily wrecked city in the Reich.

Bochum-Gelsenkirchen

Date.	Target.	A/C Despatched.	A/C Attacking.	Bomb Tonnage.			A/C Missing.
				H.E.	Incendiaries.	Total.	
13/14 May ..	Bochum ..	442	378	566	489	1,055	24
12/13 June ..	Bochum ..	503	454	878	718	1,596	24
25/26 June ..	Gelsenkirchen	473	424	630	764	1,394	30

Bochum is primarily a coal producing centre, and the area to the north and north-east of it contains the same kind of scattered industrial districts as the English Black Country. It is not, in fact, easy to know where one township ends and another begins, and Gelsenkirchen, which is credited with a population of over 300,000, has itself no compact central city area of the type found in Dortmund, Bochum and Essen. Hence Bochum itself required concentrated attack, but the whole Gelsenkirchen area is especially suited for blind bombing with sky markers, which, with the striking exception of recent attacks on Cologne, does not normally produce the same degree of concentration as ground marking technique. The normal accompaniments of a big coal-producing area, such as coking, the production of gas, ammonia, benzol, etc., steel smelting, iron founding and iron and steel manufacture are all found in and around Bochum and Gelsenkirchen, and are all of importance in what used to be the carefully co-ordinated production of the Ruhr area.

Both the Bochum attacks were highly successful. The first caused heavy damage in the centre of the town, where many fires were still burning nine hours later. The most important steelworks (Vereinigte Stahlwerke A.G.); railway stations and tracks also came off badly. The second attack carried the process much further and definitely put Bochum for the first time among the heavily devastated cities. Again high priority steelworks, the city administrative and business centre and railway transportation were the chief sufferers.

It was after this attack that Goebbels encouraged the population by telling them that the Fuehrer's personal interest in their welfare had led him to put through a telephone call to ask how they were getting on, thus showing his profound knowledge of and sympathy with their troubles.

As photographic cover of the Gelsenkirchen area was not obtained until after other attacks had been made here, the results of this one will remain uncertain.

Duisburg-Oberhausen-Mülheim

Duisburg, like Bochum, is the centre of a large number of important satellite towns. Essentially, it is the largest inland port in Europe and occupies geographically a key position on both land and water trade routes. Unlike Dortmund and Bochum, it had been the object of many Bomber Command attacks before the main Ruhr offensive opened and had suffered a larger amount of scattered damage. Oberhausen and Mülheim to the east of it had also suffered, though not fatally.

During this quarter, all have received considerable attention, and, though the results obtained are not yet fully covered by day photographs, they are known to be sufficient to put the whole area out of efficient action for a long time.

Date.	Target.	A/C Despatched.	A/C Attacking.	Bomb Tonnage.			A/C Missing.
				H.E.	Incendiaries.	Total.	
8/9 April ..	Duisburg ..	392	304	434	412	846	19
9/10 April ..	Duisburg ..	109	99	168	153	321	8
26/27 April ..	Duisburg ..	561	523	813	679	1,492	17
12/13 May ..	Duisburg ..	572	517	903	651	1,554	34
14/15 June ..	Oberhausen	203	165	357	288	645	17
22/23 June ..	Mülheim ..	557	499	787	856	1,643	35

As a result of these attacks, of which the most successful was that of 12/13 May, the centre of Duisburg itself has been gutted and a vast amount of housing damage has been caused in all the

suburban areas and satellite towns. The docks and warehouses of the port have suffered heavily both from H.E. and fire damage and direct damage to high priority factories has been caused throughout the area. In Duisburg itself and its immediate environs the following may be mentioned :—

“ Four factories of the Thyssen Vereinigte Stahlwerke A.G. have been affected, two of them very severely, and a coke and benzol purifying plant apparently put out of action. Extensive damage is seen also to a tar distillation plant, the largest in Germany. Beside munition-making factories, other firms damaged include chemical works, zinc and sulphuric acid plant, ships' boiler works, wire works, cotton and cellulose weaving mills, a silk fabric factory, soap works, malt works and two collieries.”

The Möhne and Eder Dams

The disasters in Western Germany have been accentuated by the bursting of the Möhne and Eder Dams, which was carried out by 19 Lancasters with special mines on 16/17 May. The Möhne Dam controlled the level of the Ruhr. Its primary object was to store the winter rains and thus prevent shortages in the summer and autumn and flooding in the winter months. The Eder compensated the River Weser for the water taken to feed the Mitelland Canal north of the Ruhr and to prevent flooding at Cassel and the towns lower down the Weser.

The immediate results of the successful breaching of both dams were naturally spectacular. The long-term consequences, of which our knowledge is and can only be fragmentary, are far more important. It is, however, established that severe shortages of water for all purposes have occurred in all the important Ruhr towns. This has been accentuated by the pollution of filter beds all down the Ruhr Valley, which has made it necessary to boil the small amounts available for domestic use before they are fit for human consumption. Damage to rail transport both directly by the destruction of bridges and indirectly by the undermining of tracks and embankments was on a large scale. There are further reports, which may well be true, of flooded coal workings and air raid shelters made unusable.

In fact this brilliant attack by a very small force produced results which in themselves could fairly have been described as catastrophic even if they had not been multiplied in importance many times by the concurrent devastation spread by fire and high explosive over the entire Ruhr area.

THE RHINELAND CAPITALS

Düsseldorf

Date.	A/C Despatched.	A/C Attacking.	Bomb Tonnage.			A/C Missing.
			H.E.	Incendiaries.	Total.	
25/26 May	759	686	1,082	955	2,037	27
11/12 June	783	693	1,063	1,038	2,101	38

Düsseldorf is the leading commercial city of Western Germany and as such contains the important administrative departments of industrial concerns of the Rhine and Ruhr. It is also the seat of many major armament firms, the production of the latter being as important as those of Duisburg and Essen. The first attack which employed deliberate blind bombing technique was not a great success. Heavy cloud up to 20,000 ft. prevented the best concentration obtainable by this method from being achieved. Considerable damage was caused, however, in the south-west part of the city and several factories engaged on war production were hit. The second attack on 11/12 June was made in good visibility and a very heavy concentration was obtained round the aiming point. Photographs prove that overwhelming devastation was caused. It is estimated that this city of over half a million inhabitants is now for practical purposes written off. Schiess Defriess and Rheinmetall Borsig A.G., producers of heavy machine tools and all types of heavy armament, were among the 64 factories which were more or less severely damaged. The main railway station was hit and incalculable damage has been done to warehouses, store sheds and railway goods depôts throughout the city. Over one-third of the business and residential property in the built-up area has been completely destroyed, or so damaged as to be useless without major repair work. Some buildings were still smouldering a week after the attack. It is evident that the fire services were completely beaten and a conflagration seems to have raged unchecked over the entire city.

Cologne

Date.	A/C Despatched.	A/C Attacking.	Bomb Tonnage.			A/C Missing.
			H.E.	Incendiaries.	Total.	
16/17 June	212	179	458	260	718	14
28/29 June	608	540	864	864	1,728	25
3/4 July	653	589	952	927	1,879	30
8/9 July	288	255	688	409	1,097	7

Since the 1,000 bomber raid of May, 1942, strenuous efforts had been made to rehabilitate Cologne as both an administrative and production centre. These had been to a considerable extent successful and it was therefore necessary to destroy the city as completely as possible in order to round off the Ruhr-Rhineland campaign. Although two of these attacks fall outside the period covered by this *Review*, it is essential to include them in order to give a complete picture of what has taken place.

In some ways, the most striking feature of these attacks is that although three of them employed blind bombing technique, the concentration and success achieved, except on the first and smallest, was quite outstanding. Briefly, the attack on 28/29 June disposed of the central city area. On 3/4 June the most important industrial area across the river at Deutz and Kalk was eliminated. On 8/9 July the industrial suburbs and marshalling yards to the north and north-west were largely written off. The details of this achievement are still not completely analysed but nothing would be gained by attempting to set them out. The simple fact is that the third city of the Reich, though a few suburbs and industries survive in the south and south-east, is reduced to a burnt-out shell. Direct industrial damage is very heavy and includes large sections of the Humbolt-Deutz works. Indeed, it is fair to say that German propaganda in its laments for Cologne Cathedral has drawn attention to one of the few buildings of importance in Cologne which has received only minor damage.

THE SUBSIDIARY TOWNS

Wuppertal

Date.	A/C Despatched.	A/C Attacking.	Bomb Tonnage.			A/C Missing.
			H.E.	Incendiaries.	Total.	
29/30 May	719	644	897	997	1,894	33
24/25 June	630	554	824	922	1,746	34

The Wuppertal cities of Barmen and Elberfeld are mainly the homes of light industries complementary to the heavy industry of the Ruhr, and are of great importance in the production of smaller components and consumer goods. Barmen was attacked first and it is known that over 90 per cent. of the fully built-up areas and more than half of the slightly less closely built-up areas are devastated. Many of the factories situated within the built-up area were practically destroyed, and numerous public utilities were severely damaged. On 24/25 June, 630 aircraft were sent to Elberfeld and crews' reports which were entirely confirmed by night plots made it evident that Elberfeld was obliterated. Day cover has since been obtained of both ends of the Wuppertal ruins. Elberfeld is if possible in worse condition than Barmen.

Krefeld

Date.	A/C Despatched.	A/C Attacking.	Bomb Tonnage.			A/C Missing.
			H.E.	Incendiaries.	Total.	
21/22 June	705	661	1,028	1,040	2,068	44

This town, which is an important centre for the production of special steels and textiles, was attacked under favourable weather conditions. Day photographs show that Krefeld has had about 900 acres of fully built-up area out of its 1,100 completely gutted. Reinforcements both for fire and police services are said to have been requested as far afield as Dortmund and Münster. Direct industrial damage was very heavy and included a large number of important factories.

Münster

Date.	A/C Despatched.	A/C Attacking.	Bomb Tonnage.			A/C Missing.
			H.E.	Incendiaries.	Total.	
11/12 June	72	65	127	60	187	5

Münster, which is now of great importance as one of the main transportation centres through which relief can come to the Ruhr, was attacked by a comparatively small force. Both night plots and day cover show that heavy damage was done to both railway stations as well as to railway tracks and the surrounding industrial area. This attack was largely an experiment with improved navigational aids used outside the Ruhr area proper and as such was a great success.

Thus the battle of the Ruhr has demonstrated that the reduction of Germany "City by City" is a practicable possibility. It is for the enemy to decide when the process has gone on long enough.

(b) Attacks on Targets outside the Ruhr and Rhineland

Our plans for the decisive bombing of the Ruhr involved the spreading out of the German flak and fighter defences. This was to some extent practicable during April so that attacks on targets outside the Ruhr and Rhineland were mainly concentrated in this month.

On 4/5 April, a large force of aircraft was despatched against Kiel and a similar force was sent to Frankfurt on 10/11 April. In both cases weather conditions over the target were worse than had been expected and the scattered bombing which resulted caused little material damage.

Stuttgart experienced a heavy raid on 14/15 April, and the Germans got a better idea of what was in prospect from the simultaneous attacks made on Stettin and Rostock on 20/21 April. Although the total force was not very large, Stettin suffered very heavily, both in industrial and residential destruction, while the 77 aircraft which attacked Rostock produced considerable results. A successful attack was carried out on 16/17 April against Mannheim by a comparatively small force operating primarily to divert attention from an attack on the Skoda works at Pilsen. The latter which had gained an added importance as a result of our earlier attacks on Krupps, unfortunately escaped almost unscathed from this and also the repeat attack in June. This run of luck, due largely to unexpected cloud conditions, is unlikely to continue indefinitely. The Italian port of Spezia, on the other hand, was severely dealt with on two occasions. April was thus rather mixed as regards both targets and successes.

Only twice during May and June did any considerable bomber force attack targets outside the Ruhr. Le Creusot, which was reported to have recuperated to a considerable extent from the daylight attack in October, 1942, was again put out by a heavy blow on 19/20 June. On the next night, a formation of Lancasters visited North Africa, successfully attacking Friedrichshafen on the way there and Spezia on the return journey, both without loss. Berlin underwent a series of nuisance raids and was attacked 12 times by Mosquitoes.

As with the results of the raids on the Ruhr, it would be impracticable to give a detailed account of the damage done to these targets outside the Ruhr and Rhineland. It is, therefore, only possible to give a summary of the more important targets attacked and results achieved.

ATTACKS AND RESULTS ACHIEVED

GERMANY AND CZECHO-SLOVAKIA

Stuttgart

Date.	A/C Despatched.	A/C Attacking.	Bomb Tonnage.			A/C Missing.
			H.E.	Incendiaries.	Total.	
14/15 April	462	393	350	451	801	23

In good weather conditions an excellent concentration was achieved after the target had been located and accurately marked by the P.F.F. First reports gave the impression that the attack had devastated the central built-up area which had been the objective. This, however, was incorrect. Night plots showed that the main force had moved away slightly from the aiming point and the weight of the attack therefore fell on the industrial suburbs to the north and north-east. This was confirmed by day cover which showed a high proportion of serious industrial damage. The most effective damage from the point of view of the German war effort was that done to the ball-bearing factory V.K.F. Norma at Bad Cannstadt. This is second in importance only to Schweinfurt and it is well known that ball-bearings are a critical point in German production. Photographs show several hits on the factory and it is reported that damage to the extent of £300,000 was done there.

In all, some 40 industrial undertakings in Stuttgart were hit and the generator at the power station was gutted.

Housing damage was less serious, and much remains to be done in this direction.

The attack was another instance of what had previously been experienced at Berlin, Nuremburg and Munich, namely, the great effectiveness of a heavy attack in doing serious damage to the industrial fringe of a large city when the main concentration is slightly off the selected aiming point.

Pilsen

Date.	A/C Despatched.	A/C Attacking.	Bomb Tonnage.			A/C Missing.
			H.E.	Incendiaries.	Total.	
16/17 April	327	285	470	147	617	37
13/14 May	168	150	520	7	527	9

U.S.A.A.F. JOIN IN THE RUHR BATTLE



FIG. 7.—The Synthetic Rubber Works at HÜLS has been out of action ever since the very successful U.S.A.A.F. daylight attack on 22 June. Arrows indicate three bursts on the overhead pipeline, followed by fires.

- (A) A huge volume of smoke and steam rising about 7,500 ft. from the main power station and cooling plant, merging with a cloud formation over the target. (See inset view.)
- (B) Numerous bursts on the east railway sidings. (C) Bombs falling towards target. (F) Flak positions, one of which has just fired. Circles indicate part of the ineffective balloon barrage, far below the Fortresses.

FIRST ATTACK ON WUPPERTAL



FIG. 8.—On 29/30 May, BARMEN—the eastern half of WUPPERTAL—suffered damage extending to about 1,000 acres. About four weeks later ELBERFELD, the remaining half of the combined city, experienced a similar fate. Among the damaged buildings in the area shown above are :—

- (A) Vorwerk & Co., manufacturers of light machinery.
- (B) The Town Hall, Barmen.
- (C) The Power Station.
- (D) A station on the overhead (mono-rail) railway.

ATTACKS ON TWO IMPORTANT STEELWORKS

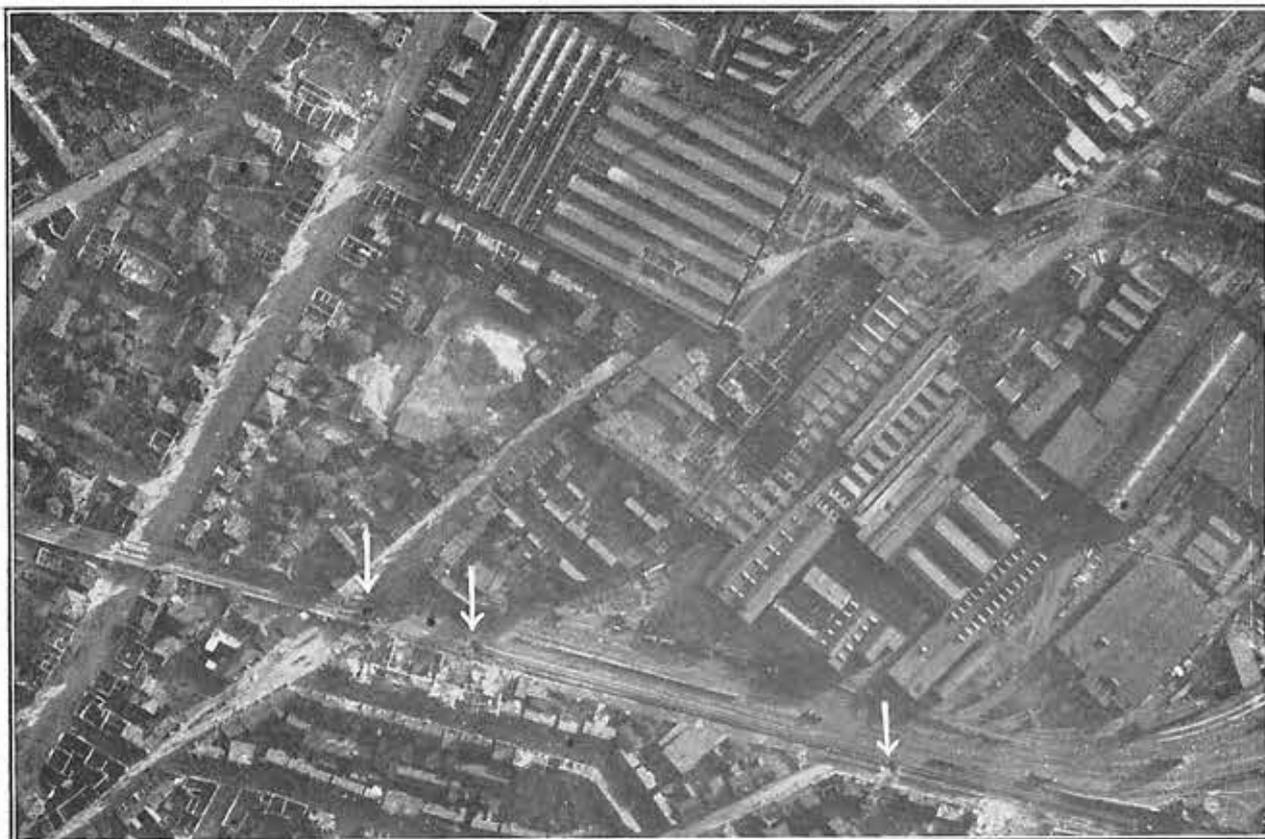


FIG. 9.—Nine main buildings in the first-priority "Gussstahlfabrik" at BOCHUM were extensively damaged on 13/14 May. This branch of the Vereinigte Stahlwerke is one of the enemy's chief sources of high-grade steel for aircraft and aero-engines, and also produces gun-barrels, complete artillery, armour-plate, and naval gun-turrets and mountings. This figure shows the finishing section of the plant, with three large workshops gutted over a considerable area. The rolling mill and steel furnaces (not shown) were also damaged. Arrows mark direct hits blocking the main railway line, the collapse of one side of a railway bridge, and serious damage to the other side.



FIG. 10.—The start of the night attack on the LE CREUSOT Steel Works on 19/20 June. Bombs (*left*) are falling towards the Armament and Locomotive Sections. An arrow indicates an H.E. burst on the shop for autogenous welding, which was seriously damaged. The light tracks are those of flares over the target, and at the lower edge of the print can be seen the puff of a photo-flash. Note the patched roofs indicating repairs effected since the Lancasters' daylight raid. Most of these buildings were again hit during the night raid.

FRIEDRICHSHAFEN

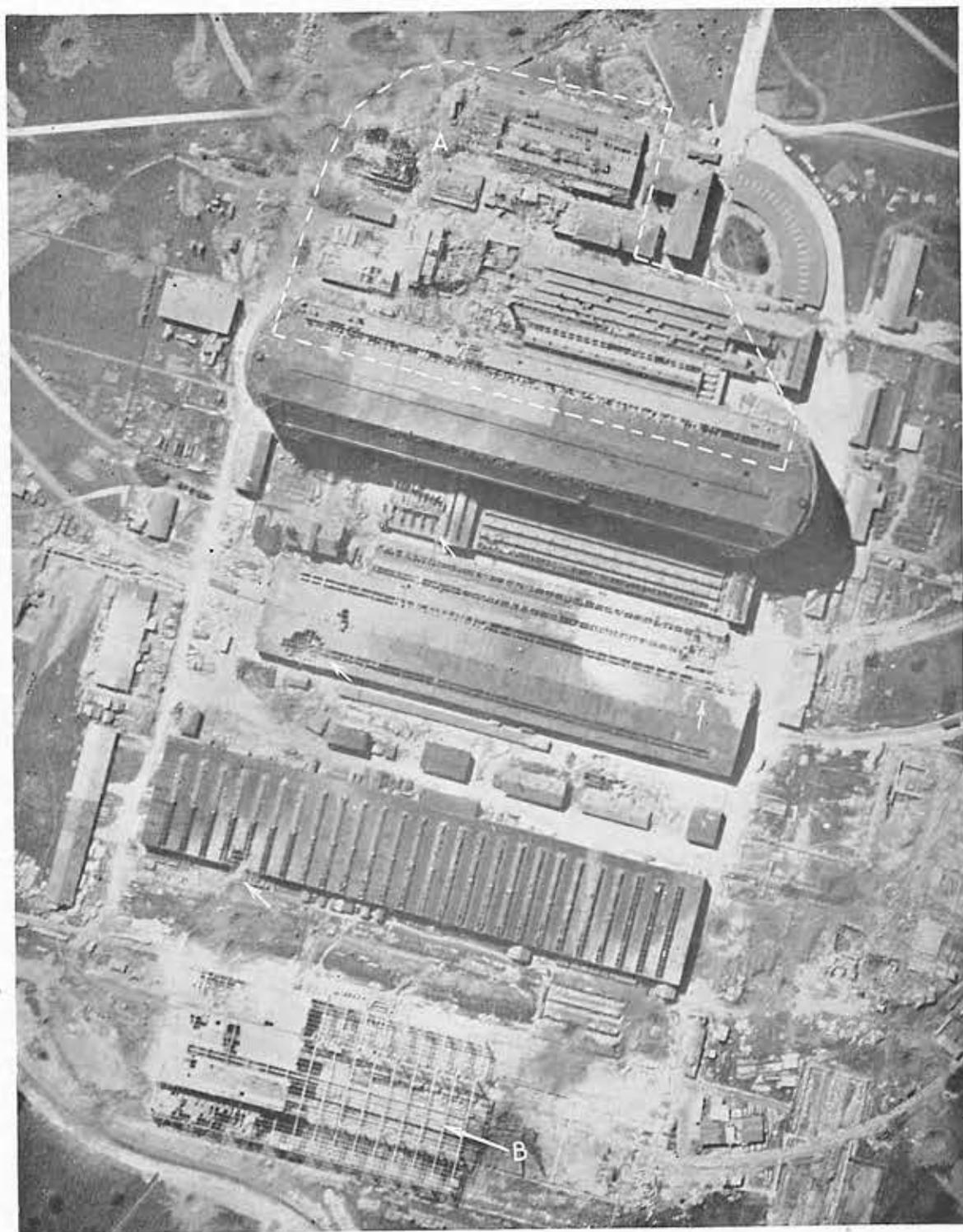


FIG. 11.—The former Zeppelin Works, making radiolocation apparatus and acoustic and magnetic mines, had all its large workshops damaged in the Lancasters' first "shuttle" raid on 20/21 June. The south wall of the 975-ft. hangar was blown out over half the length of the building. An adjoining area of the works (A) of about 3 acres was very heavily damaged. Direct hits and near misses affected nearly all the other buildings, including that under construction (B).

The damage and dislocation produced by attacks against Essen on the armaments production of Krupps automatically enhanced the value of Skoda at Pilsen and to a lesser extent that of Schneider at Le Creusot.

The distance of Pilsen from home bases and its comparatively small size made it an extremely difficult target to locate and attack successfully. For these reasons, and also to reduce to a minimum the risk of heavy casualties to the civilian population, it was necessary to make the attack in conditions of full moon in spite of the advantages thus given to the enemy fighter defences. To offset these to some extent, diversionary attacks were carried out against Mannheim on 16/17 April, and Bochum on 13/14 May.

The first attack on Pilsen was unlucky. Unexpected cloud conditions over the target handicapped the P.F.F. with the result that a number of markers were placed on the small town of Dobrany, south-west of Pilsen, and this town, which had the misfortune to resemble superficially Pilsen and the Skoda works, thus received most of the attack by the main force.

The second attack also achieved no substantial results. On this occasion a number of night photographs were plotted on the aiming point, but the main concentration, which was outstandingly good, again missed the target, this time by a small margin.

It is not to be expected that the same degree of accuracy can be obtained even with navigational aids against very distant targets as against objectives in the Ruhr and Rhineland, but both the Pilsen attacks were quite near enough to success to demonstrate that better fortune combined with the added experience now gained will suffice to make the elimination of Skoda practicable in the future, in spite of the disappointing results achieved hitherto.

Mannheim

Date.	A/C Despatched.	A/C Attacking.	Bomb Tonnage.			A/C Missing.
			H.E.	Incendiaries.	Total.	
16/17 April	271	225	258	103	361	18

Although this raid was primarily designed to support the Lancasters in their attack on Pilsen, it achieved highly satisfactory results. The target was accurately identified and marked by the P.F.F. Large fires were started and subsequent photographs showed that considerable damage had been done. Large scale devastation was not to be expected, but a number of hits were scored on the workshops of I.G. Farben, mostly in the area which is reported to be devoted to synthetic oil production. The works of Joseph Voegelé A.G., which produce components for tanks and tractors, suffered devastation over 5½ acres. Heavy and valuable damage was also done to sheds and warehouses in the docks area, thus adding considerably to the general dislocation of Rhine transport and contributing to the much greater destruction lower down the river at Duisburg, Düsseldorf, and Cologne.

Stettin and Rostock

Date.	Target.	A/C Despatched.	A/C Attacking.	Bomb Tonnage.			A/C Missing.
				H.E.	Incendiaries.	Total.	
20/21 April ..	Stettin ..	339	326	415	433	848	22
	Rostock ..	86	77	41	92	133	8
	Berlin ..	11	10	9	—	9	1

Stettin is Germany's main port in the Baltic and has especial importance as the main channel for supplies proceeding to the northern sector of the Eastern Front. No successful attack had previously been made on it, and this fact no doubt contributed to the success which the moderate force of Lancasters sent to attack it was able to achieve. Weather conditions were satisfactory, and the diversionary attack on Berlin was highly successful in producing the effect desired—which was to lead the enemy defences to expect an attack on the capital by the Main Force. In consequence, Stettin was left to handle the situation as best it could, and the local fire-fighting organization proved quite inadequate to deal with it. First attempts to get day photographs were largely unsuccessful because the town was still covered by clouds of smoke. Later, however, it became evident that the southern sector, which included nearly all the important industrial undertakings, had been virtually wiped out. Over 100 acres of closely packed industrial buildings in the Pommerensdorf area were completely devastated. Shipyards, the naval base, the barracks and the artillery magazine all suffered extensive damage. Public buildings and utilities as well as residential property were destroyed on a large scale. The administrative authorities seem to have been quite unequal to the strain, which was increased by failure of the water supply. It is clear from the local press that nothing approaching normal conditions obtained for some weeks after the attack, and it is fair to assume that the result on supplies to the Russian front must have been very serious. Matters were made considerably worse by the big mining effort, which is dealt with later in this *Review*.

The Rostock attack was also highly successful considering its small scale. Many fires were still burning on the following day and although naturally no large areas of devastation were seen, considerable damage was done to the central built-up area and to the ship-building yard Neptun Werft, which produces submarines, minesweepers and motor torpedo boats.

The success of these attacks against relatively inefficient A.R.P. defences indicates the tremendous amount of labour and organisational work which has to be diverted to such defences in the attempt to keep down the damage done by really heavy attacks on more vital objectives in the Ruhr and Rhineland.

Friedrichshafen

Date.	A/C Despatched.	A/C Attacking.	Bomb Tonnage.			A/C Missing.
			H.E.	Incendiaries.	Total.	
20/21 June	60	59	155	20	175	Nil

This attack, carried out by a small force in bright moonlight without loss did valuable damage. Day photographs show 3 acres of devastation in the Zeppelin works which now produces R.D.F. equipment. It is reported that substantial quantities of stores were wrecked and that almost half the equipment of the factory was destroyed.

Damage, though on a smaller scale, was also done to the Maybach motor works which produce Diesel and internal combustion engines.

An important subsidiary aim of the attack was to encourage a feeling of insecurity in the "safe" areas of Germany, and thus increase the reluctance of the inhabitants to accept any reduction in their own flak defences for the benefit of more vulnerable targets.

ITALY

Spezia

Date.	A/C Despatched.	A/C Attacking.	Bomb Tonnage.			A/C Missing.
			H.E.	Incendiaries.	Total.	
13/14 April	211	193	404	101	505	4
18/19 April	178	164	325	108	433	1
23/24 June	52	49	106	14	120	Nil

The attacks on Spezia, the most important Italian naval base with every facility for building and docking large warships, were, of course, connected with more general naval and military operations in the Mediterranean. Three "Littorio" class battleships and other smaller naval units have been located there for some time. The primary aim, however, was not to hit these, but to destroy, as far as possible, the port and repair facilities of the base. Both the April attacks achieved considerable success inexpensively, in spite of a smoke screen covering the port area and of incidental confusion caused by forest fires started in the surrounding hills. The first attack caused severe damage in the port and town. Five acres of storehouses at one of the docks were completely gutted. Both the infantry and artillery barracks were badly hit and damage to house property was on a considerable scale in view of the comparatively small size of the target.

The second attack produced even better results. The torpedo workshop, believed to be the second largest in Italy, and the shipbuilding shop were badly damaged by H.E. The electricity workshop was still burning on the day after the attack, the fitter's shop and boiler shop were both damaged and further hits were registered on the artillery and naval barracks.

A 2,000-ton destroyer of the most modern type was sunk in the course of this attack, a very serious loss to the enemy in view of the depleted condition of the Italian destroyer strength.

The third attack in June was not on a sufficiently large scale to add much to the damage caused by these and subsequent attacks by U.S. aircraft from N. Africa. It was, however, delivered without loss by the Lancasters returning from N. Africa after the attack on Friedrichshafen and no doubt added to the prevailing gloom and despondency of the Italian population.

During the first six months of 1943 a total of 779 aircraft were despatched against Italian targets for the loss of only eight aircraft.

FRANCE

Le Creusot and Montchanin

Date.	Target.	A/C Despatched.	A/C Attacking.	Bomb Tonnage.			A/C Missing.
				H.E.	Incendiaries.	Total.	
19/20 June ..	Le Creusot	287	273	701	50	751	2
		29	29	104	3	107	Nil

Le Creusot was known to have been heavily restored since the daylight attack on 17th October, 1942, and to have again become an important element in Germany's diminished armaments production. This renewed attack successfully destroyed seven buildings in the steel and processing works, severely damaged four more and affected a further seven in various degrees. Included in these are the steel

foundry and the building containing the electric furnaces. In the locomotive and armament section of the Works, 31 buildings have been hit.

At Montchanin, the main building of Henri Paul et Cie has been seriously damaged. Photographs do not reveal any direct damage to the transformer station. There is, however, reason to believe that it was considerably affected by the attack, though details are not known. Although these important targets have now been roughly treated on two occasions, it would be premature to claim that they are written off. Strenuous efforts will no doubt be made to restore as much as possible of Le Creusot to production as quickly as possible, especially in view of the urgent need to maintain the production both of armaments and locomotives in spite of the disasters which have overtaken the Ruhr and Rhineland.

(c) Minelaying

During the quarter 1 April to 30 June, 1943, minelaying operations were carried out on a very large scale and many records have been substantially exceeded. The following table shows the extent of the effort made :—

	<i>Records for Quarter under Review.</i>	<i>Previous Records.</i>
Number of mines laid during one quarter	4,191	3,574
Number of miles flown during one quarter	1,367,135	1,204,161
Number of mines laid in Baltic areas during one quarter ..	573	535
Number of mines laid off French West Coast during one Quarter	2,079	1,345
Number of mines laid during one month	1,869	1,285
Number of mines laid by one Bomber Group during one month	726	563
Number of mines laid during one night	593	346

The general purpose of this large scale minelaying was identical with that of our previous operations though the extent of it was considerably greater. It may be summarised thus :—

- (i) To cause serious embarrassment and dislocation to the enemy's vital seaborne traffic, especially in regard to raw materials for the Ruhr and military supplies either for the Russian Front or for the Norwegian theatre of occupation.
- (ii) To assist the Battle of the Atlantic by interrupting the passages of U-Boats leaving or entering the French West Coast bases, and by rendering the Baltic U-Boat training areas unsafe.
- (iii) To interfere with the arrivals and departures of Blockade Runners, Armed Merchant Raiders, iron ore ships and sundry traffic using the Gironde River or other Atlantic ports.
- (iv) To force the enemy to maintain numbers of experienced personnel and much valuable material for the purpose of sweeping his widely spread harbours and channels.

Two consecutive nights in particular are indeed noteworthy in the history of minelaying by aircraft. On the 27/28 April, 160 aircraft laid 458 mines in areas along the French West Coast and Frisian Islands. On 28/29 April, 226 aircraft laid 593 mines in the Heligoland Bight, off the Norwegian coast, in the Kattegat and Baltic approaches, and in channels off Baltic ports from Kiel to the Gulf of Danzig.

In less than 48 hours, 386 aircraft had laid 1,051 mines from the Spanish Frontier to the Gulf of Danzig.

Although it was intended that the effects of this extensive minelaying should be widespread, the main enemy routes along the Frisian Islands and in the Baltic received particular attention. By mining these waters thoroughly, the effort became co-ordinated with the Battle of the Ruhr and with the devastating attack on Stettin of 20/21 April. It was appreciated that repercussions of the mining would certainly delay shipments of war materials to the much distressed industries of the Ruhr ; while in the Baltic, in conjunction with the destruction at Stettin, a direct effect would become exercised upon the transportation of military supplies to the Russian Front.

In spite of his greatly increased minesweeping fleet, there is every reason to believe that the casualties inflicted upon enemy shipping by mines laid from aircraft of Bomber Command continue to be most satisfactory.

The outstanding casualty for this quarter was the modern German liner "Gneisenau" of 18,200 tons. This valuable ship was being used as a transport between Germany and the Russian Front. On 2 May, she detonated a mine in the Cadet Channel to the south of the Sound, and became a total loss.

Other known casualties are :—

M/V (150 tons)	Sunk.
"Malmö"—train ferry	Damaged.
Two salvage vessels	Sunk.
Two tugs	Sunk.
Three minesweepers	Sunk.
German naval auxiliary	Sunk.
M/V (150 tons)	Sunk.
M/V (225 tons)	Sunk.
Minesweeper	Damaged.
M/V (1,200 tons)	Sunk.

II. FLYING INCIDENTS

(a) Encounters with Night Fighters

The people of Western Germany, in spite of vigorous propaganda to the contrary, have no genuine cause for satisfaction with or confidence in the performance of the Reich defences. Yet the failure of the Flak artillery and night fighter squadrons to prevent the destruction of German industrial cities is due neither to inefficiency nor to inadequate strength. On the contrary the enemy High Command have gradually built up a truly formidable defensive front against Allied air attacks, and it is only because our own tactics and equipment have developed at least as fast that we can continue to operate successfully and on a larger scale than before.

The superior performance of the current bomber types and their equipment, and the superior training of our air crews, coupled with advances in air-fighting technique, enabled our aircraft to counter bitter opposition from controlled night fighters, of which Goering entertained the highest expectations. In spite of the deepening of the controlled-fighter zone, which now extends in a solid belt from the Ruhr to the Dutch and Belgian coasts, our losses during the past quarter show no appreciable increase as compared with last year. Indeed, they show a slight reduction as far as bombing raids on German targets are concerned. Reports from air crews indicate that night fighters frequently give up the attack without firing a shot if they see the bomber has discovered them. It is very seldom that a crew which carries out the correct defensive manœuvres comes off worst. During the April-June quarter some 50 night fighters were driven off in a seriously damaged condition, while 55 are considered to have been completely destroyed. The following are given as contrasting examples of encounters with night fighters during that period:—

A Wellington Destroys Two Me.110 Fighters.—A Wellington X ("T" of 431 Squadron) returning from the raid on Stuttgart on the night of 14th/15th April, observed a square of four white lights on the ground some 60 miles north-west of the target. These lights, which were slightly to starboard, changed to a single line of white lights when the Wellington had passed, as if indicating its track. The moon was on the port bow at the time, and visibility was good; our aircraft was flying at 10,000 ft. Presently the wireless operator, who was in the astrodome, reported an Me.110 at about 400 yards range on the starboard quarter. As the bomber turned in towards the attack the rear-gunner fired a short burst. The enemy broke away immediately without firing and, passing underneath, came in again on the port quarter below, fired a short burst at 400 yards and broke away to port. He came in again, level on the port quarter, opening fire at 300 yards. Meanwhile our aircraft was "corkscrewing," but the rear-gunner was able to reply with an accurate short burst, hitting the Messerschmitt in the nose. This was followed by a longer burst which caused the fighter to explode with a brilliant flash.

The rear-gunner and wireless-operator were temporarily blinded by the flash. The latter left the astrodome to replace intercommunication leads to the rear-turret which had become fouled by a loose parachute during the evasive action. His place was taken by the bomb-aimer.

Meanwhile, a second Me.110 attacked from astern and underneath, fired a short burst which missed, and broke away to starboard. As the intercommunication was unserviceable the rear-gunner signalled these attacks to the pilot by means of the call light. The enemy came in again on the starboard quarter but broke off without firing at 200 yards when the rear-gunner gave him a short burst. The Wellington was now flying at a very low level as the pilot had dived repeatedly to avoid attacks from below. But the Messerschmitt attacked once more, on the port quarter above, firing a long burst which passed over our aircraft. At 200 yards range the rear-gunner fired and hits were seen on the Hun's starboard engine. As he passed overhead flames were coming from the nacelle of his engine, the aircraft turned on its back and disappeared behind some trees. In view of the extremely low altitude there is little doubt that this aircraft also was destroyed as a result of the rear-gunner's skilful performance. There was slight damage to the Wellington's port wing, while the crew were unscathed.

An Eventful Mission.—Another aircraft of the same squadron engaged on the same operation successfully drove off two Ju.88s and, but for some further complications, would doubtless have returned undamaged. As things turned out the whole crew eventually returned safely after baling out over neutral territory.

About 25 minutes after crossing the French coast the Wellington's constant speed unit became unserviceable. The propeller speed remained at 2,050 r.p.m. and it was decided to continue with the flight, which was uneventful until about 20 minutes before the aircraft was due to bomb.

Then, in bright moonlight, the rear-gunner sighted two Ju.88s following, one on either quarter. That on the starboard quarter closed in and the rear-gunner instructed the pilot to turn to starboard and lose height. As the crew had practised such manœuvres many times the plan was immediately carried out. The fighter on the port quarter then came in with guns firing and a running fight developed. The Wellington's rear-gunner was expecting this attack. He scored hits on the enemy's starboard engine which caught fire and emitted smoke and flames. The wireless-operator also saw the flames from his position in the astrodome as the enemy broke away. That was the end of the combat and the Wellington proceeded to the target area. The only damage it had sustained during the attack affected the starboard elevator, which was partially stripped of its fabric with the result that the aircraft became sluggish on the controls.

The next incident occurred over the outer defences of the target about 5 minutes before bombing. The Wellington was flying a gently weaving course at 16,500 ft. when the port wing was suddenly thrown up by a flak burst close under it. So violent was the bump that the navigator's instruments shot up from his table. The port engine was damaged, boost and revs fell, but as the propeller could not be feathered it continued its windmill at 1,700-1,800 revs. The aircraft went into a spiral dive, and the crew prepared to abandon it. The pilot managed to regain control after losing 4,000 ft., although the port engine refused to pick up. The Wellington then headed for the target and bombed it from about 12,000 ft.

Their mission achieved, the crew were confronted by a succession of troubles. The rear turret was found to be unserviceable. The bomb doors would not close under power so the pilot pumped them shut by hand. When the navigator checked the petrol gauges the port ones showed zero, the starboard 150 galls. The air-bomber, who was a qualified pilot's assistant, tried manipulating the balance cocks again but without effect on the port engine. This still failed to pick up even when the port nacelle tank was turned on and the starboard main tanks off, although oil temperatures and pressures were about normal. Nevertheless the aircraft was flying reasonably well on the starboard engine and, as it was impossible to fly back to England, a south-westerly course was set for Switzerland.

Soon the starboard engine began to lose power. At length Swiss territory was reached and, after all possible measures had been taken to improve the performance of the remaining engine, the crew prepared for the second time to abandon their aircraft. As rotation of the rear turret reduced the airspeed still further, the gunner locked it and came forward. The navigator and wireless-operator detonated their special equipment. Then the whole crew baled out from a height between 5,000 to 6,000 ft.

The pilot was the last to leave the aircraft and by then flames were coming from the starboard engine and wing. About 20 minutes later the navigator saw the Wellington burning on the ground with ammunition exploding. Meanwhile the pilot had successfully completed a difficult descent: his parachute failed to open when he pulled the rip-cord—it came away in his hand. He managed to pull out the parachute by hand and made a good landing on the roof of a house. An unfriendly dog was successfully evaded and, apart from one ankle injured on landing, all five members of the crew came down unharmed on the right side of the frontier.

Successful Evasive Action.—A good instance of the value of well-timed evasive action occurred during the attack on Krefeld on 21/22 June. The rear-gunner of Halifax "R" of 51 Squadron was on his first operational sortie. Just before reaching the target area special signals gave warning of an approaching aircraft. This proved to be a F.W.190, which came in to attack but made off without firing when the rear-gunner opened fire at 600 yards range.

Twelve minutes later, after leaving the target, another F.W.190 was sighted 500 yards away on starboard quarter. The rear-gunner at once opened fire while the Halifax turned in towards the direction of attack. After a repetition of this manoeuvre on the port quarter the enemy desisted without firing.

The third fighter, encountered twenty minutes later, was most determined. This was a Ju.88 and was first sighted about 1,000 yards away on the port quarter bearing a bright light in the nose. It passed astern of the Halifax and came in on the starboard quarter. The Halifax turned to starboard, at 400 yards both rear and mid-upper gunners fired, and the enemy broke away. During nine subsequent attempts on the part of the fighter the rear and mid-upper gunners opened fire at the same time as the Halifax "corkscrewed" or turned in towards the attack. On no occasion did the enemy have a chance to fire and after his tenth attempt he disappeared. The rear-gunner gave the orders for evasive action and remained throughout complete master of the situation. The Halifax returned to base without damage of any kind.

Encounters at a Disadvantage.—A Halifax Ia of No. 10 Squadron, detailed to attack the Le Creusot Steel Works on the night of 19/20 June, experienced engine trouble before reaching the target and had to abandon its mission. The aircraft had just turned for base, with port-outer engine feathered, bomb doors open and part of its load jettisoned in the sea, when the rear-gunner sighted a Me.109. The fighter was above our aircraft, on fine starboard quarter, about 300 yards range and coming in on curve of pursuit attack. The Halifax rear-gunner gave instructions for evasive action and as the bomber began to corkscrew to starboard opened fire with a 4-second burst. Strikes were observed on the engine and fuselage of the enemy aircraft, which attempted unsuccessfully to follow the Halifax's manoeuvre and no return fire was experienced. The mid-upper gunner then opened up with a 3-second burst and further strikes were scored on the fighter from nose to tail. At this stage the rear-gunner experienced stoppages in three of his guns and he instructed the mid-upper gunner to watch the fighter. The latter broke away below the tail of the Halifax, climbed above and closed in again on the port quarter. As the mid-upper gunner fired a long burst the fighter again broke away below and the rear-gunner, having cleared all but one of his guns, got in a long burst of 5 or 6 seconds. This decided the issue and four members of the crew saw the Me.109 diving seawards at a steep angle. About 1½ minutes later it exploded on impact with the water and burned for several minutes.

Since the Halifax was encountered at a serious disadvantage, and excellent visibility and full moonlight also favoured the enemy, the destruction of the latter was a very creditable performance. No return fire was experienced at any stage in the combat.

"P" of 77 Squadron (a Halifax II) was hit by flak immediately after bombing Mülheim on the night of 22/23 June. The port-inner and starboard-outer engines caught fire and both became unserviceable. By the time the Halifax crossed the Dutch coast it was still flying on two engines at a height of about 2,000 ft. Then it was attacked by an Me.110. The mid-upper guns and ammunition, and all radio aids, had been jettisoned in order to maintain height.

The fighter was first seen by the rear-gunner on the same heading 800 ft. below. It disappeared beneath the Halifax but was then sighted by the bomb-aimer through the under blister. The Messerschmitt pulled up sharply and fired a burst which put the rear-turret intercommunication out of action and also damaged the ammunition tracks and call-lights system. The pilot executed a slight diving turn—all that was possible in the crippled state of the bomber. As the fighter came into view the rear-gunner fired two short bursts which caused it to break away to starboard.

The second attack came from 600 yards astern, while the rear-gunner was remedying stoppages on all guns. By the time the enemy opened fire at 400 yards range the rear-gunner had his guns working again and a short burst forced the Hun to break away below.

The bomber was now down to 1,000 ft. and the fighter came in once more. He fired from 400 yards astern and well below the Halifax, but the rear-gunner replied with a long burst from two guns, the others having sustained stoppages owing to the damage to ammunition tracks. An explosion was seen inside the fighter and it swerved to the starboard quarter. The rear-gunner kept firing as the enemy plane swerved back astern until it went down out of control and hit the sea in flames. This was seen by several other members of the crew.

In spite of damage caused in combat with the Me.110 and by flak over the target the Halifax crew suffered no injuries and brought their aircraft back to this country.

The End of a Searchlight Fighter.—On route for Düsseldorf on 25/26 May a Lancaster of 106 Squadron sighted a Ju.88, 350 yards on the port quarter. Immediately after sighting, the enemy switched on a searchlight in the nose of his aircraft.

As the Lancaster pilot glanced back at the light he instinctively turned his aircraft to port and at the same time the mid-upper gunner fired a 3 sec. burst. The searchlight went out, and a red glow was seen to develop inside the fighter's cockpit. The rear gunner did not fire as he was maintaining search to starboard. Eventually the fighter burst into flames and both gunners saw it go down and hit the ground.

There was no moon at the time of this engagement but visibility was good. The Lancaster proceeded to bomb the target.

(b) Daylight Attacks on U-Boats

Bomber Command Whitleys of 10 O.T.U. assisted in the rout of the enemy's spring offensive in the Atlantic. Between the beginning of April and the end of June they operated on 80 out of 91 days, and attacked with depth-charges a total of 29 U-Boats. Two of these attacks are of special interest.

On the afternoon of 14 June, "P," of 10 O.T.U. was flying at 5,000 ft. through 3/10 cumulus cloud, with base at 2,500 ft. Visibility was about 5 or 6 miles and the sea was moderate when the bomb-aimer sighted the wake of two U-Boats in line abreast about $3\frac{1}{2}$ miles dead ahead. A moment later the wake of a third U-Boat was sighted about a mile away from the others on their port quarter. The pilot decided to attack the straggler, which was a mile nearer the Whitley, but headed as a feint towards the pair of U-Boats. He lost height rapidly, "weaving" to evade the light flak which all three submarines put up at him. When little more than half a mile from the pair, with the straggler about the same distance on the starboard beam, he swung sharply in that direction and tracked across the U-Boat from the port beam well forward of the conning-tower. Six depth-charges with true spacing of 90 ft. were released accurately from 50-100 ft. and straddled the U-Boat, three falling on either side. (See photographs, Figs. 12-13.) While the plumes of the explosions rose apparently dead abeam of the conning-tower the Whitley turned to port, heading between the attacked U-Boat and its consorts, which continued firing until out of range. When the plumes had subsided the U-Boat emerged from the depth-charge pool, and began to circle tightly to starboard at a reduced speed. As the Whitley had already reached the prudent limit of endurance the captain set course for base 12 minutes after the attack, leaving the U-Boat still circling aimlessly beside the depth-charge pool on the surface. It had evidently sustained serious damage. The pilot had joined his detachment only a month before and this was his first attack on a U-Boat, carried out with perfect accuracy in the face of intense opposition.

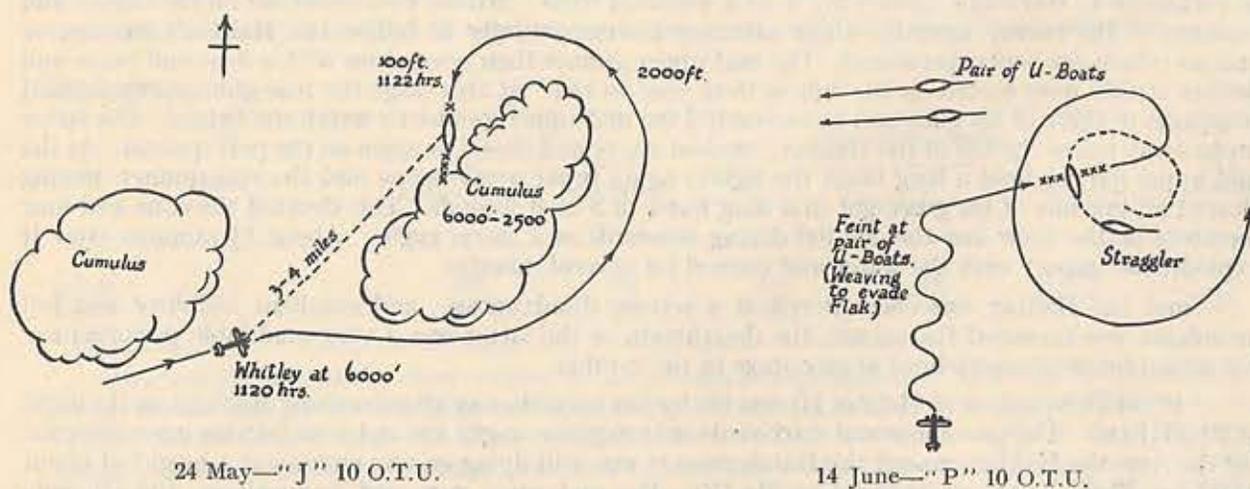
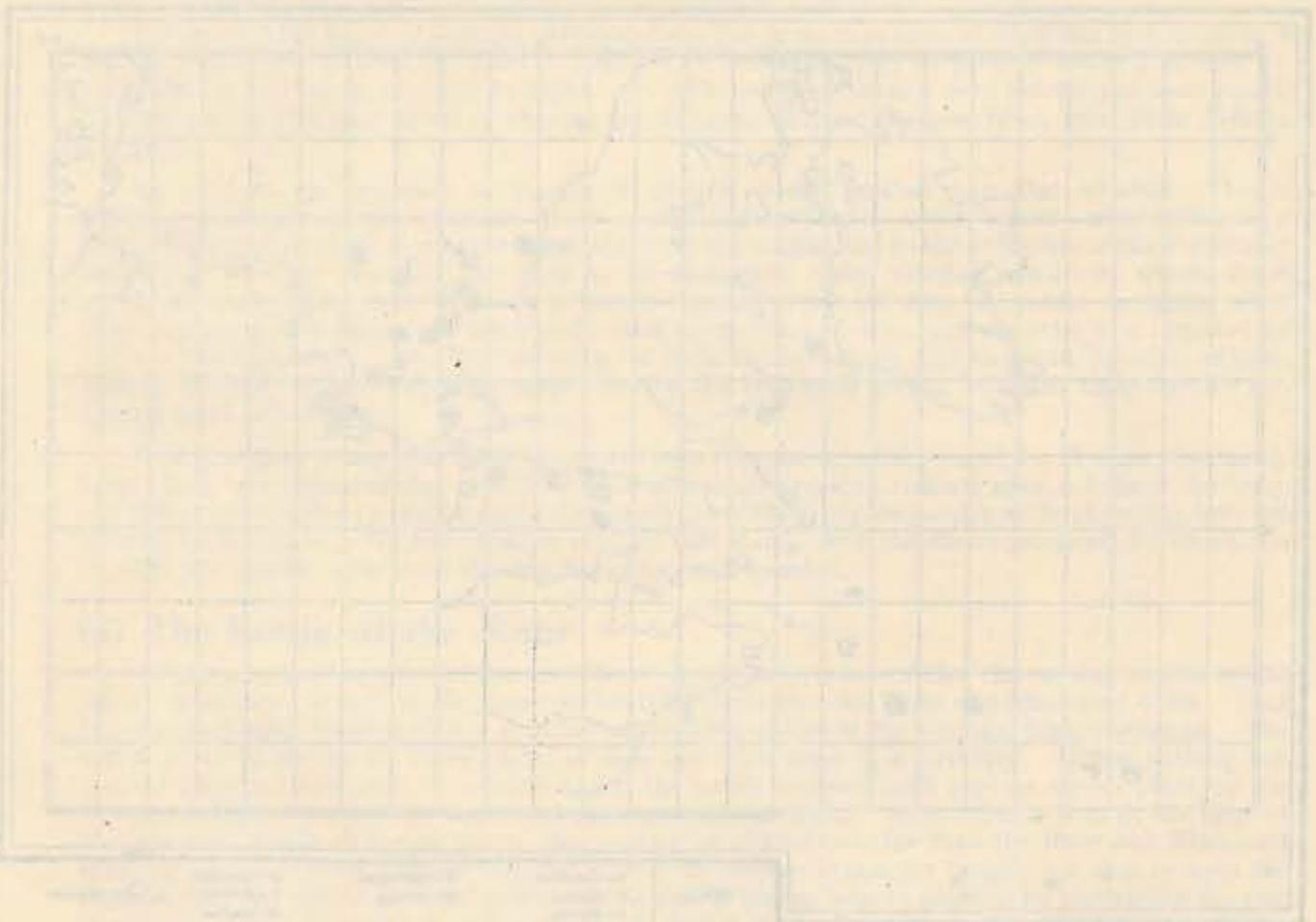


DIAGRAM OF ATTACKS ON U-BOATS.

Another Whitley on anti-submarine patrol on 24 May carried out a particularly skilful attack, the second by this crew on successive sorties.

Flying at 6,000 ft. between cumulus clouds with bases at about 2,500 ft., the captain (who was at the controls) sighted a marked wake 3 or 4 miles away on the port bow. This was seen to proceed from a fully surfaced U-Boat travelling at a considerable speed, the wake being several times the length of the vessel. The captain continued on course thus placing a bank of cumulus between the aircraft and the U-Boat, and also getting up-sun. Losing height rapidly in a wide turn to port the Whitley emerged from behind the cloud-screen at 2,000 ft. and not more than a mile away on the port quarter of the submarine. Complete surprise was achieved and, within 2 minutes of the first sighting, six depth-charges were released from a height of 100 ft. The rear-gunner saw the first explode immediately astern of the U-Boat, which was momentarily silhouetted against the plume before being obscured by four other explosions ahead of the vessel and directly on track.

When the depth-charge plumes subsided the U-Boat was seen stationary on the surface before it practically disappeared on a level keel. Then the stern rose into the air at a very steep angle, hung for 7 or 8 seconds, and slid gradually from view without apparent forward movement. Markers were released and baiting tactics carried out, but nothing more was seen of the U-Boat or its crew.



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III. MISCELLANEOUS ITEMS OF OPERATIONAL INTEREST

(a) The Success of Air/Sea Rescue

Although the organisation of the Air/Sea Rescue Service is primarily the concern of Fighter and Coastal Commands, its work and achievements are of very real importance to Bomber Command personnel. Already well over 2,000 lives have been saved in Home Waters alone since the establishment of A.S.R. in February, 1941, and bomber crews constitute a substantial part of this total. During the first half of 1943 some 606 airmen were saved, of whom 151 belonged to this Command. Many of these were saved by operational aircraft of Bomber Command engaged in backing up the official search organisation. The latter is not large enough to deal with every possible contingency without temporary reinforcements: hence bomber crews are required to be familiar with two aspects of A.S.R.—how to carry out search operations to rescue others, and how to give themselves the best possible chance to be rescued should they happen to come down at sea.

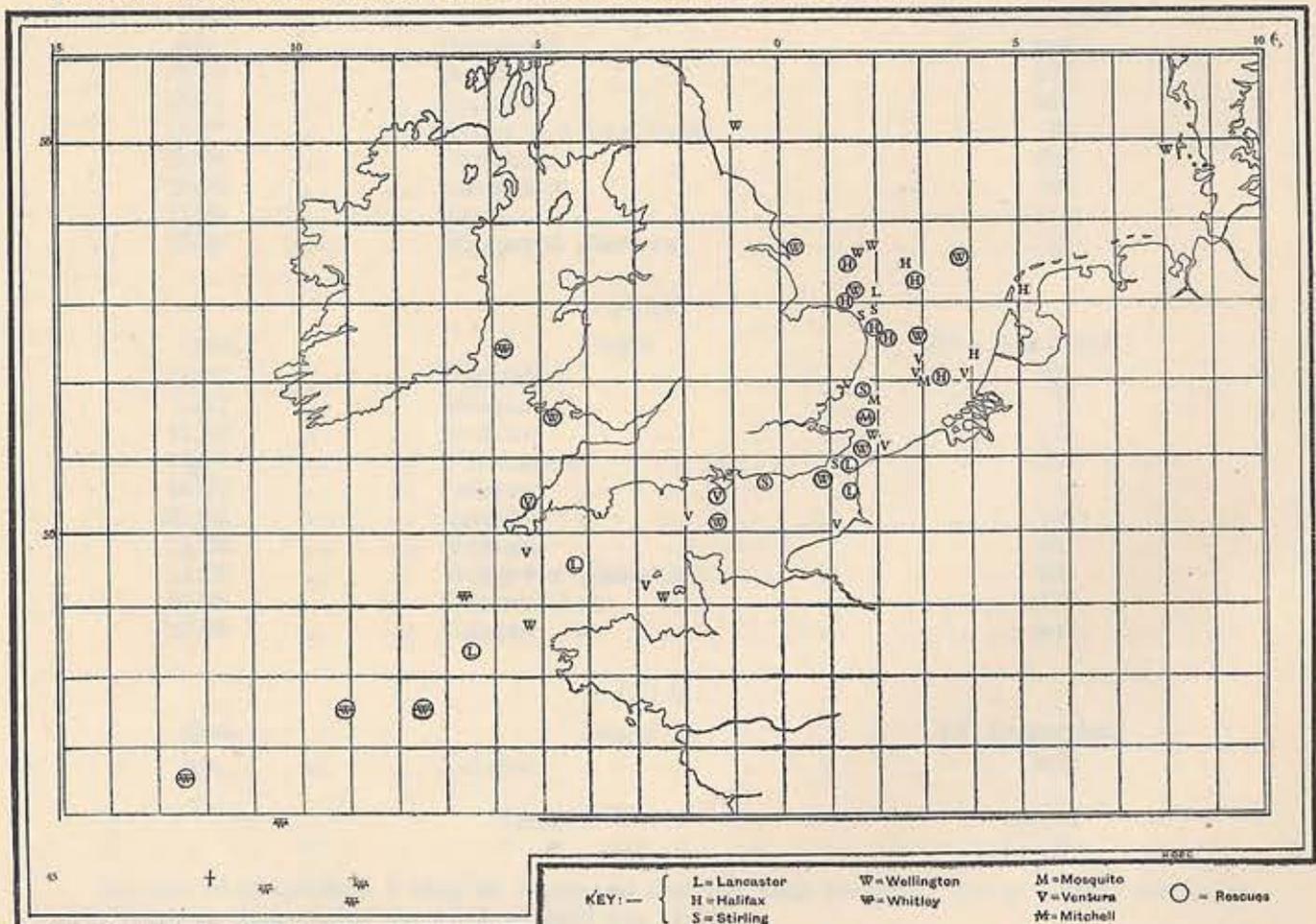
The following table indicates that personnel have been saved from 44 per cent. of the bomber aircraft known to have come down at sea in the course of the last six months' operations:—

Air/Sea Rescues 1st Jan.—30th June, 1943

Type.	Aircraft Ditchings.		Aircrews.	
	Total.	Successful.	Total.	Rescued.
<i>Four-Engined Bombers</i>				
Lancaster	5	4	36	26
Halifax	9	6		
Stirling	5	2		
			64	41
			34	13
<i>Twin-Engined Bombers</i>				
Wellington	15	8	74	26
Whitley	13	4		
Ventura	11	2	44	5
Mitchell	1	1		
Mosquito	2	0		
			4	0
Total	61	27 (44 per cent.)	338	138* (41 per cent.)

* A further 13 members of bomber crews were rescued from aircraft which ditched in the course of search and training flights.

The annexed diagram shows the plotted position of every Bomber Command aircraft on operations known to have "ditched" between 1 January and 30 June, 1943. From this it will be seen that rescues have been effected successfully in practically all areas where such incidents are known to have occurred.



DISTRIBUTION OF DITCHINGS AND RESCUES 1st JAN.—30th JUNE, 1943.

Only Bomber Command aircraft on operations are plotted on this map. In addition to those shown, four Whitleys and one Ventura ditched in positions unknown.

A DEPTH-CHARGE ATTACK ON A U-BOAT



FIG. 12.

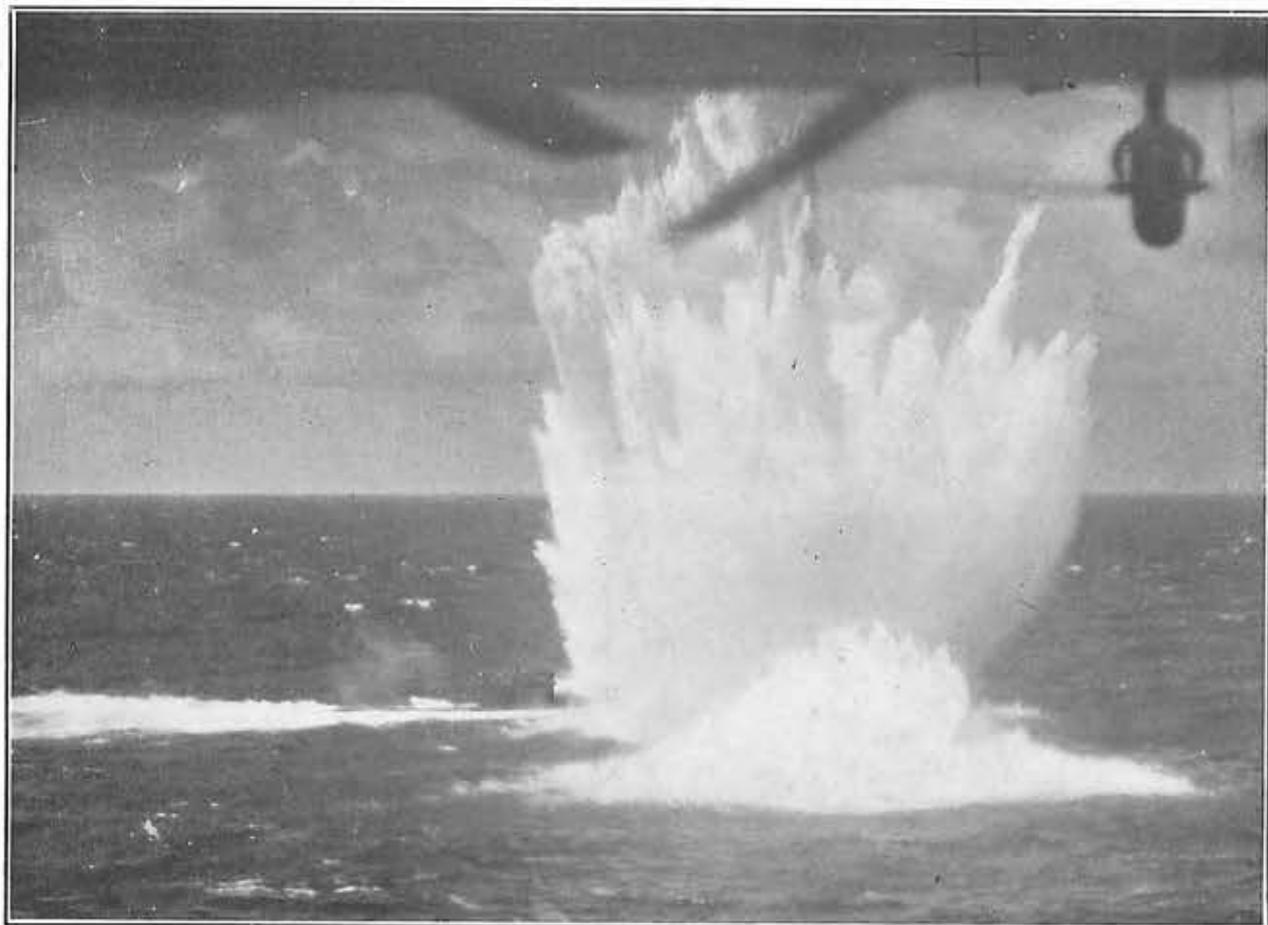


FIG. 13.—Whitley "P" of 10 O.T.U. carried out a perfect attack on one of three surfaced U-Boats encountered simultaneously in the course of A/S patrol on 14 June. Intense opposition was experienced from all the U-Boats, but the depth-charges straddled the forward part of the target. The splashes can be seen in Fig. 12 (above) and the subsequent plumes from the explosions in Fig. 13. (See account on page 14.)

BOMBER CREW RESCUED BY AIRBORNE LIFEBOAT

(See page 17)



FIG. 14.—A Hudson aircraft releasing an Airborne Lifeboat during a trial of this new development in Air/Sea Rescue.



FIG. 15.—The Lifeboat descending on three parachutes. In whatever position the boat enters the sea it immediately rights itself.



FIG. 16.—The first rescue by Airborne Lifeboat. The lifeboat settled on the water no more than 20 ft. downwind of the dinghy containing the crew of Halifax "V" of 102 Squadron.



FIG. 17.—The Lifeboat under way. Air cover was provided until the crew were taken aboard an A.S.R. high speed launch 14 miles off shore.

Ditchings must occur in circumstances which prevent the crew from sending out the necessary distress signals; but the map demonstrates that it is possible to rescue aircrews coming down anywhere within the area shown. For instance, in February of this year one of our Whitleys of 10 O.T.U. on anti-submarine patrol in an area west of the Bay of Biscay ditched in the Atlantic 360 miles south-west of Land's End: but the whole crew of six were found by search aircraft and brought home.

An even more difficult rescue was effected in April. A Lancaster of 50 Squadron, damaged by flak while returning from Pilsen, ditched in the Channel at 0200 hours on 17 April. The crew were unable to send out the regulation distress signal but were sighted by a patrolling Spitfire at 2054 hours—only 6 miles off the French coast off Le Touquet. Seven hours later they were picked up by naval M.G.B.s right under the enemy's nose.

Another good rescue was carried out on 22 June and the full narrative is of interest:—

While crossing the enemy coast at 19,000 ft., on the way to Krefeld, a Halifax of 102 Squadron was damaged by flak. Three engines and the hydraulics were put out of action, the coolant tanks holed and, after the load of bombs and leaflets had been jettisoned, the bomb-doors could not be closed. Height was lost rapidly and at 16,000 ft. the captain decided to ditch his aircraft. He, therefore, instructed the wireless-operator to send out a distress signal, but the trailing aerial could not be reeled out and the range obtained on the fixed aerial was insufficient for reception.

Meanwhile the Halifax was approaching sea-level about 18 to 20 miles W.N.W. of Overflakkee, at a speed of about 120 m.p.h. A full moon and 15 miles visibility favoured the ditching, although the wind (15-20 m.p.h.) was blowing across a slight swell. In the circumstances the captain decided it was preferable to land up-moon rather than into the wind. This was performed very successfully at 85 m.p.h., with full boost on the starboard-outer engine—the only one serviceable.

All the crew were at their ditching stations and the pilot's Sutton harness secured. The first impact with the water was gentle and the final impact only slight. The Halifax floated level while water entered through the open bomb-doors and the nose. The dinghy, inflated automatically by the immersion switch, came out of the stowage the right way up and the last man had evacuated the aircraft before the water reached a depth of 3 ft. in the fuselage. Thirty minutes after ditching the bomber sank, slightly down by the nose.

Various items of emergency equipment, including the dinghy radio, were taken into the dinghy, but as rockets and kites were left behind only visual means could be used for signalling to any aircraft that might appear. Fortunately the crew were observed by bombers returning from the raid. Two A.S.R. Walruses were subsequently despatched with escorting fighters and succeeded in picking up the whole crew some 18 hours after ditching. One Walrus aircraft took on board three of the crew and flew back to base; but the other, with the remaining four men, was unable to take off and taxied back to Harwich. In spite of difficult circumstances the pilot had ditched his aircraft most successfully and, apart from a cut which the bomb-aimer received when the Halifax was hit by flak, no injuries were sustained by any of the crew.

It may be noted that this was the third successful ditching accomplished by 102 Squadron during the quarter under review. One of the lessons to be remembered from this particular incident is the need for both radio and ancillary equipment in the dinghy: but for accidental sighting by returning aircraft the rescue might not have been effected. Naturally most rescues are completed more speedily than this rather exceptional incident—the average for the month in which it occurred being 5½ hours per rescue.

How Bomber Crews can Help

It cannot be too strongly emphasised that the chances of rescue are tremendously increased with the co-operation of the crews who are in distress. In that hour their drill will stand them in good stead.

Immediately the captain of an aircraft considers it unlikely that he will reach home the appropriate W/T procedure must be carried out, although the ditching may not be imminent. This and subsequent signals set the Air/Sea Rescue machinery in motion and establish the position of the ditching. Failing this action a rescue will only happen by pure chance, but the next job is the more difficult and no less important—to land the aircraft on the water as gently as possible.

Landing an aircraft at sea even under ideal conditions requires a certain amount of skill. Darkness, bad visibility and a rough sea add to the difficulties. Yet successful landings are frequently carried out both night and day by all our bomber types. Each member of the crew must be braced and in his correct ditching station, not relaxing until the aircraft has come to rest. Then the aircraft should float at least long enough to enable the crew to get into the dinghy in the correct order. All this can be achieved only if the crew are thoroughly acquainted with each stage of the ditching procedure and have taken the measures needed to ensure that their gear and drill are both equal to the emergency.

Recent Improvements

When a crew have got themselves and all necessary equipment safely into the dinghy they have carried out their part in the proceedings. Then the rescuers get busy and their main problem is to locate the dinghy. While this is by no means simple from the air, a surface craft is handicapped in its search because of the small area of the dinghy visible above water. Drift under the influence of wind and tide increases the searchers' difficulties. However, the problem has been greatly simplified by providing the dinghy with a W/T transmitter so that rescue craft may home on it; a telescopic mast to carry a flag; and a rocket kite to carry up the aerial. Pyrotechnic signals and the provision of food and water have also received considerable attention and improved accordingly. The "Q" type sailing dinghy, which will come into service in place of the circular types, is practically foolproof, scarcely possible to capsize, and equipped with compass, charts and simple instructions for rigging and sailing.

The most striking of all recent developments is the Airborne Lifeboat, used for the first time on 5 May to rescue the crew of Halifax "V" of 102 Squadron returning from a raid on Dortmund (Figs. 14-17). This lifeboat is a seaworthy 24-ft. vessel dropped on three parachutes from A.S.R. aircraft to crews who have ditched near enemy shores or out of range of surface rescue aircraft. Buoyancy tubes ensure that if the boat becomes inverted it will immediately roll back on to its keel. It is equipped with two petrol engines and fuel capable of an endurance of about 18 hours, and a mast, gib and mainsail. In waterproof lockers are stowed a compass, charts, warm clothing, heating bags, dinghy radio and rations to last a crew of seven for at least a week.

Since the first rescue in May the airborne lifeboat has been used most successfully to rescue a Wellington crew 17 miles west of Havre. There is doubt that this addition to the Air/Sea Rescue Service will further increase the number of lives saved. But the success of Air/Sea Rescue will always remain dependent on the skill, judgment and good drill of the aircrews themselves.

(b) The Assessment of Damage to Industrial Buildings

The bombing of Great Britain has taught us lessons which British scientists have been able to apply to our offensive strategy. While London and Coventry, Birmingham and Bristol and many other towns and cities of this country were being subjected to air attack, we were able to observe and record the behaviour of different types of domestic, public and industrial buildings. The lessons we have learnt and are learning can now be applied to the assessment of our own attacks on the centres of Axis war production.

The degree of damage caused to buildings by air attack is closely related to the structural form of the building. To appreciate the effects of bombing it is necessary to understand in general terms the behaviour of different structural types under the stress of these special conditions. It is impossible in so short an article to explain fully the cause and effect of the many forms of damage which can occur to the wide variety of buildings to be found in the industrial centres of Europe, but the broad principles can be summarised.

Types of Buildings

Industrial buildings may be broadly divided into two main types: single-storey shed-type buildings, and multi-storey buildings. A further classification by methods of construction is necessary in order to understand the mechanism of certain forms of damage. This classification also has two categories. In technical language these are defined as "load-bearing-wall buildings" and "framed buildings." The resistance of a building to the effects of H.E. and fire is dependent to a large extent on this structural distinction.

To define a wall as "load-bearing" simply means that its foundations rest on the solid ground over their whole length. It is usually constructed of small units such as bricks or masonry. Thus a building with load-bearing walls carries its own weight, and the weight of its contents, on a continuous foundation round its periphery and on intermediate walls across its plan. In contrast to this a "framed" building carries its own weight, and the weight of its contents, on a number of steel or reinforced concrete columns on widely spaced points of foundation in the solid ground. The vertical and horizontal members of this frame are rigidly fixed together, but the tensile qualities of steel nevertheless allow a certain degree of flexibility. The visible external walls and internal partitions and floors have therefore little structural function except as screens against weather and noise.

Roof coverings fall into two general types according to the angle of the roof. The heavier forms of roof covering, e.g., concrete slab, concrete-slab units or heavy sheet-steel decking are used on flat and low-pitched constructions, and the lighter varieties of sheeting and tiles on sloping roofs. In this country where sloping roofs are most commonly used, coverings are usually of asbestos cement or corrugated-iron sheeting, sometimes lined internally with insulating board. The heavier types of covering on flat and low-pitched roof structures are extensively used on the Continent, possibly owing to the wider variations in temperature and the resultant greater need for insulation.

Damage to Single-Storey Shed-Type Buildings. (See Figs. 18-21, and 24)

There are two forms of damage which are fundamental to this type of building, superficial and structural. Superficial damage leaves the main framework intact, so that temporary weather-proofing and black-out can be fitted with the help of tarpaulins in two days, while even permanent repairs only take a week or so. On the other hand, structural damage involves the serious distortion or collapse of the framework and takes several months to repair; it will be realised that the cost of repair and the interference with the normal working of the shop is very different for these two categories.

In single-storey shed-type buildings every effort is made to obtain as large and unobstructed a floor space as possible with the lightest possible covering, so that relatively large areas of the roof rely on widely spaced points of support. The framework which supports the roof covering may also carry cranes and runways to serve the working space. This will be constructed of steel, reinforced concrete or timber members supported on columns of similar materials or of cast iron. In the case of "load-bearing wall" buildings, brick or stone walls will carry the roof framework. Combinations of column and load-bearing wall support are common.

With the "framed" variety of light shed-type building a liability occurs: where one column is undermined or severed, the horizontal members of the roof framework may be unable to span the damaged column, and a collapse may ensue. This situation may be exaggerated when the additional load imposed on members adjacent to the damaged area is much greater than the structural junctions have been designed to carry, and a further failure at these points occurs. Such overloading of the structural junctions and their consequent failure may spread across a large area of the building, greatly increasing the original area of damage caused by the bomb. This is known as "spreading collapse." (See Fig. 19.)

If the shop is dependent on cranes for moving heavy materials (as in the Nuremburg transformer works, Fig. 5 in B.C.Q.R. No. 4), or if it contains machines driven by overhead shafting supported from the roof framework, structural damage must hold up work until repairs are complete. Nor can any temporary weather-proof covering be installed until repairs to the main framework are complete. The great importance of differentiating between structural damage, in which the main framework is affected, and superficial damage in which only the covering is blown off, will thus be readily appreciated.

ASSESSMENT OF INDUSTRIAL DAMAGE

(See page 18)

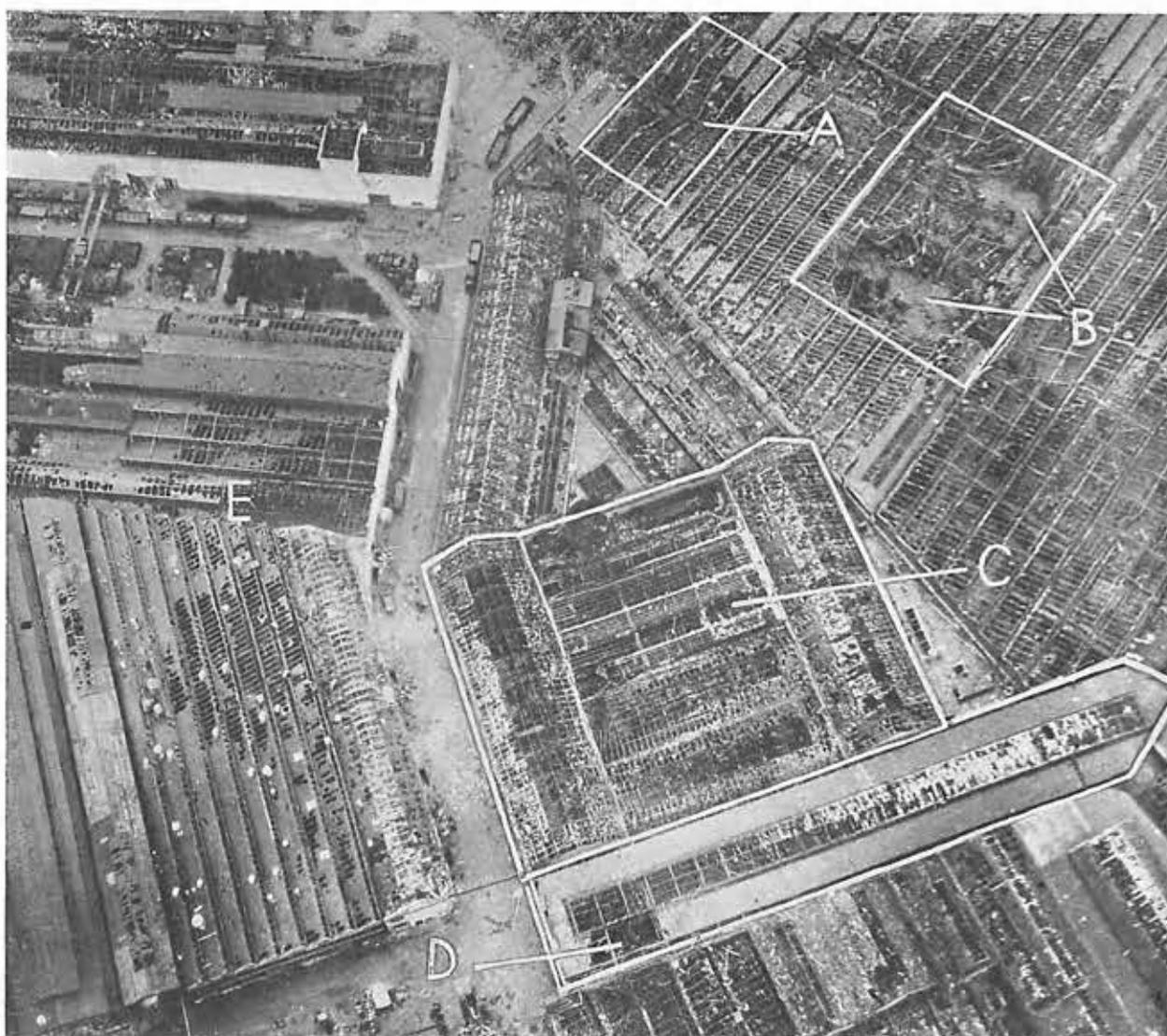


FIG. 18.—This remarkable low-level photograph of the centre of the Renault Works, Paris, after Bomber Command's night attack (3/4 March, 1942) shows clearly the main types of damage caused by H.E. bombs.

- (A) A bomb has apparently severed one or more columns supporting the roof in this single-storey steel-framed workshop. The horizontal members of the roof-frame have sagged down here, but beyond this point the structure has been strong enough to resist further collapse.
- (B) Two bombs, probably detonating among the roof members, have destroyed a large area of the steel frame.
- (C) A large single-storey building with steel frame probably covered with asbestos sheeting has had this roof-covering completely stripped, but without serious damage to the structural members.
- (D) A similar building with a flat reinforced concrete slab roof. The bomb has destroyed one and a half panels with no other serious effects on the roof structure. The extent of the blast can be observed from the damage to the glass-covered lantern-light running down the centre.
- (E) The buildings to the left of the roadway show typical roof damage to steel-framed buildings, varying from localised stripping to direct hits at several points.



FIG. 19.—A typical example of "spreading collapse"—a ground photograph of a steel-framed single-storey building in the Renault Works, March, 1942. The framework has collapsed to the ground over an area unaffected by the direct action of the bomb.



FIG. 20.—A large area of the Loco Assembly Shop, Le Creusot, was demolished in October, 1942. (This steel-framed single-storey building was again damaged in June, 1943.)

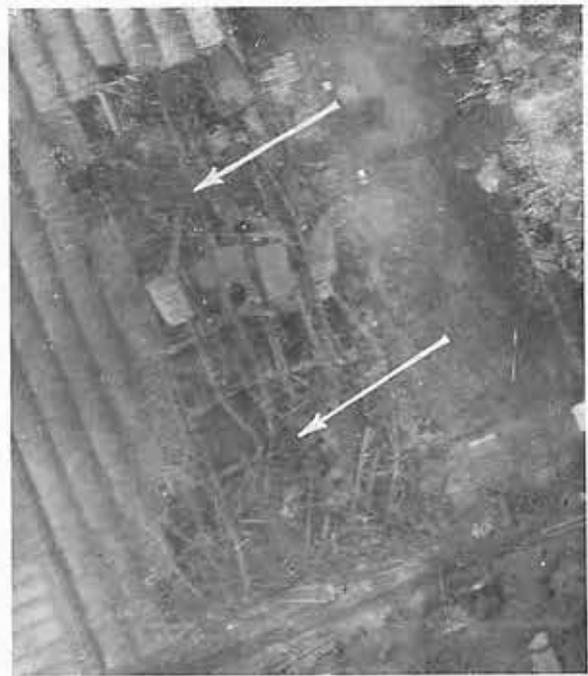


FIG. 21.—Detail of Fig. 20. Serious damage to the structure—probably caused by two direct hits—has been aggravated by further structural collapse (*lower right-hand corner*).



FIG. 22.—Direct hit on a multi-storey framed building (Phillips', Eindhoven). The bomb penetrated below the roof before detonating, probably two or more storeys below. Panel walls and floor slabs were probably extensively damaged, but only the point of entry can be seen.



FIG. 23.—A similar incident (A) occurred at Cologne (Gummifäden Fabrik) but here reconnaissance showed debris from panel walls blown out by the explosion. The whole of the large building to the right was gutted by fire.

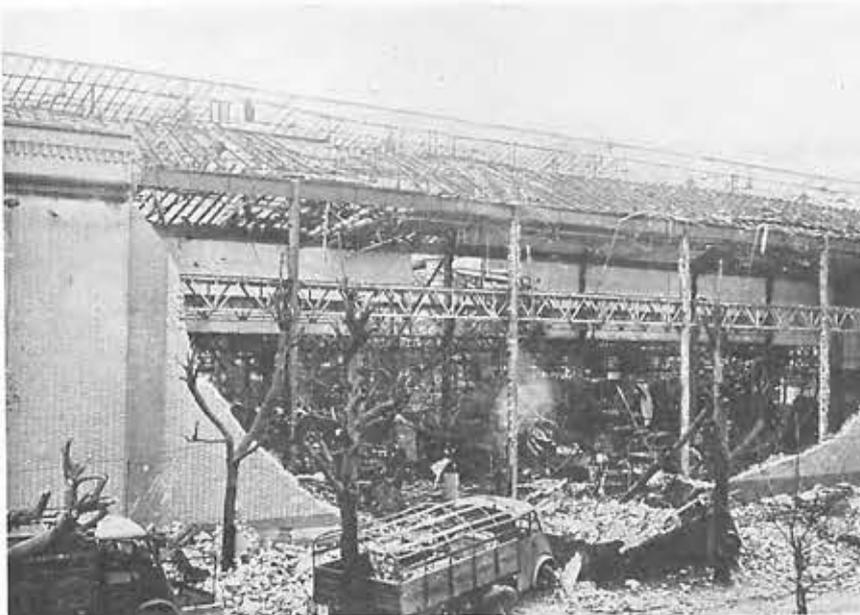


FIG. 24.—This damaged building in the Renault Factory clearly shows the construction of a typical single-storey workshop. Widely-spaced columns support the roof framework on heavy girders. A lattice girder below the eaves carries a gantry crane. The external "panel" wall has been demolished with little effect on the steel-framed structure. (Remnants of brickwork can be seen attached to the columns.) Reconstruction of this type of damage generally presents no serious problems.

Allied raids on individual factories, such as the night attacks on the Renault and Peugeot works and particularly the U.S.A.A.F. daylight attacks, are much more concentrated than anything we experienced in this country. First-aid repairs are therefore out of the question, and the steel frame of most of the shops affected must be rebuilt before work can be resumed. Our own experience shows that structural damage in a typical machine-shop immobilises about three times as much of the area of the building as can be seen to be structurally damaged. Therefore, if a third of a German machine-shop is assessed as structurally damaged, it is reasonable to assume that the whole shop is "out."

The effect of H.E. on the roof-covering, whether or not associated with damage to the structure of the building, is dependent on the type of roof and the material employed. Using the general classification already defined, the heavier concrete slab and concrete-slab-unit construction on flat or low-pitched roofs will not be so vulnerable to the effects of blast as the lighter sheet-coverings on sloping roofs. In the latter category, an important difference of behaviour in sheeting materials is to be noted: asbestos-cement sheeting, being very brittle, behaves not unlike glass—so that very extensive areas of roofing can be stripped without damaging the structural supporting members. (*Fig. 18C.*) Much smaller areas of corrugated iron roofing will be affected by a comparable intensity of blast and, in general, still smaller areas of concrete roofing. (*Fig. 18D.*)

The effect of fire as a weapon of attack on shed-type buildings is somewhat unpredictable, since the combustibility of the contents will determine their vulnerability to a greater extent than the structure. It is therefore not really possible to fit the categories of structural type and materials already discussed into a general relation with their expected behaviour, and in the case of fire damage the clear-cut distinction between structural and superficial damage does not exist.

There are, in fact, three possibilities:—

- (i) The roof covering may be burnt off with little damage to the contents of the building. Roofing materials in most industrial buildings are usually not highly combustible, except where timber boarding has been used as a lining. In such cases fire may sweep across a building and, if not of great intensity, leave the main structure intact.
- (ii) The contents of the building may be destroyed with little visible damage to the roof.
- (iii) The whole of the building may be gutted.

In the typical "steel-framed" shed-type building intensive fire may cause serious damage to the structure. Heat causes steel to expand and to become malleable. The combination of these effects on a member carrying a heavy load may cause a serious distortion and consequent failure: where this occurs to an area of the structural frame, a collapse is probable, and this may be further exaggerated by a "spreading collapse" of adjacent areas of the building as in the case of the failure of a supporting column.

Clearly, which of these possibilities occurs in any particular building depends on a number of factors, the most important of which are the combustibility of the roof framework and covering, the height of the building and, perhaps most of all, the combustibility of the contents. It does appear, however, that when a fire occurs in a single-storey building it most commonly destroys both contents and roof-covering over the area of the fire. Krupp's at Essen provides some excellent examples of the effects of fire. The photograph reproduced as *Fig. 3* in the last issue of *B.C.Q.R.* showed a large workshop (marked C) in which contents, roof and roof-frame were almost entirely demolished. The great locomotive erection shops nearby (marked A) were swept by fire from end to end, doubtless destroying most of the contents but leaving the roof framework intact.

Damage to Multi-Storey Buildings

Warehouses, offices, light engineering workshops and textile factories are frequently housed in this type of building. As in the case of single-storey shed buildings, both "load-bearing-wall" and "framed" construction is used, though the latter predominates in the newer buildings.

Floors may be either of reinforced concrete or timber, and will be carried on steel or reinforced concrete framework in "framed" buildings, and on masonry or brick walls in "load-bearing-wall" buildings. Combinations of both structural systems are frequently used.

H.E. bombs, other than those fitted with instantaneous fuses, will normally perforate several floors of multi-storey buildings before exploding. Their explosion will always cause direct destruction of walls and floors within a fairly limited distance from the bomb, but the subsequent behaviour of the building will depend on the details of its construction. If the floors are supported on brick or stone walls (as in a "load-bearing-wall" building) then the destruction of the walls will usually result in the collapse of all floors above the explosion and the resulting debris will probably cause collapse of the lower floors also. If, on the other hand, the floors are supported on an independent framework of steel or reinforced concrete, then the serious damage will probably be limited to the comparatively small area of direct destruction. Since walls in "framed" buildings are merely weatherproofing panels between the framework, it is common for them to be blown out without injury to the frame and consequently without collapse. In such a building the only damage visible from the air may be the small hole in the roof made by the bomb at entry, but there will, of course, be a certain area of collapsed floor within the building, and partitions and contents will be extensively damaged. It is not uncommon to see debris from external panel walls and partitions which have been blown out, lying round the periphery of the building. (*Figs. 22-23.*)

In the case of multi-storey buildings even more than with the single-storey shed type, the amount of fire damage likely to be visible from the air depends on the combustibility of the contents of the building and on the degree of fire resistance of its construction. In a building of fire-resisting construction it is possible for the contents to be totally destroyed without any damage being visible from the air. On the other hand, a comparatively small fire in a building not of fire-resisting construction may be sufficient to soften the steel framework and cause total collapse.

Application to Aerial Reconnaissance

These visible characteristics of damage to industrial buildings may now be applied to the interpretation of aerial photographs. In its undamaged state, it is not possible to assess with certainty the construction of a building. Obviously other factors, such as a knowledge of its functions, will help the expert to come to a decision on this point, but only when a building has suffered damage can an assessment of its construction be undertaken. Even then the extent to which it is a fully "framed" building is sometimes difficult to establish. The more important categories of material employed in roof-covering, particularly in the case of sheeting and tiling can usually be differentiated where damage has occurred. An examination in terms of structural type—single-storey shed, and multi-storey—is the best method of classification since heights and spans of buildings can be easily calculated.

The notes on the illustrations show the interpretation of some of the types of damage discussed. It will be seen that with knowledge of the behaviour of structures the interpretation of damage to a building can be carried into a "third dimension." Damage can now be studied not only in terms of the gross area affected, but the probable actual conditions brought about by the attack can be estimated on a scientific basis. The area of building completely demolished is in fact the only accurate measurement that can be taken directly from the photograph; and in the case of framed buildings such a measurement alone may not give a true indication of the amount of building rendered permanently unusable, but has to be interpreted in the light of knowledge of the type of structural damage that has occurred. Where the interpretation is dealing with superficial damage it is evidently impossible on direct measurement alone to assess its full meaning. The interior of a shop may be completely gutted and production brought to a full stop with little visible sign of damage. Conversely a totally stripped roof, while giving the impression of very extensive damage, may delay work in the shop only for the period of resheeting which, under properly organised conditions, is never a very long job. An assessment of such damage made with a knowledge of comparable damage in this country can give a more detailed picture of the state of affairs.

This technique has been developed in further branches of specialised study. By survey and statistical calculation the expected performance of known weapons has been calculated and their effectiveness against plant and machinery established in broad terms. Given a knowledge of the processes carried on in a particular industrial unit it is possible to undertake a study not only of the physical damage to the building but, by statistical methods, to extend this analysis to the probable effects on the productive capacity of the plant and the time that repair and rehabilitation would be expected to take. Much of this work will naturally be aided by information contributed from a wide variety of sources, but interpretation from aerial photographs supplies the groundwork for analysis and research from which a detailed report of the attack and its results can be prepared.

(c) A German Misconception

Dr. Goebbels has now explained to the German people that the only effective answer to mass air attacks is a counter attack on the same scale. He mentions too that, as Germany is not in a position to make this reply and as the British offensive cannot be checked, they must simply put up with it as best they can. No doubt the Germans, contemplating the ruins of the great industrial cities of the west from Essen to Hamburg, feel that this is disappointing. How far they took Goering literally when he told them they would never be bombed at all, we do not know. But, in view of the carefully encouraged belief in the invincible Luftwaffe, they would have been unpatriotically sceptical if they had doubted its capacity both to inflict crippling casualties on any force which attacked the Fatherland and to give the enemy something more than the blow for blow which the Führer himself promised them. Both these promises indeed were renewed as recently as June, 1943.

What has happened? Have the German Air Staff really been criminally incompetent in their planning and overlooked an obvious strategic move by their opponents? Or how can one explain the fact that at the moment when the Wehrmacht is facing a final show-down with the Red Army both its supplies of essential munitions and the whole morale of the home front behind it are visibly endangered?

To attribute this critical position to elementary blunders by Germany would be grossly unfair both to the German and the British Air Staffs. The Germans indeed have made a monumental mistake—one of those mistakes by which wars are lost. But it was not childish or elementary. To see this it is necessary only to recall the relative positions of the R.A.F. and the Luftwaffe after the fall of France in 1940.

At that date Bomber Command had about 30 squadrons of light and medium aircraft. Nearly half of these were Blenheim and Battle squadrons, almost useless as far as attacks on Germany were concerned. There were no heavies. For this pitifully small force to drop as much as 50 tons of bombs inside German territory was an achievement. The Luftwaffe, on the other hand, could expect to drop over 300 tons (which in those days seemed quite a lot) on British cities and go on doing so fairly regularly for weeks on end. The R.A.F. had only a rudimentary night fighter force and, by German standards, there was hardly any flak in England. Weather was thus the only limiting factor. It looked easy.

Now consider the position as it appeared to the British Air Staff. Britain was facing Germany alone. There was no prospect whatever of either Russia or the United States entering the war to support what might have seemed to them a lost cause, though the prospect of aircraft supplies from America (provided the Atlantic routes could be kept open against U-Boats operating from French bases) was quite good. After the battle of Britain the day skies were safe against large scale Luftwaffe attacks. But the night bombing picture was gloomy. However, the building up of a really powerful force of night bombers was our only offensive strategy against Germany and, in spite of the scepticism and opposition forthcoming from many quarters as to the wisdom of committing a large part of our limited man power and production resources to the execution of a new and untried strategic

method, the policy was accepted. All who really knew the implication of this decision, including the vast expansion of our production of heavy four-engined bombers and the tremendous drain on operational strength required to build up the world-wide training organisation to provide the necessary aircrews, knew that this meant we should never bomb Germany seriously till 1942, and that no all-out bomber offensive could take place till 1943. It seemed a long time to wait—and the German Air Staff no doubt thought that the war would by then be over in Germany's favour. They built more dive bombers and more day fighters to support the ever-victorious German Army. Things still looked good for them at the end of 1941, though the failure of the Army to capture Moscow, even with air superiority to help it, was a disappointment. The British bomber force was building up very slowly, but the heavies were at last becoming noticeable.

In March, 1942 a German town went up in flames for the first time. This attack on Lübeck, followed by another on Rostock a few weeks later, really marks the beginning of the Bomber Offensive. But it was only a beginning and the Luftwaffe could still afford to regard it as a nuisance rather than a menace. The "Thousand Raid" on Cologne was a different matter—but it was obvious to the German staff that the R.A.F. could not keep up that sort of thing. It involved using the training organisation on operations and thereby cutting into the future output of aircrews on which the expansion of the main force was based. No doubt, however, it was a nasty jolt. Perhaps the German staff wondered then for the first time whether their policy had been right. But they had still one great comfort. Only on exceptional nights could the British hope to hit their targets. For they needed not only clear moonlight conditions but also absence of fog and ground haze. Weather of this kind is not common in north-western Europe—and, in the absence of it, no bomber force seemed likely to do more than produce scattered damage apart from a few lucky attacks. This belief must have been confirmed as the summer of 1942 went on. The Ruhr and Hamburg received no really serious damage. Düsseldorf suffered a serious, but nothing like a lethal, attack. Relatively unimportant places like Mainz and Karlsruhe were smashed. But it looked as if neither industry nor morale had very much to fear even if the damage done in 1943 was double that of 1942.

From the British standpoint the problem now was not so much that of building a bomber force, as that of enabling it to get its bombs on to the target. It is the successful solution of this problem in the past nine months which has converted the bomber offensive from a major nuisance to a threat—and far more than a threat—of total disaster to Germany's entire war plan. There were two aspects of the problem, the one scientific and the other tactical. Scientifically it was necessary to invent and put into production a device to enable our air crews to ascertain with certainty their exact position over Germany in spite of mist, fog and cloud which precluded visual identification of targets. This was not easy, but it has been done. It is now possible for our air crews to know precisely where they are irrespective of their distance from their base and of the atmospheric conditions over the target. As some of our aircraft carrying these new navigational aids have been lost over Germany the German staff may possibly know how they work, but in any case, after the successful bombing of many German cities through dense cloud, there is unlikely to be any dispute about the main facts. Thus the Ruhr in particular lost the protection of its industrial haze which had served better than any artificial smoke-screen to protect it in 1942. The R.A.F. had solved the problem of how to hit their targets without seeing them.

But this is not the whole story. If bombs are to be effective against efficient A.R.P. defences, they must be heavily concentrated, both in time and space. Random bombing of built-up areas might produce scattered damage on a considerable scale, but it is not really effective. In 1940/41 the Luftwaffe obtained a few good concentrations on British towns, but on the whole its attacks were scattered. It did, however, invent and improve to some extent the tactics of an advance-guard, marking and illuminating the chosen target for the benefit of the main force which Bomber Command have since developed with devastating effect. The enemy no doubt suspects that the Pathfinder Force does not drop pyrotechnics solely as a means of entertaining the inhabitants of Germany. According to a report which appeared recently in the Swedish press, the R.A.F. now use "target-marking bombs which look like a large incendiary and can be dropped from a great height with some certainty of aim. They contain 60 luminous bodies which are flung out of the bomb when it reaches a height of between 800 and 400 metres, and fall to the ground covering an area about 100 metres in diameter, which can be seen by the airmen even through a thick layer of cloud. The illuminated area serves simply as a fixed point for the bomb-aimers".

The result is that since March, 1943, when the first great attack on Essen was successfully delivered, the German Staff have been faced with the growing certainty that Bomber Command can write off the cities of Germany one by one, and that there is as yet no means of stopping the process. It is also clear to those on the ground that there is no answer to be given by A.R.P. and fire services to a thousand tons of bombs which really hit a selected target in something less than an hour.

In fact, the German Air Staff have made their big mistake and the German people must pay for it by losing the war. The transfer of production from bombers to fighters and the building up of a powerful night fighter force in an attempt to stop our bombers are only palliatives. They are mere defence measures which lead nowhere, and do not even achieve their purpose of reducing the weight of Bomber Command's attack. The simple truth is that the Luftwaffe has not merely been outfought—it has been out-planned as well. And that is why the German armies in the East had not enough material resources to stage a successful summer offensive or ward off the counter offensive which the Russians launched against them. Germany, indeed, has made two absolutely lethal mistakes since the beginning of 1941. The first was to suppose that the Red Army could be dealt with as the French had been in a single short campaign. The second was to assume that the British would be incapable of producing a bomber force large enough and accurate enough to win the war in the West. Had she been right on both points she would have won the war. Had she been right on either of them she might at least have gained a reasonable draw. But she has been fatally wrong on both.