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THE ANTI-AIRCRAFT DEFENCE OF THE UNITED KINGDOM FROM 28TH JULY, 1939, TO 15TH APRIL, 1945.

The following despatch was submitted to the Secretary of State for War on the 21st October, 1946, by GENERAL SIR FREDERICK A. PILE, Bt., G.C.B., D.S.O., M.C., General Officer Commanding-in-Chief, Anti-Aircraft Command.

PART I.

PREAMBLE.

1. I have been commanded by the Army Council to submit a report on the Anti-Aircraft defence of the United Kingdom during the war and have the honour to present my despatch herewith.

2. For convenience the report has been divided into two parts and in this first part I propose to deal with events from the outbreak of war until May, 1941.

SECTION I—GENERAL.

3. In September, 1939, the Anti-Aircraft defences of the country were organised in a Command Headquarters, seven Divisional Headquarters, a varying number of Brigades in each Division and a number of gun and search-light units in each Brigade.

4. Anti-Aircraft Command Headquarters was situated at Stanmore, adjacent to the Headquarters of Fighter Command, R.A.F., and with them was jointly responsible for the Air Defence of Great Britain, the A.O.C.-in-C. Fighter Command being in operational command.

A system of responsibility such as this obviously entailed the closest liaison and willing co-operation on both sides. I wish to put on record that the relations between my Headquarters and Fighter Command Headquarters were always most cordial.

5. The areas allotted to each of the seven Divisions were as follows:—

1st—The Metropolitan area of London.

2nd—Northern East Anglia, the East Midlands and Humber.

3rd—Scotland and Northern Ireland.

4th—North-west England, the West Midlands and North Wales.

5th—South Wales, south-west and southern England.

6th—South-east England and southern East Anglia.

7th—North-east England.

An additional organisation, directly controlled for operations from my Headquarters, was responsible for the defence of the Orkneys and Shetlands. It is essential to emphasise that A.A. Divisions were in no way comparable to Divisions in the Field Army, being of no fixed size and at times being up to four times as large and covering many thousand square miles of country.

6. The failure of our first overseas campaign in Norway confirmed my opinion of the paramount importance of the Anti-Aircraft defences; if we could obtain mastery in the air, there would be no invasion; if we could not, no expeditionary force could be launched from the United Kingdom. I therefore pressed for and secured a large expansion of our Anti-Aircraft defences during 1940.

7. At the end of 1940 I felt it essential to propose a considerable re-organisation in order to relieve the burden on the existing Command and Divisions and also to achieve closer co-ordination of boundaries with Fighter Command. Five new Divisions were created as follows:—

8th—covering the south coast as far east as Bournemouth.

9th—South Wales.

10th—Humber.

11th—the West Midlands and central Wales.

12th—Clyde and Northern Ireland.

In addition, to ease the supervision of this organisation, three AA Corps were created:

1 AA Corps in the South (1, 5, 6, 8 and 9 Divisions) corresponding with 10 and 11 Groups R.A.F.

2 AA Corps in the Midlands (2, 4, 10 and 11 Divisions) corresponding with 9 and 12 Groups R.A.F.

3 AA Corps in the North (3, 7, and 12 Divisions) corresponding with 13 and 14 Groups R.A.F.

8. When I was appointed to the command of the Anti-Aircraft defences on 28th July, 1939, I was faced with the most grave shortage of equipment. At the outbreak of war the total number of Heavy Anti-Aircraft guns under my command was 695, many of which were of old and obsolescent types and a number of which were only on loan from the Royal Navy. The approved and recommended total at this time was 2,232.

The position with Light Anti-Aircraft guns was even worse, there being only 253 out of an approved total of 1,200, some of which again had been borrowed from the Royal Navy. Of the best Light Anti-Aircraft gun, the 40-mm. Bofors, there were only 76.

Searchlights were in a somewhat better position, as there were 2,700 equipments out of an approved total of 4,128 and a recommended total of 4,700.

9. The increase in equipments throughout the period under review may conveniently be noted here.

At the end of 1939 there were 850 Heavy guns, 510 Light guns and 3,361 Searchlights.

At the beginning of July, 1940, when air attacks on the United Kingdom began in earnest, there were 1,200 Heavy guns, 549 Light guns and 3,932 Searchlights.

By May, 1941, there were 1,691 Heavy guns, 940 Light guns, and Searchlights had reached a total of 4,532 early in 1941 but owing to shortage of manpower the number of equipments in action had to be reduced before May, 1941.

10. The Anti-Aircraft defences at the outbreak of war were entirely manned by units of the Territorial Army. Their total strength at the time they were mobilised was 106,690.

While the training of a Territorial Army in peace time bristles with difficulties, the Territorial system has many advantages which far outweigh the disadvantages.

The Territorial Army has always attracted men anxious to fit themselves to defend their country. These men were the cream of the manhood of the country. In the Command it is no exaggeration to say that the success which it achieved was due in great part to the excellence of the personnel and without some similar voluntary organisation in the future I do not see how the Anti-Aircraft defences of this country can be adequately manned except at prohibitive cost.

11. As a result of the introduction of conscription early in 1939 it was intended to allot 20,000 militia every three months to help man the defences. In actual fact, war began three months before the arrival of the first allotment. By July, 1940, the total manpower in Anti-Aircraft Command was 157,319 and in May, 1941, just over 300,000.

12. It very soon became evident that the quality of the conscripts allotted to the Command was inferior and that I was not receiving such a good selection of the Army intake as other arms. This was due to restrictions as to age and medical fitness on the men to be posted to Arms liable to serve overseas, and I later had occasion to protest against a process of allocation of manpower which involved the posting of the best type of recruits to other Arms at the expense of A.A. Command.

13. Throughout the period covered by this part of my despatch, and indeed throughout the war, I was constantly faced with manpower problems. The shortage of manpower and the large demands made on the Command to supply personnel and units for the Field Army (in all 170 gun or searchlight regiments went overseas) led first of all to the introduction of Mixed Units and later to the Home Guard manning anti-aircraft equipment. It led also to drastic reductions in the number of searchlight units.

14. The deployment of the anti-aircraft defences at the outbreak of a war is a very delicate matter. The possibility of an immediate and paralysing attack from the air means that they must be ready at a very early stage, before the normal process of mobilization has been developed. They have a big responsibility at that time for the protection of the national economy upon which the whole war effort must depend.

15. The various means by which the troops might be called up before official mobilization took place in such a way as not to damage further any strained international relations were investigated. The B.B.C. was obviously out of the question and might in any case be off the air at the time it was needed; the telephone service would undoubtedly be overloaded; letters or telegrams provided no confirmation of delivery of the message and I finally concluded that messages by hand to key men, through whom the order would be spread downward to all who were involved, provided the only satisfactory solution. It so happened that when mobilization was required the defences were already manned in part and had been as a precaution since 28th April, 1939, with the result that the problem in the end was not fully presented.

16. When war began without any major air attack the first task was to improve the standard of training throughout Anti-Aircraft Command. Training in an anti-aircraft rôle requires progressive development. First, the individual has to be trained for his particular task on the equipment; next, the detachment has to be trained to work as a team and finally, the various detachments have to learn to co-ordinate their efforts as a tactical whole.

17. While I have already placed on record the splendid service which the Territorial units rendered in the early months of the war, their training, limited as it had been both by lack of equipment and the little time they had been able to spend on it, fell far short of that required for war. Some units, forcibly converted to a searchlight rôle, were found to contain some men unsuitable for the work and others who preferred their original rôle. The targets with which they had had to practise had been very slow and had taken no evasive action. Attempts to secure more up-to-date aircraft

from the Air Ministry were largely nullified because of the R.A.F.'s own shortage of planes. Practice by night was handicapped by the fact that all planes were ordered to fly with navigation lights, thus making exercises unrealistic. It is my opinion, an opinion not necessarily endorsed by the other military or air authorities, that it is essential that the Army should be independent of other services in the matter of providing for air co-operation in the training of Anti-Aircraft units.

18. The state of training of the Militia when they arrived was considerably lower than that of the Territorial Army.

19. The only training establishment at the outbreak of war was the School of Anti-Aircraft Defence, which proved totally inadequate for training more than a limited number of officers and N.C.Os. as instructors. To supplement this, Divisional Schools were formed in each of the seven areas into which the country was then divided. Many Brigades and even Regiments founded unofficial schools of their own, where equipment and methods had to be improvised. Owing to the wide dispersal of Anti-Aircraft detachments throughout the country these schools were able to fulfil a need which could not otherwise have been met.

20. The flow of Militia into the Command continued after the battle had been joined and in the first three months of the battle no less than 70,000 recruits received their first training in an anti-aircraft rôle on gunsites which were for the most part in constant action against the enemy.

21. While it was clear that our training was woefully deficient it was also obvious that the successful engagement of enemy planes required the highest technical excellence in equipment.

I was most fortunate in having the help of Professor A. V. Hill who obtained for the Command some of the finest scientists in the land. These scientists were indefatigable in their efforts to improve our equipment and training. They were recruited from all over the British Empire; and even before America came into the war many of her scientists had volunteered to work on our gun sites. No tribute could be too high to pay to all these distinguished men. Although we had many hundreds eventually serving in the Command we never had enough; but I believe it is true to say that thanks to their efforts Anti-Aircraft Command became the most technical and scientific Command in our own or any other army.

22. The problem of scientific training became acute with the introduction of radio-location—or radar as it was later called. A radio school was formed at Petersham at which selected specialist officers and civilian scientists were trained on the equipment. It was arranged that they would subsequently live and work on gunsites and give the Artillery officers the assistance and advice of which they must otherwise inevitably have been deprived. The work of these young men, many straight from the universities, was invaluable.

23. Mention must also be made of the formation of the Operational Research Group of Anti-Aircraft Command; an invaluable organization consisting of scientists and military liaison officers, whose study of operational problems was of such value that their activities were

later extended to embrace all forms of military warfare. This body was then re-named Army Operational Research Group.

24. For the greater part of the period under review the administration of many of the ancillary services rested with Home Commands, who were responsible for the Anti-Aircraft services within their respective areas. On many occasions I had to protest most strongly against this division of control, since I was hampered in my attempts to obtain full efficiency as long as I had no control over many aspects of the life of the troops under my command. In addition, difficulties arose because Home Command boundaries differed from those of Anti-Aircraft Corps and Divisions. In the early part of 1941 full control of most services was vested in me. This decision greatly eased our difficulties.

25. Before I proceed to the details of the battle against the Luftwaffe it is necessary to outline briefly the plans for the disposition of the various forms of defence.

26. It was envisaged that the enemy's main objectives would include aircraft factories, cities, and particularly London and the main purpose of the defences was to prevent their reaching these objectives. The area around the cities and between them and the coast was, therefore, made an Air Fighting Zone in which out fighter aircraft would operate, assisted at night by searchlights. To this end there was a continuous searchlight belt 30 miles deep which stretched from the Solent, east of London, north to the Humber and then north-west to the Tyne-Tees area. A further belt ran between the Forth and the Clyde.

To deal with aircraft which nevertheless penetrated this defence, the important cities were made Gun Defended Areas, with searchlights to enable the Heavy guns to fire by night.

For the protection of isolated points of importance, such as factories and airfields, Light guns were deployed against low level precision bombing.

As more equipment became available more cities were defended and the defences of others increased. Searchlight cover was extended to the greater part of the country.

Each Gun Defended Area had its Gun Operations Room, which was a nerve-centre of the defences and could be used either to pass information to the guns or actually to control the fire.

In each R.A.F. Sector in the Air Fighting Zone the Sector Operations Room was fitted for transmission of information or orders to the searchlights.

27. I felt it necessary to express alarm at the comparative immobility of our defences and particularly of Heavy guns, but since static guns were much more rapidly produced than mobile guns, I was forced to accept them. Consequently I was handicapped whenever it became necessary to move guns from one area to another.

It was not possible to have sufficient equipment or manpower to defend every town which might be attacked nor could even the most mobile defences be moved sufficiently fast to be at any given point as quickly as the enemy aircraft. The value of mobile defences lies in the fact that the air battle, like any other battle, has a pattern which the enemy tries to carry out.

When such a pattern is evident (e.g. the attacks on our ports; "Baedeker" raids etc.) defences can be organised rapidly to meet it.

SECTION II.—THE DAY RAIDER.

28. All the equipment available during the first year of war had been designed for shooting at seen targets. Except in cloudy weather it was, therefore, generally suitable for dealing with attacks by day and it was by day that the first attacks were made.

The principle used was the following: a predictor fitted with telescopes was laid on and followed the target, a height calculated by a heightfinder was set into it and the predictor mechanism automatically calculated where the target would be at the time the shell burst in the sky and by means of electric pointers enabled the gun to be aimed at that point.

There were, however, limitations to this equipment. Predictors were not designed to accept heights over 25,000 feet and as the enemy developed his tactics he flew more frequently at greater heights; further, there was a limit to the speed at which the predictor could traverse so that close targets often moved across the sky too fast to be followed. Except in very clear weather the "pick up" was too late to ensure adequate time to bring effective fire to bear.

29. Reference has already been made to the shortage of equipment in the early part of the war. The responsibility for allocating what equipment there was rested primarily with the A.O.C.-in-C. Fighter Command, who invariably consulted me in the matter. The demands for defence were, however, so various and the interests involved so powerful that we were continually faced with fresh agitations for defences. In order to deal with these requests a sub-committee of the Chiefs of Staff Committee known as the C.O.S. AA Committee was formed. The three services were represented on this committee and the Minister of Home Security was also on it.

30. Another effect of the shortage was that none of the units was fully equipped with the weapons it was intended they should have and though other types of weapons were brought in to fill the gap, complications arose because units frequently had to operate two, three or more types of equipment simultaneously.

31. The Heavy guns included the 4.5-inch of which I had 355 by June, 1940, when day raiders began to be serious. Secondly, there was the 3.7-inch on either a mobile or a static mounting, and this gun became the mainstay of heavy anti-aircraft armament throughout the war and in my opinion was the finest all purposes gun produced by any country during the war. Unfortunately it was never mounted in a tank. In June, 1940, I had 306 mobile and 313 static 3.7-inch guns and finally I had 226 obsolescent 3-inch guns.

Light anti-aircraft guns at the same date comprised the following:—273 40-mm Bofors, which was the chief Light weapon; 136 obsolescent 3-inch guns adapted for low level shooting; 140 miscellaneous types of 2-pounder guns on loan from the Royal Navy; and 38 20-mm Hispano cannons.

32. The first raids were made in October, 1939, upon the Forth and upon Scapa Flow.

Though the guns were successful in destroying some of the raiders, it was at once apparent that peacetime training and the existing equipment was insufficient to deal entirely successfully with wartime targets, which continually dived and turned and flew at comparatively high speeds. Steps were taken to have alterations designed and made to meet the needs of the situation, but nearly two years elapsed before these were actually produced.

Until June, 1940, enemy activity consisted mainly of sporadic minelaying or reconnaissance flights, often by single planes, and of small scale attacks upon convoys and the northern bases of the Home Fleet.

33. I do not propose to discuss on what exact date the Battle of Britain began, but what is certain is that in the second half of June, 1940, there was a marked increase in activity by the German air forces over and around the United Kingdom.

34. With the limited resources at my disposal it was impossible to give the country the degree of protection required at this time and the main weight of the attacks during the daylight Battle of Britain was borne by Fighter Command. Nevertheless it is only right to draw attention to the important part played by the guns during this battle, a part which the R.A.F. have never minimised; and indeed of the large daily totals of enemy aircraft destroyed in the battle, at times twenty, and on one occasion thirty, fell to the guns.

When the enemy began to come over in large formations the Heavy guns frequently laid the foundation of the Fighter successes by breaking up the formations with their fire, thereby rendering them vulnerable, while the presence of small groups of enemy aircraft or individual planes, which might otherwise have escaped the attention of fighter pilots, was indicated to them by bursts of anti-aircraft fire in the sky.

Light guns filled a rôle for which there could be no alternative weapon, particularly in the defence of airfields. Experience abroad had already demonstrated, and future experience was to confirm, that airfields lacking anti-aircraft defence were unable to continue in action against a sustained attack. Only guns, and lots of them, can defend an aircraft during the vulnerable moments when it is taking-off or landing.

35. The Battle of Britain may conveniently be divided into four phases although these sometimes overlapped. During the second half of the battle there were attacks by night as well as by day, but I propose to defer discussion of the night raids until later in this despatch.

The first phase of the battle consisted largely of attacks on convoys in the Channel and on south coast ports. The heaviest engagements occurred between Harwich and Lyme Bay, although places as far on either flank as the Orkneys and Cardiff received some attention. So long as the enemy confined his attacks to shipping, the guns of A.A. Command could take no part in the battle and it fell to Fighter Command, who were able by their radar to observe concentrations of aircraft in the Calais region, to endeavour to deal with them. When ports were attacked the guns were in action: and at Portsmouth, Portland and in particular

Dover, heavy engagements were frequent and several enemy aircraft were destroyed. It was at this time that Dover began to be "Hell-fire Corner" for German pilots.

36. The second phase opened on August 12th, 1940, when the enemy began to attack the coastal airfields. Reference has already been made to the importance of anti-aircraft defence for airfields and, though many raiders were shot down in these attacks, considerable damage to the airfields was in fact done and many were temporarily put out of commission. Especially in the early attacks of this phase the standard of training in the Light anti-aircraft gun detachments was insufficiently high and later, when frequent practice had led to improvement, the limited number of guns proved a handicap. The damage however, to the airfields would generally have been still more serious and of more permanent a character without the presence of the few guns which could be spared.

37. The policy of filling the gaps in the heavier equipment with Lewis light machine-guns was amply justified during this second phase. On 18th August, 1940, ten aircraft were destroyed by these weapons alone, and it was a fortunate chance of war that German aircraft were lightly armoured at the time when equipment was short and that heavier armour was only fitted when the defences had more weapons capable of penetrating it.

38. The third phase of the battle, directed against inland airfields, opened on 24th August, 1940. The Light anti-aircraft defences continued to show improved results and, because many of the attacks were delivered against the outskirts of the London area, the heavy guns in the Thames Estuary were able to take part in the battle. This was the densest concentration of Heavy guns which the Germans had so far encountered and, though only a limited number of planes was destroyed, formations were consistently broken up before they reached their objectives.

39. On 7th September, 1940, the fourth phase of the battle began with a heavy raid on London. During the preceding phases we had received constant demands for guns to defend other places, not only on the south coast but in industrial areas which were beginning to feel the weight of night attacks. We had, therefore, reluctantly drained London of its defences until no more than 92 Heavy guns remained. As soon as it became apparent that London was to be the target, I had to draw back into the capital as many guns as I could reasonably manage and within 48 hours the total had increased to 203.

40. The attack on London was made both by night and by day, and of the initial inefficacy of the night defences I shall have something to say later. By day, though it was impossible for the R.A.F. to prevent the Germans reaching the capital and though when they were there it was too late to prevent them bombing the city, the guns destroyed a considerable number in many of the formations. It was significant too that the most spectacular success which the enemy achieved by day, namely the firing of the dock area on 7th September, 1940, occurred when the gun defences were numerically at their lowest ebb. The increase in the number of guns at once

reduced the amount of damage which the enemy was able to inflict; his formations were more effectively broken and the successes of the fighter aircraft continued to mount. On 15th September, 1940, due largely to the R.A.F., the enemy effort was so decisively beaten that though attacks continued by day until 30th September, 1940, it was undoubtedly then that the turning-point of the battle against the day raider had been reached.

41. I have dealt only briefly with this battle because it was primarily a battle between air forces.

From 10th July, 1940, the day which most authorities have accepted as the opening day of the battle, until 30th September, 1940, the guns of Anti-Aircraft Command destroyed by day 296 enemy aircraft and damaged or probably destroyed a further 74.

42. During October, 1940, the enemy reserved his bombers almost exclusively for night operations but he continued for a time to attack the country by day with fighter-bombers. For the most part these attacks did not penetrate far inland and were often delivered on unprotected coastal towns. Militarily the attacks had little significance, except in so far as they were designed to wear down our fighter forces and with the existing resources it was impossible to provide gun defences for these coastal towns without denuding vital factories of protection.

SECTION III.—THE NIGHT RAIDER.

43. I come now to that form of air attack which, in the early days, before a successful night fighter technique had been developed, was essentially a gun battle; I refer to the night raids. I have already mentioned that practically all equipment had been designed for visual shooting at seen targets, and this applied to shooting by night as well as to shooting by day.

44. The equipment which was available in the first year of the war had been designed some years previously at a time when the possibility of targets taking violent evasive action at high speeds had been insufficiently realised. It had been hoped that if raiding took place at night the searchlights would be able by means of sound-locators to find their targets, illuminate them and continue the illumination without difficulty. This would enable the guns to use their normal visual methods of engagement and the fighters outside the Gun Defended Areas to make their interceptions and attacks.

45. Even before the war it was obvious however that the likelihood of night raiding had been increased by the improvement in navigational methods and the greater reliability of aircraft engines and also that, even without evasive action by the enemy, cloud would seriously handicap all forms of night defence. Visually controlled searchlights appeared to be of doubtful value to the guns.

46. There appeared to be no satisfactory solution to this problem until the invention of radar and, as the delivery of the first radar sets for guns was not due until 1940, some alternative means of dealing with unseen targets had to be found. The only available equipment was the sound-locator.

Pre-war experience had shown that under good conditions and within certain ranges sound-locators could pick up and follow single slow-flying targets and that, by making due allowance for the fact that sound travels comparatively slowly, searchlights could be directed at the actual position of the target.

47. The use of sound-locators with the guns involved the additional complication that the guns had to be directed not at the actual position but at that position where the aircraft might be expected to be by the time the shell burst in the sky. What had to be done, therefore, was to track the target by sound-locator for some time in order to establish its course, then to pass information to the guns on which a future position could be calculated, take the necessary steps to aim the guns and set the fuzes. In all, this meant allowing an interval of anything up to a full minute between the calculation of the target's future position by a sound-locator and the arrival of the shell at its destination. During this interval the aircraft might be expected to fly between four and six miles.

Moreover, in calculating the future position, it had to be assumed that the aircraft would continue to fly on a constant course at a constant height and at a constant speed, the likelihood of which was small after the first signs of interference by the ground defences.

48. The plan which was evolved for the defence of London was known as the Fixed Azimuth System. Two lines of sound-locators spaced at 2-mile intervals were sited at right-angles to the Thames Estuary on the eastern flanks of London and another similar system was laid out on the western side.

Each sound-locator was directly linked to the London Gun Operations Room and it was expected that the two nearest locators in the outer line would on the approach of an enemy aircraft be able almost simultaneously to report a bearing and an angle of sight from which the Operations Room could determine the position and height of the plane by calculating the intersection. Similar information from two locators in the inner line would supply direction and speed.

The Operations Room could then fix a "future position" at which the target would be engaged. This position would be passed in code back to the guns who would make the necessary adjustments to suit their own situation and fire on a given order.

49. In the cities of the provinces the problem was less acute because the smaller size of the target limited the area in the sky in which the enemy could operate successfully. Consequently in many places it was possible to work out geographical barrages which could be fired on an order from the local Gun Operations Room and guns were sited accordingly.

50. Sporadic night raids against this country began during the Summer of 1940. In early August they began to intensify and on 8th/9th August provincial cities were attacked by raiders endeavouring to make precision attacks on certain factories. The emphasis was on the Midlands and the West, but the enemy's effort

was scattered and no real test of the defences occurred; a few planes were shot down and others damaged in widely divergent areas.

51. Between 25th/26th August, 1940, and 6th/7th September, 1940, there was noticeable a somewhat greater degree of concentration in the enemy's attacks, though it was still in the Midlands and the West that the main attack fell, over 100 planes attacking Liverpool on four nights in succession.

Forty-eight planes were destroyed by gunfire during this period.

A few aircraft had flown over London by night during this period, but it was on the night of 7th/8th September, 1940, following the first heavy raid by day, that London was first singled out as a major objective and one which was thereafter to be continuously attacked.

52. The Fixed Azimuth System broke down completely. The enemy was now operating at greater heights and sound-locators could not always detect the aircraft; at other times more than one plane was operating between two locators and there was no certainty that both equipments were tracking the same aircraft; the assumption that the main approach to the Capital would be up the Estuary was not always fulfilled (probably owing to the new German navigational aids) and many planes passed outside the flanks of the sound-locator layout; finally, faults developed in the communication system and large sections of the front were put out of action for long periods. In consequence, few of the 92 available guns received data on which they could fire.

53. I realised that the mere introduction of more guns would not alone solve the problem, although within 48 hours the number had been increased to 203. I therefore decided, on 11th September, 1940, that guns which were unable to fire on the Fixed Azimuth System should be given a free hand to use any method of control they liked.

54. The volume of fire which resulted, and which was publicized as a "barrage", was in fact largely wild and uncontrolled shooting. There were, however, two valuable results from it: the volume of fire had a deterrent effect upon at least some of the German aircrews, so that, though it cannot be proved by records, I have every reason to believe that one third failed to reach their objective; there was also a marked improvement in civilian morale. Against this there was an expenditure of ammunition which, besides being far greater than was justified by the results achieved, could not be maintained indefinitely without seriously depleting the ammunition reserves.

55. There was a strong suspicion at this time that the German raiders were using two prominent landmarks—the Isle of Dogs and Hyde Park—over which they turned to their various objectives. Two geographical barrages, designed to explode over these two points, were, therefore, worked out and were fired for the first time on the night 26th/27th September, 1940. There was no marked improvement in the number of raiders destroyed but the plan had the advantage of controlling the ammunition expenditure.

56. It was on 1st October, 1940, that radar was first used to control anti-aircraft gunfire. The first sets had actually been received at the end of 1939 but a delay in applying them to anti-aircraft work had been caused by their complete inability to give any indication of the height of the aircraft and the intervening months had been spent in trying to overcome this handicap. In this work I must especially mention the untiring and valuable help given by Major-General M. F. Grove-White, C.B., D.S.O., O.B.E., at that time G.O.C.2 AA Division. The only use to which it had been possible to put the few available sets was direction-finding, but, as the heights still had to be found visibly by a height-finder, there was only a very small improvement on the old system, in that targets could be picked up a little earlier.

57. The first important attempt to provide an improved height-finding apparatus, which would operate against unseen targets, for use with radar arose from the invention of Visual Indicating Equipment. This was an elaborate sound-locator, the findings of which were converted electrically into a visual image on a cathode ray tube.

In practice, the equipment failed to give the results hoped for, since, apart from some difficulty in following the target and susceptibility to bad weather, it suffered from the same limitations as the sound-locators in the Fixed Azimuth System. Its range was limited, it was upset by extraneous noises such as gunfire and the presence of a number of targets at once was confusing.

58. The first real promise of a solution was found in the application of the radar principle to elevation as well as to bearing. Much of this work was achieved by Mr. Bedford, Chief Designer to A. C. Cossor Limited. The existing radar sets were modified as soon as possible by the fitting of this Elevation Finding attachment, and they went into action on 1st October, 1940. The chief limitation of this equipment was that when the angle of sight increased to more than 45 degrees the sets lost all accuracy in bearing.

To test the value of the new equipment orders were given that even against seen targets by day, provided they were over 10,000 feet up, the new unseen methods should be used and the results analysed. The results convinced me that the only real success being obtained was with this radar equipment and that the entire future of anti-aircraft shooting must be associated with it.

59. An entirely new system of unseen barrages was now developed. However great the improvement of the new equipment over the old, it was still far from attaining the required accuracy. In order to increase the chance of destroying the target we considered that it must be used to produce a volume of fire from many guns at once. Guns were, therefore, re-sited in groups, generally of eight and a master site, equipped with the new radar, was selected to control them. The master site plotted the target and informed the other sites of its position, height and direction. As soon as the enemy entered the barrage belt all guns opened fire independently.

This system was continued until 20th January, 1941, when I came to the reluctant conclusion that it could not be made to produce the success for which I had hoped. Since

1st October, 1940, the anti-aircraft defences had shot down over 70 planes by night and probably destroyed or damaged 53. I shall be referring a little later to our night fighter defences, but it is of interest to mention here that these successes were about four times the number scored by the R.A.F. in the same period.

The chief reason for ordering a change of method in January, 1941, was the limitations of the latest radar methods at angles of sight over 45 degrees. As long as guns, whether individually or in groups, were left to plot targets for themselves, there was in effect a very large blind zone right over the guns themselves and for some distance around them in which they could not operate. If control were vested once more in the Gun Operations Room, the combined information from all sites should eliminate these blind zones.

Consequently sites were ordered to pass their plots to the Gun Operations Room, where predictions were worked out and from which orders to fire would in future emanate. In other words, the plotting on the gunsite was divorced from the shooting and the greater part of the responsibility for the successful conduct of the battle was transferred from the Gun Position Officer to the Commander in the Operations Room.

60. Meanwhile, similar troubles had been experienced with searchlights. Their sound-locators had been subject to the same disadvantages as those used with guns and illuminations had consequently been erratic. In the same way as I had found them insufficient for use with the guns and had had to develop methods of unseen fire, so the R.A.F. had found them insufficient for successful co-operation with night fighters.

A further difficulty which arose when searchlights were used with sound-locators was that there was a tendency to over-estimate the speed of sound and to assume that the target was behind its actual position. Consequently, fighters following up an enemy raider frequently found themselves illuminated and an easy target for the enemy rear-gunners.

In order to give the night fighters more opportunity of engaging the enemy, a new technique was introduced known as "Fighter Nights". The theory was that the most likely place for a fighter to intercept the enemy was over the target area and that once contact was made the night fighter would have a very good chance of destroying the bomber.

The disadvantage of the scheme was that in order to safeguard the fighter our guns could not fire or, alternatively, had to be restricted to heights below that at which the fighter had instructions to operate.

Although some results were achieved on moonlight nights, the scheme was not popular. The lack of gunfire incensed the civilian population who thought the gunners were being negligent, and this resulted in a great loss of civilian morale. The enemy bombers, free from all anxiety over anti-aircraft fire, flew straight to their targets and bombed them accurately; nor was this compensated for by a larger number of bombers destroyed by fighters for, in practice, it was extremely difficult for our pilots to see the enemy and even after a "visual" had been made the bomber nearly always shook off the fighter.

The system was tried again during the "Baedeker" raids of 1942 and, after considerable protests on my part, was finally abandoned.

61. Of necessity priority in the provision of radar equipment was given to the guns; but I arranged for the provision at the earliest possible moment of similar equipment for searchlights also and the first sets were deployed towards the end of 1940. These were of the same type as was being employed with the guns; shortly afterwards, a type specially designed for searchlight control, known as S.L.C., which had been delayed in production, became available.

62. Throughout the first three months of 1941 there was an increasing amount of radar equipment coming into service, and a more advanced type for gunlaying, the G.L.II, also began to come from production. These were deployed in and around London in March, 1941.

63. The problems associated with radar were not all confined purely to theoretical matters. Sets deployed in the field produced curious results, and though some of these could be traced to bad drill or technical faults others appeared to be occurring without any good reason. One of the greatest problems was the appearance on the signal tube of spurious breaks, among which the break caused by the target was apt to disappear. It was not at first clear why these appeared; they might or might not appear whether the set was placed on high or low ground, close to or clear of buildings.

What was finally established was that the contours of the ground around the set had a pronounced effect upon it and it was suggested that, by pegging out a mat of wire mesh for some 150 feet round the receiver, an artificial level could be obtained which would largely eradicate the trouble. Experiments with a trial mat were a complete success and the principle was adopted universally. What I had not realised was that the project would involve using the whole of the country's stocks of wire net on the first 300 mats.

The project also involved the re-siting of a great number of the sets, as it was not always possible to find sufficient clear space for a mat near to the guns. Some sets were moved over a quarter of a mile from their guns and careful calculations had then to be made to co-ordinate the two positions, as the radar and the guns would see targets from quite a different aspect.

64. It was at this stage, when the equipment position at last began to look easier, that the pressure of manpower problems became severe. I was asked to economise in manpower to the utmost, and the A.O.C.-in-C. Fighter Command and I felt that any cuts which might have to be made must be in the searchlight and not in the gun units.

65. The tactical layout of searchlights had for some time been under discussion with Fighter Command with a view to finding some better means of using them with night fighters. Together we evolved a system by which the lights would be sited in clusters instead of singly. Night fighter pilots had represented that a single beam did not give them enough illumination to see and engage the enemy. Very comprehensive trials of clusters versus single lights were carried out and the majority of

the pilots gave their opinion in favour of the cluster of 3 lights. Looking back I think the idea was not sound but it had the advantage that we were able to dispense with some of the administrative troops owing to the greater concentration of detachments. Consequently the actual cut in the searchlight units was kept to a minimum.

66. Technical inventions and improvements came in a flood early in 1941. Among them was the Semi-Automatic Plotter, early versions of which supplied a continuous track of a target and later versions also incorporated a means of deriving future gunnery data. Other devices are too numerous to mention individually but the sum total was such as to renew the hope that fire control might be restored once again to the Gun Position Officer. The control from the Gun Operations Room, moreover, had proved no better than the old systems.

67. One of the prime movers in the restoration of fire control to gunsites was Major-General R. F. E. Whittaker, C.B., C.B.E., T.D., who had throughout been opposed to my decision to put control in the hands of the Operations Rooms. He carried out experiments with the various new equipments and thereby provided the most valuable contribution to date in the investigation of unseen methods of fire. These new methods of fire control convinced me that we should revert to the plan by which each gun site was responsible for obtaining its own gunnery data.

68. Having now outlined the stages in the development of our methods to combat the raider, I must describe briefly the course of the night battle. Essentially it was one battle throughout but it was possible to detect in it changes in the German policy; each change initiating in some degree a new phase; I must point out, however, that the phases merge one into another to a greater degree even than in the Battle of Britain. No good purpose would be served in a despatch of this nature in detailing all the attacks, since those details did not generally affect the policy of the defences.

69. After the preliminary raids on the West and Midlands, which have already been described, the first phase opened on 7th/8th September, 1940; in this phase the main target was almost exclusively London, which was continuously raided night after night. Supplementary and diversionary raids of smaller size were from time to time scattered across the whole country, so that it was never possible to withdraw into the Capital all the guns I wanted. On 14th/15th November, 1940, a second phase opened in which the main weight of attack was shifted from London to industrial centres and ports, although London continued to receive a succession of smaller raids. The concentration of industry and other objectives in these smaller cities and towns was far greater than in London, and the dropping of a similar weight of bombs could, therefore, cause far greater damage and dislocation than had been achieved in most of the London raids. Coventry was the first town to be singled out and others which in the course of this phase received particular attention were Liverpool, Bristol, Plymouth, Cardiff and Portsmouth. The guns defending London were at once reduced from 239 to 192, and another 36 were taken from the Thames Estuary. In the later part of

January and during the first half of February raiding was hindered by bad weather.

On 19th/20th February, 1941, a third phase began in which, though the objectives remained the same, a more determined attempt was made to put them completely out of action by raids on successive nights, which would take advantage of the dislocation caused the night before. Swansea was the first town so attacked, and other cities, and especially Liverpool, suffered from these methods. In this phase of the battle there was an emphasis on the West although other areas were frequently visited. This emphasis had a very high strategic significance, which caused us to draw 58 guns from the Midlands for the protection of western ports.

The east and much of the south coast had already been largely denied to our shipping; an attack of alarming proportions on our Atlantic sea routes had also developed. A vigorous attack on our western ports might well inflict such damage that the country would, to all intents and purposes, be isolated from the outside world, and every risk had to be taken to prevent this happening.

70. I have already mentioned that a certain amount of the equipment I had at the beginning of the war was on loan from the Royal Navy. Now I was asked for, and agreed to, the return of this equipment. As early as the beginning of 1940 I had agreed to supply Lewis guns and crews for merchant ships. In addition to the return of borrowed equipment, I was asked in turn to lend a large amount of my own equipment in the form of 300 Bofors guns for the protection of shipping, together with the men to man them and 1,000 rounds of ammunition per gun. Thus the Light anti-aircraft defences, which already stood at only 22 per cent. of requirements, were cut to 15 per cent. The Maritime Royal Artillery, thus formed, passed eventually out of my control altogether, but before it left it had given such excellent service as to ensure its continuance.

I was at the same time informed that the R.A.F. would soon be requiring the 20-mm. cannons which I had on loan. My hope that the deficiency might be made good by the employment of Rocket defences was nullified by a decision to give the Admiralty an absolute priority for these weapons.

71. I thus had to meet the last stages of the Battle impoverished in my Light anti-aircraft resources but with renewed hope that the technical advances of the spring would improve the results of Heavy anti-aircraft shooting.

72. The battle virtually came to an end on 12th May, 1941, after a heavy raid on London. As in every other aspect of the war, so in the air war the Germans changed their tactics as soon as it became evident that we had gained the upper hand. So, while the preparations they had to make for the Russian campaign no doubt influenced the decision, there is no doubt the German General Staff had by May, 1941, come to the conclusion that the war was not to be won by aerial attacks on this country and that the cost of such attacks was heavy. Between 1st April and 12th May, 1941, the successes scored by the guns mounted steadily. During this month and a half 72 planes were destroyed by night by the guns and 82 probably destroyed or damaged. The fighters too were now showing tremendous improvement.

73. At this point I propose to conclude this first part of my despatch. It covers a period in which success in battle was achieved with great difficulty and in which developments in technique were very considerable. At the beginning of the battle our method of defence was still the same as that of three years before; at the end I felt we had begun to make real progress; certainly the foundation of later successes had been laid. What had especially been achieved was the conversion of a large body of troops from ordinary soldiers into skilled technical operators, and this was an essential pre-requisite for successful anti-aircraft gunnery.

I have referred chiefly to the gun and searchlight units, but without the help of the ancillary services, Signals, Medical, Ordnance and Supply, progress could never have been made nor the battle continued. While full credit must be given to the troops of all kinds, and indeed their conduct under very hazardous and trying conditions was beyond all praise, the foundations of success, however, was laid by the scientist, both civilian and in uniform. The Operational Research Group has already been referred to. Its work was brilliant. The technical staff at Command Headquarters, under the leadership of Brigadier Krohn, C.B.E., M.C., T.D., was and remained throughout the war a vital factor in every scientific advance, and not least must I pay a tribute to those young American scientists who volunteered to help us and who played their part in all our Blitzes. That these gentlemen became available and for many other helpful and friendly acts our thanks are due to Brigadier Claude Thiele, U.S.A., who was one of the first American officer observers to reach this country after the outbreak of war and whose wisdom and help I continually sought throughout the whole course of the war.

PART II.

PREAMBLE.

1. In the first part of my despatch I described the problems and progress of the anti-aircraft defences during the opening phases of the war and during the first period of sustained attack by the German air forces which lasted from July, 1940, to May, 1941.

2. In this second part I propose to carry the report on from that date to the time I relinquished command in April, 1945. Though this was a few weeks before the final German capitulation there was no air attack of any kind upon the United Kingdom after that date and therefore this part of my despatch is in effect a report upon the whole of the remaining period of hostilities.

SECTION I.—GENERAL.

3. I mentioned in the first part of my despatch how the early months of 1941 saw an increase in the problems of manpower and how various innovations had to be made and some reduction in the searchlight defences had taken place.

Mixed Batteries.

4. The problem was met by the introduction of mixed units and it must at once be said that, while there were many doubters in the early days, the mixed units proved a triumphant success. In these units the proportion of

women to men was roughly 2 to 1. Women carried out every job except those involving heavy manual labour such as loading and manning the gun itself.

The problem had been considered before the outbreak of war when I asked for the advice of Miss Caroline Haslett, C.B.E., who, after spending days and nights in the field examining the various duties, told me she had no doubt that women were capable of doing all but the heaviest tasks.

It was on 25th April, 1941, that regulations were put into force making women eligible for operational duties. In May, 1941, the first mixed battery began its training and it became operational on 21st August, 1941.

5. Two projects were formulated. The first was that all Heavy Batteries coming forward from Training Regiments would in future be Mixed Batteries and the second was that, as the number of trained women increased, some of the existing male batteries should be converted to Mixed Batteries. The Mixed units would only have static and not mobile guns. It was hoped that by the end of 1941 there would be provided just under 40 batteries through each project, but this proved an over-optimistic forecast. Nevertheless, it was now clear that we could expect both to remedy existing deficiencies and to continue the expansion of the anti-aircraft defences. I was promised that of the expected total of 220,000 A.T.S. at the end of 1942, I could anticipate having 170,000. In actual fact, this estimated figure proved over-optimistic as other Army demands on the available women power limited the number of A.T.S. in Anti-Aircraft Command to a maximum, at any time, to just over 74,000.

6. The welfare of these women was one of the considerations which was uppermost in all our minds and this had a considerable effect upon the areas in which they were deployed. I wished to be quite certain that their accommodation would be suitable, and it was also necessary to ensure that they would not find themselves in the probable path of an invading army. A high standard of accommodation was set, but the general labour shortage throughout the country resulted in the programme of building falling behind schedule and it was not always possible to supply the full standard.

7. The possibility of invasion caused additional complications. Plans to counter any invasion, adapted to our increasing resources, were steadily improved. The summer of 1941 found an elaborate and detailed plan prepared, in which the anti-aircraft guns had to be ready for rapid moves in order to fit into the needs of the situation should it arise.

8. Some time previously I had reluctantly accepted a large and expanding programme of static 3.7-inch guns rather than mobile guns because the former were so much more rapidly produced. The task of shifting a static gun was very considerable and a great deal of preparation was necessary before it could be emplaced on a new site. As soon as the Chiefs of Staff advised me which defences must remain and which must be moved in the event of invasion, an interchange of 244 mobile and static guns was ordered so that the number of moves to be made if invasion took place would be cut to a minimum.

9. This interchange had repercussions upon the deployment of Mixed batteries. Some sites where accommodation had been provided for them were now equipped with mobile guns on which women could not be deployed, so that some mixed units had perforce to be put in quarters which were below the desired standard.

10. The original projects had in fact been based upon a degree of immobility in the anti-aircraft defences which could never exist. If the enemy chose to change his objectives, as he later did, units had to be moved in accordance with operational needs rather than with some theoretical accommodation problems of our own. Consequently, as time went on and the deployment of guns changed, the general standard of accommodation for Mixed batteries became further removed from that originally set. So long as reasonable recreational facilities during periods of inaction and satisfactory ablutions at all times were available for them, the morale of women in an operational rôle was always high, and subsequent events proved their great courage. I cannot praise too highly the valuable work these women performed or the splendid spirit which they brought to it.

11. In the emergency deployments of Heavy guns later in the war, women had to be accommodated in emergency conditions if the defences were to remain operative, and they not only accepted those conditions but even chose to remain at their posts when offered an opportunity to leave.

During the temporary concentration of defences on the south coast to protect our invasion forces and later in the emergency deployments to counter the flying bomb, they were accommodated under canvas with all the accompanying inconveniences and finally some units were withdrawn from my command to serve in the anti-aircraft defence of Antwerp and Brussels during a winter campaign, a decision which was the finest possible tribute to the work of the Mixed batteries as a whole.

12. Although generally women were employed on Heavy guns where units were concentrated, the serious loss of manpower in searchlight units led me to consider whether it might not be possible to employ them in this rôle also. Owing to the impossibility of mixing the sexes in small detachments, any such units had to consist wholly of women and though one searchlight regiment was created in this form and gave a good account of itself, I was dissuaded from extending the experiment for two reasons. First, it was not possible to find a sufficient number of women officers capable of assuming tactical as well as administrative responsibility and secondly, searchlight sites were normally provided with Light Machine-Guns for local air and ground defence, and women, however willing to do so, were not allowed to handle guns of any kind.

Home Guard.

13. However, further demands for economies in manpower were already upon us. In October, 1941, a cut of 50,000 men for the Field Force was ordered. In order to man the equipment which was now reaching the Command in large quantities, the employment of Home Guards for anti-aircraft defence was once more considered. Home Guard personnel could not, however, do continuous manning and it was not easy to

arrange a scheme which could use part time soldiers effectively.

Their terms of service provided that they should not perform more than 48 hours of training and duty in 28 days and in the event of raids taking place they could only volunteer for extra duty with the permission of their civil employers. It was impracticable to permit any of the major defences of the country to be manned on those terms, even if, as later occurred, the terms were somewhat modified.

14. It was at this time that we had been planning an extension of the anti-aircraft defences by the widespread introduction of Rocket Batteries; the supply of rocket weapons had now increased to the extent that demands for shipping had been met and a surplus was rapidly becoming available for home defence. Unlike other forms of defence the principle involved was simple and required no long and complex training. Rocket weapons appeared to be eminently suitable for operation by the Home Guard and I accordingly proposed the introduction of Home Guard Rocket Batteries. The proposal was approved and units began training immediately.

15. It was agreed that each man should be called upon one night in eight, so that where 178 men were required to keep a site in action on any one night, a total of 1,424 were necessary in order to permit full and continuous manning of the site. These figures will give some idea of the dimensions of the new project, but this was far from being the only difficulty. It was decided that a call for volunteers would be unsatisfactory because many would probably be young men who would shortly be lost under conscription. The responsibility for providing men therefore devolved upon the Ministry of Labour and they selected those who were not otherwise employed on any form of National Service.

16. Disciplinary control over members of the Home Guard was virtually impossible and it was an easy matter for those who were so inclined to evade all duty. It was due entirely to the service given by the unselfish that the Rocket Batteries became and remained a force which the German aircrews treated with the utmost respect.

17. Within a year the Ministry of Labour was showing signs of being unable to fulfil demands and men were transferred from Home Guard infantry battalions. The Home Guard infantry battalions, formed when invasion was an ever-present threat, contained all the keenest and most enthusiastic elements and whole units might have transferred to an anti-aircraft rôle. But, when called upon to give up men while retaining an infantry rôle, it was natural that they should allow only their least efficient members to transfer to the Rocket Batteries.

Arrangements were made whereby one or more Home Guard General Service Batteries were affiliated to the local AA Battery from which the latter could draw recruits. Those unsuitable for AA duty, due either to medical reasons or change of civilian employment, were drafted back to the Home Guard Battalion concerned.

18. In 1942 manpower pressure increased further. In July, 1942, the *ad hoc* sub-committee, charged with relating the requirements

and availability of equipments with the availability of manpower for anti-aircraft purposes throughout the world, allotted to Anti-Aircraft Command a ceiling of 264,000; in October, 1942, a reduction to 180,000 was suggested. By introducing what was termed "over-gunning" the ratio of men to guns in Heavy Anti-Aircraft units was further reduced. In places where guns were concentrated, batteries became responsible for more than the normal eight guns and the Home Guard were also introduced to Heavy anti-aircraft gunnery, taking over one or more guns under supervision of the local unit.

Where guns were scattered no over-gunning was possible. The effect in saving therefore became more pronounced as the defences increased and as more guns could be concentrated, rising from about 6 per cent. with 1,500 guns to 15 per cent. with 2,500. By this means the number of Heavy equipments in action was not reduced. Nor was it found necessary to reduce the number of Light guns in action, for the Home Guard took over the defences of certain factories and railways with these weapons and it was agreed that the R.A.F. Regiment should take over the defence of airfields.

19. Anti-Aircraft Command was at the same time largely absolved from the responsibility of holding and draft-finding, which had been such a burden hitherto, so that ultimately this 1942 cut was limited to ten searchlight batteries.

Cuts in Man-Power.

20. The size of this cut was, however, only kept within these limits by reducing the number of male Heavy anti-aircraft batteries from 92 to 64, that is, by replacing men with women in 28 batteries. I regarded 64 as the absolute minimum number of male batteries I should have, since there were certain commitments which I hoped not to have to ask mixed units to undertake. I still envisaged using male batteries only for emergency deployments and I had to retain some male batteries for training and holding purposes. Fortunately the threat of invasion had receded and I was now able to move mixed units into those south and south-eastern areas from which they had been previously excluded.

21. In September, 1943, the question, now a regular annual one, recurred again. An assessment of German air strength at this time led to the conclusion that certain risks might legitimately be taken in the way of considerably reducing the defences in some of the northern and western areas and cuts were made in all forms of defence, the manpower in Anti-Aircraft Command being reduced by 13,700.

22. In June, 1944, further cuts were suggested which had to be postponed because of the attacks by flying bombs; but in August, 1944, it was proposed to regard large areas of the country as probably immune from further attack and during September, 1944, I lost all Smoke Defences and 28 Searchlight batteries, followed in November, 1944, by 11 male and 101 Mixed Heavy batteries, 34 Light batteries and 14 more Searchlight batteries. Finally in January, 1945, I lost 6 male Heavy batteries, 35 Light batteries, 33 Searchlight batteries and at the same time the Home Guard Rocket

batteries, which had been allowed to become non-operational in November, 1944, were finally disbanded.

23. This bald statement of the progressive reduction in the country's anti-aircraft defences gives no idea of the intensity of the problem which it presented. The men suitable for an infantry or an R.A.S.C. rôle were to be found in every unit under my command and these had to be extracted to meet the urgent requirements of the field force and had to be replaced by less fit men from disbanding units in such a way as to minimise the effect upon the batteries which were at the time heavily engaged in the flying bomb battle.

24. Nor were reductions in the defences the only manpower problems of those difficult years. I have already mentioned that the general labour shortage caused the building of A.T.S. accommodation to fall behind schedule and as the number of mixed batteries increased and redeployments of Heavy guns became more necessary, so the acuteness of the difficulty increased. Finally, we concluded that we must have within Anti-Aircraft Command a labour force which could be applied exclusively to our own needs and early in 1943 certain batteries were withdrawn from their operational rôle for this purpose.

These were reconstituted as Construction Batteries and 1,800 men were finally employed in this manner. In this unspectacular rôle the Construction Batteries made a most valuable contribution to the defence of the country.

Supplemented by 7,500 unskilled workers from disbanding Light Batteries, they were largely responsible for the success of a vast building operation during the flying bomb battle to which I shall refer later.

New Equipment.

25. Concurrently the equipment problem became easier. The 3.7-inch gun on a static mounting remained the standard Heavy equipment with a number of similar guns on mobile mountings as a supplement. A special 3.7-inch barrel was designed for the 4.5-inch guns and the conversion of these weapons began at the end of October, 1943; the work was still proceeding at the end of the war but all the 72 4.5-inch guns in the London area were modified by the end of November, 1943; this gun, which was known as the 3.7-inch Mark 6, was remarkable for its high muzzle velocity. A still more effective Heavy gun of 5.25-inch calibre also began to come from production during this period. The first guns of this calibre to go into action were of naval design with twin barrels and these operated from April, 1942. A model with a single barrel, designed especially for anti-aircraft work, began to appear in May, 1943.

The chief Light anti-aircraft weapon continued to be the 40-mm Bofors but it was supplemented by increasing numbers of 20-mm equipment, largely Oerlikon or Polsten guns, and from the beginning of 1944 by an increasing number of twin 0.5 inch Brownings in power-operated turrets.

There was also a steady flow of new radar designs intended to give greater accuracy than the earlier models. These later designs were able to work successfully at high angles of sight. Auto-following was introduced by which

the sets were kept on the target, once it had been located, by an automatic electric control; this auto-follow system first operated in action on the American SCR 584 sets during the flying bomb battle.

Though the numbers of the various equipments in action were, until the closing stages of the war, always below the totals regarded as necessary, there was generally a steady and progressive improvement throughout the period covered by this part of my despatch. The only serious setback occurred when war broke out in the Far East. Anti-Aircraft Command gave up 66 Heavy and 216 Light guns for the new theatres of war and for six months afterwards received practically no fresh equipments from production.

26. At the outbreak of war with Japan in December, 1941, the Heavy guns which were available to me totalled 1,960, made up of 935 static and 465 mobile 3.7-inch guns, 416 4.5-inch guns and 144 of the obsolete 3-inch guns.

At the end of 1942 the total was 2,100, made up of 3 twin 5.25-inch guns, 1,200 static and 475 mobile 3.7-inch, 406 4.5-inch guns and 16 3-inch guns.

In June, 1944, at the beginning of the flying bomb battle, I had 2,635 guns, made up of 3 twin 5.25-inch and 25 single 5.25-inch guns, 1,672 static, 527 mobile and 149 Mark 6 3.7-inch guns and 259 still unconverted 4.5-inch guns.

The position with the Light anti-aircraft weapons when Japan entered the war was that I had a total of 1,197, made up of 1,056 40-mm Bofors, 8 obsolete 3-inch guns, 71 miscellaneous types of 2-pounders and 62 20-mm Hispanos.

At the end of 1942 the total had increased to 1,814, of which 1,717 were 40-mm Bofors, 6 3-inch guns, 5 2-pounders and 86 20-mm Hispano and Oerlikon guns.

In June, 1944, the total had risen sharply to 4,589, made up of 2,681 40-mm Bofors, 1,257 20-mm Hispanos and Oerlikons and 651 twin 0.5-inch Brownings.

Rocket projectors in action numbered 4,481 at the end of 1942 and 6,372 at the end of 1943.

In addition to the increase in the numbers of equipments and to the introduction of new types, certain important inventions were made for use with the older types. The first important one appeared in 1943 and was the Automatic Fuze-Setter for the 3.7-inch gun; the earliest designs had the effect of increasing the rate of fire of those guns to which it was fitted by about 50 per cent. while later designs increased it by over 250 per cent. and greatly improved the accuracy of the fuze-setting.

The second invention was the proximity fuze which did away with the need for fuze-setting altogether and was extensively used in the flying bomb battle. With these fuzes the explosion was controlled automatically by their proximity to the flying body; the rapid loading by means of Automatic Fuze-setters was continued with the new fuzes.

Tactical Employment.

27. The tactical plans for the employment of guns in Gun Defended Areas did not change during this period but considerable changes were made in the tactical employment of searchlights.

The scheme for using searchlights in clusters which had been introduced in the autumn of

1940 had not proved as successful as had been hoped; the spacing of lights proved too great for continuous engagement so that night fighters still failed to intercept with searchlight assistance; low-flying raiders were often able to slip through unobserved and the anticipated increase in the range of beams was not noticeable.

In September, 1941, therefore, lights were re-deployed on single sites. The basis of the redeployment was a mathematical conception known as the Fighter Box; this was the area within which a night fighter with nothing to aid him except his own eyes and the visual indication of searchlight beams could intercept a bomber which entered that area. After trials had been carried out the size of the box was established as being 44 by 14 miles. The Box system remained the basis of searchlight deployment for the rest of the war.

The country was divided into a complete system of boxes around the various Gun Defended Areas. In the centre of each Box was a stationary vertical searchlight beam around which a night fighter circled until he received an indication that a bomber was entering the Box. At the ends of each Box searchlights were spaced at about 6 miles intervals and in the middle the spacing was about $3\frac{1}{2}$ miles. A series of boxes placed side by side thus created a continuous belt in which lights were thin at the edges, where they constituted an Indicator Zone and dense in the centre which was the Killer Zone.

Later, when enemy penetrations became so shallow that they often failed to reach the Killer Zone altogether the Indicator Zone spacing was thickened and the orbit beam was moved forward if it was thought to be necessary.

28. Just as in March, 1941, the responsibility for fire control had largely passed from Gun Operations Rooms to the gun sites themselves, so now the responsibility for searchlight control tended to shift from Sector Operations Rooms to the searchlight sites. The old form of control had done much to destroy initiative and it was only by degrees that it was possible to instil into the junior officers the sense of responsibility necessary for the successful operation of the new system. In addition there was at the outset a shortage of S.L.C. Radar equipment.

Consequently there developed a distrust of searchlight-assisted interceptions among R.A.F. night fighter crews and Commanders who preferred interceptions ordered on the findings of their own G.C.I. radar. It was towards the successful co-ordination of the two methods of interception that all our energies were now bent, and co-operation became steadily closer and more satisfactory as time went on.

29. Though the main use to which searchlights were put was naturally the illumination of night raiders, they were also employed for a number of other special purposes throughout the war, in an anti-minelaying rôle, to illuminate balloons for our bombers and to make meteorological observations of cloud bases at night. Especially worthy of mention was the system of homing beacons for friendly aircraft which operated from the end of 1939; figures were only kept for a period between September, 1942, and August, 1943, but in that time 525 aircraft were saved from imminent disaster,

600 were homed to alternative airfields and 184 were helped to base.

Re-organisation.

30. The organisation of Anti-Aircraft Command into three Corps and twelve Divisions remained until October, 1942, when a further re-organisation took place. This was prompted by a number of reasons; the desire to economise in manpower, the need for fewer intermediate formations between Command Headquarters and units allowing a quicker dissemination of orders, the need for still closer co-ordination with R.A.F. Groups and the desire to achieve a better balance of responsibility since the shifting of the emphasis in defence southwards had over-loaded 1st Anti-Aircraft Corps.

Corps and Divisions were therefore abolished altogether and were replaced by seven Anti-Aircraft Groups. There were three grades according to the operational commitments in the Group area and establishments appropriate to each grade were worked out. The system was extremely flexible since the grade of any one Group could be changed to meet current needs.

31. The seven groups were situated as follows:—

1st. London.

2nd. The Solent, south-east England and southern East Anglia (these two Groups coincided with 11 Group R.A.F.).

3rd. South-west England and south Wales (coinciding with 10 Group R.A.F.).

4th. North Wales and north-west England (coinciding with 9 Group R.A.F.).

5th. Northern East Anglia and the East Coast as far as Scarborough (coinciding with 12 Group R.A.F.).

6th. North-east England and Scotland (coinciding with 13 Group R.A.F. (except Northern Ireland) and 14 Group R.A.F.).

7th. Northern Ireland.

The defences of the Orkneys and Shetlands remained a separate organisation, responsible in operational anti-aircraft matters direct to Anti-Aircraft Command Headquarters.

In the later stages of the war there were at times concentrations of defences in certain areas quite beyond anything visualised in October, 1942, and the local Group Headquarters was not sufficient to deal with the tremendous increase of work. In these circumstances, group boundaries were altered to permit the insertion of an extra Group in the affected area.

Thus, 6th Anti-Aircraft Group took over the Solent area during the preparations for invasion, Scotland becoming the responsibility of a new 8th Group. 6th Anti-Aircraft Group was disbanded when its responsibilities in the South had ended.

The progressive reduction of defences in the North and West in 1944 enabled me to disband the 3rd, 4th and 7th Anti-Aircraft Groups and to extend the responsibilities of the 2nd and 5th Groups westwards into their areas.

A 9th Anti-Aircraft Group was especially created in southern East Anglia when there was a heavy concentration of equipment there in the later stages of the flying bomb battle.

SECTION II.

Attacks by piloted aircraft.

32. In the first part of my despatch I referred to the cessation of heavy night raiding

in May, 1941, when the greater part of the German air forces were transferred to the Russian front. After May there were a few major raids (e.g., on Birmingham on 4-5th June, Southampton on 21-22nd June, and Hull on 17-18th July). The scale of attack, however, gradually decreased, and for the rest of the year, apart from occasional attacks on other targets, the remaining German forces in the West were thrown mainly into the Battle of the Atlantic by attacks on ports and shipping and by heavy minelaying. The position in the Atlantic was still most precarious and the attacks made were designed to increase our shipping difficulties.

33. Attacks on convoys continued, and activity was most intense on the East Coast, Hull being frequently subjected to attacks by aircraft which were either on navigational and operational training or which failed to locate the shipping they had come to attack. The Thames Estuary, St. George's Channel and the Mersey were also continually mined.

34. The fact that much of this activity never came overland and that the defences were not therefore able to do much to hinder it caused us much concern and I therefore proposed that anti-aircraft forts might be situated out in the various estuaries to hamper these attacks.

35. Mr. G. A. Maunsell, a well-known consulting engineer, produced a design for a spider-like tower which, in its fully developed form, would carry 4 3.7-inch guns, 2 40-mm. Bofors, 1 searchlight and a radar set. Work began on these towers at once but the first was not ready until October, 1942, when much of the minelaying effort had subsided.

Although it had originally been intended to place them in a number of different estuaries, tidal and other difficulties finally caused the project to be limited to the Thames and the Mersey. In the former, in particular, the Maunsell Forts covered an approach which had always been a serious gap in the defence system and they played an important part in the defence of London when heavier raiding began again later.

36. Overland night raiding began again suddenly in April, 1942, and was apparently stimulated largely by a desire for revenge for Bomber Command's attacks on German cities. The main stream of German raiders kept clear of Gun Defended Areas and in these so-called "Baedeker" raids attacked open towns and cathedral cities; where any of the raiders strayed into range of the gun and rocket defences of a Gun Defended Area, the defences went into action with success. Exeter was particularly a target for the enemy in the first phase of these attacks.

Within 72 hours the defence of 28 towns from Penzance to York which had hitherto been undefended was put in hand. A total of 252 guns were withdrawn chiefly from Gun Defended Areas in the North and West. Success was almost immediate and in the last two raids of the April full moon period the defences destroyed 4 enemy aircraft and probably destroyed or damaged 4 more. With the May full moon raiding began again and Canterbury was subjected to severe attacks, but this form of attack also petered out in the following months.

37. A less spectacular move, of 120 Heavy guns, was made at the same time as the "Baedeker" deployment to augment the defences of ten South Coast anchorages in which was assembling a fleet for the invasion of North Africa in the late Autumn. I was still much concerned at this time with the shortage of equipment, for almost all new production was being diverted to the Far East and the defences of the west coast ports were dangerously weak. As large American forces were at the time disembarking there, an attack on that area might have had serious consequences. Moreover, there was a distinct possibility that we would have to yield a large number of guns to the field forces under a plan, which did not actually mature, for the invasion of North Europe in 1943.

38. Meanwhile on 27th March, 1942, a day battle had begun. This was in answer to our own fighter sweeps across the channel and consisted of tip-and-run low level raids on coastal towns by fast fighter-bombers. There appeared to be no military significance in these attacks nor were they on a scale to do much harm.

It would appear that one of the most striking lessons from these raids was the very great value of A.A. guns and balloons in minimising civilian casualties and damage, quite apart from the infliction of casualties on the attacking aircraft. Objectives with no balloons and few guns (e.g., Exeter) suffered badly in these raids, whereas those with adequate static defences came off comparatively lightly.

39. The weapon with which to counter the low-flying raider was the Light gun but the supply of these was seriously limited. Not only had I yielded up some for the Far East but new production was also fully absorbed by that theatre of war. When 189 guns were needed to help defend the anchorages on the south coast I was able only to provide 76, and many of those were withdrawn from the defence of vital industrial plants. Further, no less than 57 different coastal towns between St. Ives and Aldeburgh had been attacked by September, 1942, and the problem of defending all of these and also others which might be subject to attack would have required a number of guns far in excess of those available. As it was, in June, 1942, when guns from production began to come forward once more, we allotted 104 of these to what were termed the Fringe Target towns.

40. Towards the end of September, 1942, it was clear that the attacks, however unimportant from a military point of view, must be stopped and it was at that time that the equipment situation had eased sufficiently to allow steps to be taken. Production had improved and Anti-Aircraft Command was receiving a greater share of it; inland industrial targets had had their defences replaced and these could be denuded once again, and the Admiralty were steadily returning the guns lent them a year previously. My intention was now to join the battle with all the forces I could muster with a view to inflicting such losses on the enemy that he would have to give up this form of attack. No half-measures could be successful. By the end of September, 1942, 267 40-mm. Bofors guns had been deployed on the coast, another 110 could be withdrawn from factories and I was informed that I could expect 142 from production in October, 1942.

41. As was always the case, however, the mere deployment of guns was not in itself sufficient. The raiders approached at heights of less than 100 feet, having found that by this means they could almost always escape radar detection; consequently it was impossible either to warn the anti-aircraft defences in time for the guns to be manned or to scramble fighter aircraft into the air to make an interception. To watchers on the shore the enemy planes could only be seen at the last minute and they used every device which would help them to make an unobserved approach such as sneaking in up undefended valleys and hedge-hopping along the coast.

42. Orders were therefore issued that every Light anti-aircraft gun within five miles of the coast from the North Foreland to Land's End would be constantly manned during daylight hours, but even so it was difficult to secure the necessary degree of alertness when a town might go unattacked for months at a time, while the cold of the approaching winter did not help.

43. To secure freedom of action for the guns we arranged that no R.A.F. plane should cross the coast at less than 1,000 feet except with undercarriage lowered, so that all low-flying single-engined aircraft could be assumed to be hostile without the necessity for prior identification.

44. In December, 1942, the defences were further reinforced by the addition of large numbers of 20-mm. guns, and other 20-mm. equipments were manned by the R.A.F. Regiment; batteries of 40-mm. Bofors were loaned by Home Forces and the Canadian Forces. By March, 1943, the Fringe defences had increased to 917 40-mm. guns, 192 20-mm. (with another 232 expected shortly to be available) and 674 light machine-guns of various kinds.

45. The winter successes were limited and the pattern of attack remained similar, though the average number of planes in each attack showed a slight tendency to increase.

46. There were, however, two attacks of an exceptional size and aimed at targets further inland. On 31st October, 1942, a sweep of 60 raiders made a sharp attack on Canterbury and this was followed by two bomber raids the following night. On 20th January, 1943, a similar number, aided by diversionary raids elsewhere, made an attack on London. We thereupon deployed a small number of 40-mm. guns on Heavy gun sites and had a simplified drill worked out for the Heavy anti-aircraft gunners.

47. Meanwhile, the winter had been spent in improving and elaborating the warning system. Use was made of certain R.A.F. stations on the coast and new marks of radar were deployed. Radio links between these and Light Anti-Aircraft Troop Headquarters were established and the signals organization, besides installing and maintaining these radio sets at the receiving end, also laid a network of land lines for every Troop Headquarters to the guns they controlled. It was now possible to warn guns when an attack was imminent and in April, 1943, an improvement was beginning to be observed in the results when the attacks suddenly ceased.

48. On 7th May, 1943, the German attacks were renewed with much stronger forces and between that date and 6th June, 1943, 15 attacks by about 300 aircraft were made. The

guns destroyed 25 and probably destroyed or damaged 13, the R.A.F. destroyed 17 and probably destroyed or damaged 4. Thus the battle was brought finally to a successful conclusion. Altogether 94 different towns had been attacked, of which the heaviest sufferers were probably Eastbourne and Hastings. Though Light anti-aircraft shooting was not as much a science as Heavy anti-aircraft shooting, there is no doubt that it was largely the result of the application of scientific assistance to the Light guns which in the end achieved success.

Smoke Defences.

49. I must now digress in order to refer to the Smoke Defences, the responsibility for which had on 1st April, 1943, been transferred from the Ministry of Home Security to Anti-Aircraft Command. The smoke screens were manned by the Pioneer Corps and once again we were to experience all the disadvantages of a divided control. It was only with the greatest difficulty that sufficient control was obtained to enable us to secure even the most limited efficiency.

50. After the successful attack by Bomber Command upon German dams in May, 1943, it was feared that there might be retaliations in kind and the Chiefs of Staff placed a very high priority upon the defence of our own reservoirs throughout the country. For a short time these were defended by Light anti-aircraft guns and searchlights withdrawn from aerodromes and "Baedeker" towns. Since April, 1943, however, very considerable technical strides had been made in smoke production; chemical, as opposed to oil, smokes were rapidly developed on the basis of earlier work by the Ministry of Home Security and entirely new methods of rapid multiple ignitions were evolved. Training of the Pioneer troops, which had previously been much neglected, was improved and long overdue steps for the improvement of their welfare and health services were taken.

51. Consequently, I was able to suggest that the defence of our dams might more economically be provided by smoke screens, since what had to be feared was a precision type of attack. For six dams this proposal was accepted and it is worthy of note that this was the only occasion throughout the war when smoke alone was accepted as a sufficient defence.

52. For thirteen other dams, however, the smoke defences were to be supplemented by catenary defences and no guns or searchlights were to be withdrawn until the chains were in place. The task of producing and erecting the necessary masts and chains proved much slower than had been anticipated and as a result, for the greater part of the following winter (1943-44), two conflicting forms of defence were in operation at these dams. Apart from the fact that this was uneconomical, it aggravated the already difficult problem of providing accommodation. The troops were generally placed in remote hills where weather conditions were notoriously bad and it was fortunate that the winter proved to be unusually mild and dry.

53. No attack on the dams actually took place, but the defences remained operational until the disbandment of the Smoke Companies in the autumn of 1944. Other Smoke Companies took part in the defence of southern ports from Great Yarmouth to South Wales during the preparations for the invasion of Northern Europe.

Resumption of Night Attacks.

54. Apart from mine-laying, with the concurrent attacks on coastal towns, the "Baedeker" raids and a few other sporadic attacks, the United Kingdom had been comparatively free of attacks by night ever since May, 1941, but in the autumn of 1943 the German air forces once more began to apply themselves to this form of raiding.

55. The fast fighter-bombers now began to come over at night and they were later accompanied by new fast bombers. At first the raids were comparatively small and of shallow penetration but from October, 1943, they began to increase in size and to aim again at London.

56. I have already mentioned that night fighters might be put on to a bomber either by searchlights controlled from the Sector Operations Rooms or by the R.A.F. Controllers using their G.C.I. radars from G.C.I. stations. The unpredictable behaviour and speed of the present targets sometimes meant that a night fighter failed to secure an interception because it was limited to one or other of the two forms of control. It was only at this stage that successful co-ordination of the two forms of control began to be achieved, the chief step towards which was the shifting of the control of the searchlights from the Sector Operations Rooms to the G.C.I. station. After this it was possible to change from one method of control to another and back again and so to exploit the advantages of each with perfect flexibility. It was also possible to use without friction both methods in order to maintain the maximum number of night fighters in operation. This series of attacks may be said to mark the peak of searchlight performance, for not only were they used to the best advantage in co-ordination with fighters but their own performance in illumination exceeded everything that had been achieved before.

57. The guns on the other hand were somewhat disappointing and I looked for considerable improvements as soon as experience with new equipment had increased. At this time the Automatic Fuze-setter was just coming in, so were new marks of radar, the 4.5-inch guns were about to be converted into 3.7-inch Mark 6 and 5.25-inch guns were also beginning to be deployed.

58. The new radar sets were very sensitive to interference and on 7th/8th October, 1943, the Germans began to drop strips of metallised paper similar to those which our own bombers had for some time been using over Germany. These had the effect of producing spurious breaks in radar cathode ray tubes which could either be mistaken for aircraft or else appeared in such profusion that an aircraft break could not be identified and followed. It was a move which had been anticipated but to which no satisfactory answer had been found.

59. At first no great trouble was caused because of the limited amount of paper dropped and lack of tactical application in its use. An improved and increased use of it soon followed, however, with very serious effects. Early warning radar equipments were unable to give any accurate estimate of numbers of aircraft approaching nor of the heights at which they were flying nor even where they might be expected to make landfall. Similarly, inland sets found themselves largely unable to track individual aircraft and in places sets were rendered

absolutely useless. While, in October, 1943, only the leading aircraft used to drop the paper, by February, 1944, every raider was doing so and sometimes areas 50 miles long and 25 miles wide were completely infected.

60. Searchlights were the most seriously affected and frequently had to resort to the old and ineffective control by sound-locators. Many gun control radars were affected but a few types were able to continue in service.

61. There was every reason to anticipate a renewal of heavy attacks on London, for the German air forces had for some time been experimenting with pathfinder technique. The quality of their navigation had greatly deteriorated and it was common for many raiders to lose their way completely during this period and if pathfinder flares had been wrongly placed over open country to have no hesitation in bombing there.

62. The anticipated heavy raids began on 21st/22nd January, 1944, with 200 aircraft in the first raid; the improvement in gunnery was considerable, eight raiders being destroyed, while searchlights contributed to half of the R.A.F.'s eight successes. Other raids followed and the attacks culminated in a week of intensive raiding beginning on 18th/19th February, 1944. In March, 1944, raiding became much more sporadic though still heavy on individual nights.

63. At the same time Heavy and Light guns, searchlights and smoke screens were moving southward for the protection of the invasion ports. Some experience on a more limited scale had been obtained in July and August, 1943, when there had been a large increase in coastal defences in the South for a large scale exercise known as "Harlequin". On that occasion the area affected had stretched from Dover to the Solent and the defences there, which already consisted of 266 Heavy guns, 319 Bofors and 171 searchlights, were increased by 348 Heavy guns, 432 Bofors and 93 searchlights. After the exercise in September, 1943, the additional defences had dispersed.

64. Now, during the spring of 1944, we began to build once more the defences all round the coast from Great Yarmouth to South Wales. I was responsible not only for equipment in Anti-Aircraft Command but also for a large number of Heavy and Light guns which were loaned to me by the Field Army, at any rate until the invasion had been launched and they were wanted overseas; I also received assistance both in Heavy and Light guns from the U.S. Army forces on the same terms. These loaned equipments had to be most carefully woven into the fabric of defence so that their early withdrawal would not disturb the balance of defence remaining.

65. I have already referred to the valuable scientific help given me by the Americans in the early stages of the war; this help was continued right through. There was the closest liaison between us at all times and in the second half of 1943 a specially selected Demonstration Battery from Anti-Aircraft Command had conducted a most successful six months' tour in the United States with a consequent valuable exchange of views. In December, 1943, U.S. anti-aircraft units had become operational in the United Kingdom, some batteries being deployed for the defence of London while their

main responsibility was the protection of U.S. Army and Air Force installations.

The largest number of U.S. anti-aircraft troops so deployed at any one time had been just over 10,000. During the summer of 1944 English and American Light Anti-Aircraft units exchanged parties of all ranks, each party taking a fully operational rôle with their hosts and this exchange similarly provided a valuable exchange of ideas and did much to foster goodwill. The U.S. forces were naturally anxious to participate in all our major activities.

66. Before any additional defences were introduced for the protection of invasion ports, the equipments between Great Yarmouth and South Wales consisted of 842 Heavy and 332 Light guns and 4 smoke screens. These were supplemented from A.A. Command resources with 252 Heavy and 244 Light guns and 13 smoke screens. In addition we were to receive from our field forces 248 Heavy and 360 Light guns and from the U.S. forces 32 Heavy and 184 Light guns. The total defences of the various ports would therefore amount to 1,374 Heavy and 1,120 Light guns and 17 smoke screens. In addition the Balloon defences were to be increased from 342 to 535. As it turned out these figures had to be reduced by 56 Heavy and 188 Light guns in order to provide a reserve against the possibility of a simultaneous attack by flying bombs which had for some time been feared and to which I shall refer again later.

67. So important in its effect on the whole course of the war was the plan now unfolding and so well known to the German Intelligence that considerable interference from the German air forces was anticipated. In the event, however, raiding of invasion ports was not serious and in most cases the deterioration in German navigation enabled even those few places which were attacked to escape without serious damage.

68. Apart from some desultory intruder activity in March and April, 1945, these were the last attacks by piloted German aircraft on this country. There were, however, fears towards the end of March, 1945, that a desperate low flying suicide attack on London might be launched and plans were made to increase the Light anti-aircraft defences of the capital from 36 to 412, Anti-Aircraft Command providing 236 of the guns and the R.A.F. Regiment the remaining 140. Whether the attack would ever have taken place or not, had the Germans retained control of the airfields in north-west Germany, it is impossible to say but in the end this deployment never took place.

SECTION III.

Attacks by Robot Weapons.

69. The first official intimation that attacks might be made by pilotless aircraft upon the country were received on 7th December, 1943. The estimated scale of attack at that time was 200 missiles an hour and targets were expected to be London, the Solent and Bristol.

70. Plans were at once made to meet the threat. London was to be protected by a belt of about 1,000 Heavy guns, sited on a line south of Redhill and Maidstone to the southern bank of the Estuary. There was to be a belt of searchlights in front for co-operation with fighters and a belt of balloons behind. A similar plan was made for the defence of Bristol, with a gun belt to the north and a

searchlight belt to the south of Shaftesbury and a balloon belt south of Shepton Mallet. Little could be done for the Solent beyond a readjustment of the Isle of Wight defences.

The decision to deploy well inland was taken in order to reduce enemy jamming of radar equipment; to allow fighter aircraft the maximum area for manoeuvre and to leave the coast defences free to engage attacks by piloted aircraft. It was not intended to use either static guns or mixed units in these plans.

The constant attacks by Bomber Command on the launching sites on the French Coast caused the threat to recede, and with the increasing need for a large deployment to protect the invasion ports the plans were at first abandoned and then revived in a very modified form so as to interfere as little as possible with that deployment.

Had the enemy begun his flying bomb attacks before or even at the time the invasion was launched, the strain upon our resources would have been extremely serious, but fortunately at the time the attacks began it was already apparent that no serious scale of attack was to be expected against the ports.

71. On the night of 12th/13th June, 1944, the first missiles, known by the code name "DIVER", arrived.

72. It was believed that these were only tests and no special deployment was ordered until sustained attacks began on 15th/16th June, 1944. The original plan for the defence of London was then put into operation in the modified form it had had to assume to permit the simultaneous protection of the invasion ports, although certain withdrawals from those defences were made.

Three hundred and seventy-six Heavy and 592 Light guns were deployed and in addition the R.A.F. Regiment on the south coast was operating 560 Light equipments, consisting of 192 40-mm. Bofors and 368 20-mm. guns. To achieve these figures without seriously affecting the defences elsewhere, units of the Royal Navy (including D.E.M.S.* personnel) and the Royal Marines, from the Field Army, from training camps and others were employed. It had been estimated that 18 days would be necessary to complete this deployment but it was actually completed in a week and was quickly in action since Anti-Aircraft Command Signals had, ever since the first warning in December 1943, been laying the necessary lines for intercommunication all over the area. The Signals under command of Brigadier G. C. Wickins, C.B., C.B.E., T.D., were outstandingly efficient throughout the whole war. The personnel was drawn largely from the G.P.O.

For three nights the guns in London fired at those targets which had penetrated the primary defences, but after that they were restricted since it was clear that it was better to allow the flying bombs a chance of passing the more densely populated parts of the Capital rather than to shoot them down into it.

73. Reference has been made in the first part of my despatch to the peculiar difficulties of Heavy Anti-Aircraft gunnery, the chief of which was that an assumption had to be made as to the behaviour of the target between the initial plotting and the burst of the shell in the sky. Any form of evasive action, however slight, could seriously affect the accuracy of

* Defensively Equipped Merchant Ships.

the shooting. Now, for the first time in the war, the guns were presented with a target which did not take evasive action and which obeyed all the assumptions upon which Anti-Aircraft gunnery had been based. It might have been expected that exceptional results would at once be obtained but this was not the case and successes were less than 10 per cent.

74. The whole question had been carefully examined as far back as February, 1944, and it was believed that the targets could satisfactorily be dealt with, especially if certain new American equipments could be acquired in large numbers, provided—and this was especially emphasised—that good results were not expected at heights between 2,000 and 3,000 feet, where the target would be too high for light guns and too low for heavy guns and where the effectiveness of Anti-Aircraft fire was likely to be small. I was therefore perturbed to find that it was exactly in this 1,000 feet band that the targets were almost invariably flying.

Arrangements were made immediately for a personal representative to fly to America to speed up, if possible, the delivery of the new American equipment, and General Marshall, who interviewed him, promised to send at once 165 of their latest radar sets, the SCR-584, together with all the necessary ancillaries including the No. 10 Predictor. This promise was fulfilled.

75. There were many other difficulties. The spheres of influence of guns and fighters overlapped, and a most awkward system of limiting one or the other according to meteorological conditions was worked out. The radar sets, which had been sited in hollows to avoid enemy jamming, were cluttered up with spurious breaks caused by contours of the ground. The balloon barrage was extended and many guns had to be re-sited, with resulting difficulties over the radar.

76. Above all, the low height at which the targets flew required a higher rate of traverse by the guns than the mobile 3.7-inch was capable of giving. The static 3.7-inch gun, on the other hand, though capable of traversing sufficiently quickly, required an inordinate length of time for its emplacement on concrete. It was at this point that Brigadier J. A. E. Burls, C.B.E., and the R.E.M.E. Staff produced a platform on which the static 3.7-inch guns could be emplaced quickly, which was portable, and which in the end proved to be one of the keys to success. It consisted of a lattice work of steel rails and sleepers filled with ballast.

I must here pay a sincere tribute to the work of R.E.M.E. from the day the Corps was first formed. Under Brigadier Burls' inspired leadership there was no job they did not tackle.

77. We decided to replace all the mobile 3.7-inch guns with the static version, and the first 32 had been emplaced and were showing improved results when the whole policy of the co-ordination of guns and fighters was changed.

Neither fighters nor guns were being given full scope, for the guns had to ensure that the break on their radar tube was not a friendly plane before opening fire, while the fighters in pursuit of a V.I. often had to give up the chase when approaching the gun zone. Lieut.-Colonel H. J. R. J. Radcliffe, M.B.E., at that time my Technical Staff Officer, suggested that we should re-examine the plan of locating the

guns on the coast. This plan had always seemed to us to have great advantages from the gun point of view, but there were difficulties from the fighters' point of view in that their scope was thereby limited by having to break off an engagement on approaching the coast and start it again if the target got through the gun zone.

It was, however, now very clear that without some very radical re-arrangement, two-thirds of the V.I.s would continue to get through to London. The fighters were still having only a limited success, though that success was much better than the guns were experiencing.

Fighter Command were evidently thinking on the same lines, for at a meeting called on the afternoon of 13th July, at their H.Q., after a lengthy discussion the C.-in-C. Fighter Command decided that the guns should be moved to the coast, and orders to that effect were given.

78. The new belt was to extend from Cuckmere Haven to St. Margaret's Bay, and the first guns began to move on 14th July, 1944. Apart from the move of all the equipments in the existing belt to the coast, there was a simultaneous move of 312 static guns coming in to replace the mobile guns and a further move of 208 Heavy, 146 40-mm Bofors and over 400 20-mm guns in a deployment on the Thames Estuary to which I shall refer later. The moves involved 23,000 men and women, for with the introduction of the static 3.7-inch gun came the Mixed Batteries and 30,000 tons of ammunition and a similar weight of stores; 3,000 miles of cable were laid for inter-battery lines alone.

In four days the move to the coast had been completed.

79. There were various advantages in this new coastal belt. First, radar sets were freed from the clutter of inland interferences and, since the enemy was not using active jamming methods, they were able to be put to the best possible use; secondly, there was a good chance that many bombs destroyed by the guns might now fall in the sea instead of on land; thirdly, the existing defences on the South coast, including those of the R.A.F. Regiment, could now be incorporated in one scheme, and fourthly, the unsatisfactory and alternating limitations on guns and fighters, introduced because of mutual interference arising from the fighters' inability to identify the position of an inland belt, could now be dispensed with, since the line of the coast would clearly reveal the position of the belt to aircraft. The move to the coast was the second of the keys to success.

80. Almost immediately after this the new American equipment, which we were so anxiously awaiting, began to arrive, and as soon as troops could be trained in its operation it was deployed along the belt. Not only was the SCR-584 the most suitable of all the radar equipments available, but its use, in conjunction with the No. 10 Predictor, directed fire with a degree of accuracy hitherto unattained. At the same time the problem of exploding the shells at the correct height was solved by the introduction of the proximity fuze. This equipment provided the third of the keys to success.

81. As soon as the coastal deployment was in action results began to improve, but although I have emphasised three points which in my opinion did more than anything else to

contribute to success, there were also innumerable other smaller matters which each in its own way played its part. No less than 200 modifications, for example, were made to the Heavy guns by my R.E.M.E. Services, while an almost equal number of adjustments had to be made to the American equipments before they could finally be put into action.

82. General Eisenhower himself took the greatest personal interest in the battle, maintaining that London was as much a base for American troops as for British ones; he insisted on being allowed to increase the defences by the welcome addition of 20 American Anti-Aircraft Batteries equipped with 90-mm Heavy guns. The total of Heavy guns in the belt rose to nearly 600.

83. My ultimate object was to provide an almost robot defence to a robot attack; I visualised the battle as the culmination of the scientific development and training of more than four years and the final proof, if such proof were needed, that the troops of Anti-Aircraft Command, though they must be soldiers first, must become far more than mere soldiers; they must be scientists and technical operators of the highest quality.

84. For the moment training was still a tremendous problem, and there was much more to be done than simply to train Heavy Anti-Aircraft on the new equipment, itself a serious enough problem in the middle of a major battle. Besides lowering the normal base of Heavy Anti-Aircraft fire in order to cover the unprotected height band in which the bombs were flying, we endeavoured to raise the normal ceiling of Light Anti-Aircraft fire. For this purpose arrangements were made to use radar for the first time to control light guns, and light anti-aircraft troops had therefore to be instructed in methods of unseen fire, hitherto a closed book to them.

85. The flying bombs also presented an unparalleled opportunity for trying out equipments still in the experimental stage. It provided all the difficulties of an operational target flying at great speed with the security that no reports of our counter-action would become available to enemy sources. Interspersed with more normal equipment along the belt were anti-aircraft tanks, experimental versions of the Polsten gun, Ministry of Aircraft Production experimental quadruple 20-mm guns, other 20-mm guns with gyro sights, Bofors guns linked to No. 7, No. 9 and No. 10 predictors, Petroleum Warfare Department 9-inch mortars, 2-inch Naval rockets and others. More was learnt about the potentialities of anti-aircraft work in 80 days than had been learned in the previous 30 years.

In addition one Searchlight Regiment was converted to a Rocket rôle and manned 4 twin Rocket Batteries, 512 barrels in all.

86. The original inland searchlight belt did not move to the coast with the guns and it was only at this stage that it began to give full value. There were now two fighter areas, one out to sea and one behind the gun belt. With the latter the Searchlights co-operated at night. Although the flame from the propulsion unit of the flying bomb made it self-illuminating at night, fighters were not usually able to judge its distance or course without the assistance of

a searchlight intersection, especially while making a fast dive and turn towards it. Owing to the low flying height of the bomb a rapid traverse was required and this called for skilful operation, especially since it was essential not to dazzle the fighter, which, at such low heights and high speeds, would then have been in imminent danger of crashing. Of the targets which penetrated the coastal belt at night, searchlights assisted fighters in the destruction of 142, or something over 30 per cent.

87. The continuous nature of the attack, the simultaneous need for training and the constant building of sites (and re-building as they were moved to admit new equipment) caused a very severe strain on the men and women in the battle line. Guns were sometimes manned for 100 per cent. of the 24 hours and often for between 80 per cent. and 90 per cent. Relief forces had to be drawn in from units in other parts of the country.

88. On 19th August, 1944, the eastward advance of the armies in France rendered the westward end of the belt largely superfluous, and the portion between Cuckmere Haven and East Hastings was closed down and the units used either to reinforce the remainder or to extend it from St. Margaret's Bay to Sandwich. At the same time units from 21st Army Group and from Training Establishments were largely withdrawn so that the burden of the battle devolved more upon the units of Anti-Aircraft Command itself. This had the advantage that a greater degree of uniformity in fire control discipline could be secured, and much rather wild shooting was now eliminated.

89. The re-adjusted belt continued to show improved results until activity ended on 5th September, 1944, with the capture by the armies in France and Belgium of the remaining launching sites. The degree of improvement since the period of the inland belt, when the successes were under 10 per cent., is shown in the percentages of flying bombs destroyed in the following successive weeks; these were, in the first phase of the coastal belt, 17 per cent., 24 per cent., 27 per cent., 40 per cent. and 55 per cent., and, in the second phase of the coastal belt, 60 per cent. and 74 per cent.

90. It had been established early in July, 1944, that the Germans were not only launching their flying bombs from ground sites on the French coast, but were also launching a few from specially adapted aircraft. Some of these flew westwards down the Channel, aimed either at Southampton or Bristol, others came in from the North Sea towards London. The latter threat was the more serious, and a deployment was ordered along the coast from the River Blackwater to Whitstable, known as the "Diver Box". The Maunsell Forts in the Thames Estuary proved an invaluable addition to this defence scheme.

91. On 16th September, 1944, attacks were renewed, but many of the bombs came down upon London from the north-east, thereby outflanking the Diver Box to the north. On 18th September, 1944, therefore, 16 Heavy Batteries and 9 Light Batteries began to move to the area between the River Blackwater and Harwich. The attackers moved further north and the outflanking continued. On 21st September, 1944, it was decided to create a new belt

as far north as Great Yarmouth; initially intended to consist only of male batteries, it later included mixed batteries as well. Steps were taken to protect Bomber Command aircraft and U.S. Air Force bombers which regularly crossed this strip of coast.

92. On 22nd September, 1944, orders for the deployment of the "Diver Strip", as it was called, were given.

For a variety of causes, many beyond our control, the deployment was not completed till 13th October, 1944. Even this date would not have been achieved but for the excellent work of the R.A.S.C. drivers who drove both themselves and some of their transport to a standstill in their effort to meet the conflicting demands made upon them.

93. Generally, the deployment in the Diver Strip followed the lines which had proved so successful in the Diver Belt. 34 Heavy Batteries were deployed and 36 Light Batteries; the rôle of the latter, however, was changed from that previously used in an attempt to produce an intermediate effect between Heavy and Light anti-aircraft fire. Of the 36 Batteries only 15 were equipped normally, the remaining 21 had 2 static 3.7-inch Heavy guns in place of 4 of their 40-mm. Bofors; these were controlled in 15 instances by No. 10 predictors and in 6 instances by No. 3 predictors modified for range-finding by radar means. Thus there were in all 516 3.7-inch guns and 503 40-mm. guns. Within a month it was clear that the Light Anti-Aircraft units, even when modified for an intermediate rôle, were not providing a satisfactory contribution and they were withdrawn. The total of Heavy guns was increased to 542.

For initial intercommunication 200 wireless receivers were distributed, but these were replaced as soon as land lines could be provided. In the marshy districts of the deployment, where the country was everywhere intersected by considerable streams, this was a considerable task, involving 2,000 miles of cable, much of which had to be carried on poles. Once more our Signals showed their quality.

94. In this new phase of flying bomb activity the average height of the missiles dropped to 1,000 feet. Guns firing proximity fuzes could still deal with them though they had to be most carefully sited if they were to do so successfully; the radar sets in particular provided a problem since the need to detect the bombs at long range and the need to eliminate clutter at low angles of sight were mutually antagonistic; searchlights were most affected because the lower the height of the target the more difficult was continuous illumination.

95. The need for constant alertness produced that same degree of strain which had been evident for a time on the South coast, but I had not now available, owing to manpower cuts, the same reserves on which to draw for reliefs.

96. For some time we had been representing to the War Office that the war establishments of Anti-Aircraft Command units were anomalous, based as they were on the assumption that A.A. units were similar to units in a field army which had spells out of the line however continuous the fighting. In a spell of continuous air activity, no unit of Anti-Aircraft Command could anticipate any period of rest, and to base

its war establishment on the assumption that air activity would be sporadic was a fallacy. It was agreed therefore that, if a spell of continuous air activity threatened or occurred, a special increment could be made to the establishment. This is not altogether a satisfactory solution owing to the consequent lack of team training.

In the present instance it was possible to allow units to rest by day because attacks were almost always made at night, and radar information from sets in both the Low Countries and in England gave detailed advance information of impending attacks.

97. This series of air-launched flying bomb attacks continued until 14th January, 1945, but of a total of 1,012 plotted only 495 bombs came within range of the guns, for in spite of the extension of the Strip to Great Yarmouth many still outflanked it to the north and many were inaccurately aimed and flew elsewhere than to London. Of the 495 targets only 66 got through and reached London.

98. On 14th October, 1944, that is as soon as the deployment was complete, a decision was taken about providing winter quarters in the area. Events at the approaches to Germany had shown that the war was likely to continue through the winter; and the extreme wetness of the autumn weather made living conditions in the already marshy land extremely uncomfortable. The Mixed batteries were offered the opportunity of leaving the Strip for better quarters inland but unanimously they asked to remain.

The project was a considerable one, involving the building of 60 miles of road, 3,500 huts and the laying of 150,000 tons of rubble and hardcore in the mud as foundation for guns as well as buildings. The cost of the project, which was equivalent to the building of a town the size of Windsor, was £2,000,000 and the building trade estimated the work would take 6 months to complete. It was carried out by the Construction Batteries, reinforced by 7,500 men of Anti-Aircraft Command, the latter being responsible for the collection, loading, unloading and distribution of materials and for providing unskilled labour. The work was completed in 2½ months.

99. On 24th December, 1944, a further deployment was ordered when 40 flying bombs were launched across the Yorkshire and Lincolnshire coasts towards the industrial areas of Lancashire. In spite of heavy snow and fog the deployment was completed in 5 days, for all the necessary preliminary reconnaissance had been carried out some months previously. These defences, known as the "Diver Fringe", extended from Flamborough Head to Skegness and remained in position until the end of hostilities although no further attacks on the North were made. 152 Heavy guns were involved in this area.

100. During February, 1945, information was received that land-launched attacks with bombs of longer range might be resumed from the Dutch coast, and on the 2nd/3rd March, 1945 attacks began and lasted until 29th March, 1945. Out of 157 bombs plotted, 107 came within range of the guns who destroyed 81. On eight days 100 per cent. successes were obtained. Only 13 bombs reached London.

: Perhaps the most remarkable tribute to the results being obtained by the guns lies in the fact that the A.O.C.-in-C. some weeks before the end of the attack withdrew all his squadrons, except two, for service overseas. The defence in these last weeks rested almost entirely on the guns.

101. Although this was in effect the end of the operational activities of Anti-Aircraft Command there was one more development with which I must deal. I refer to the attacks by long-range rockets, the first of which had fallen upon London on 8th September, 1944.

I had already been advised of the possibility of such attacks and twelve radar sets had been deployed on the south and south-east coasts to endeavour to track any rockets that were fired.

When the attacks were found to approach London from the east, the sets were re-sited on the east coast and though nine were subsequently withdrawn for use on the Continent, others were brought in to take their place.

It was established that the range was about 200 miles, the maximum height something over 50 miles, the maximum speed more than 3,000 m.p.h. and the landing speed about 1,800 m.p.h. In effect it was a high velocity shell of alarming explosive power, the flight of which was long enough to permit calculations to be made as to where it might land. These calculations were not always accurate but at the same time not widely inaccurate. It was, however, not possible to secure satisfactory plots of every rocket that was fired.

102. I felt convinced that this was the beginning of one of the great problems of the future and I considered whether I could take any steps to deal with it. On 12th December, 1944, I proposed that I should be allowed to try shooting at the rockets with a view to destroying them in the air. The idea of shooting at a shell was admittedly revolutionary, but there seemed to me to be no reason why it should not be anything more than a further development of the present unseen firing methods. My proposal was rejected as it was not considered that it had a theoretical background of success sufficient to justify the danger to the civil population beneath the barrage.

I argued that operational shooting was an essential corollary of scientific theory and that only by experience could scientific theory advance; moreover, it was necessary to attempt to make progress before a more powerful rocket came into operation and finally, that war experience was essential for post-war planning. I was asked to prove that there was so much as one chance in a hundred of success and my proposals might go forward.

Experiments both in the matter of plotting, for which special radar sets were now developed by my R.E.M.E. staff, and of gun control instruments were pressed on with.

103. Radar sets situated north and south of the rocket's flight and another set forward in Holland tracked the parabola of flight. During March, 1945, there was an increase in the number of missiles plotted from 44½ per cent. to 48 per cent. The accuracy of the plotting showed a greater improvement. London was divided into areas 2½ miles square; the number which were predicted as falling into the correct

square rose from 11 per cent. to 31 per cent., and there was also an increase in the number which were only one square out from 44 per cent. to 50 per cent., and an overall improvement from 55 per cent. to 81 per cent. of those that were plotted at all.

104. I applied again for permission to fire. If I aimed at one of every two rockets descending and hit, as I estimated, one in 30, the chances were within the limits I had been set, although as 3 in 30 already burst in the air it would be some time before results could be proved. On the 28th March, 1945, I gave orders to the guns to be ready to fire but on the 27th March, 1945, the last rocket had fallen. On 30th March, 1945, the Chiefs of Staff again refused permission for the guns to fire at rockets.

105. The advance in the science of anti-aircraft defence since the beginning of the war has been prodigious, but I believe we are still only touching the fringe of future possibilities.

Air Defence is of such paramount importance that we must spare no effort and no expense to maintain our scientific lead.

106. On 15th April, 1945, I handed over my command to my successor.

107. I would add three names to the few already mentioned as having given outstanding service. There were many others but these can only be dealt with on a separate list.

Major-General P. H. Mitchiner, C.B., C.B.E., T.D., M.D., M.S., organized the Medical services in the Command. He was an administrator of a very high order as well as a first class Medical Officer. He rendered great services to the State.

The late Major-General Sir Hugh T. MacMullen, K.C.B., C.B.E., M.C., was Major-General in charge of Administration during the most difficult period of the war. He was outstanding. It was largely due to his administrative skill and tact that the Mixed Batteries settled down so easily and efficiently. Only sickness deprived me of his services.

Major-General R. H. Allen, C.B., M.C., was an outstanding Divisional Commander. He was responsible for the Anti-Aircraft Defences of the West Country. He made up for the limited resources of equipment by his great knowledge of Anti-Aircraft technique and by his skill.

When an attack took place it was always at only a matter of a few seconds warning yet both Gun and Searchlight units were ever on their toes.

Their discipline, judged by percentages of courts-martial and absence without leave cases, was twice as good as that of any other Command or Service.

The Corps of Royal Engineers rendered considerable service in that it trained and supplied the original Regular and Territorial Army Searchlight Units before they became part of the Royal Regiment of Artillery in August, 1940.

Other works carried out by the Royal Engineers included the designing of static emplacements and command posts, and making arrangements for a supervision of the construction of gun sites and hutted camps.

The A.T.S., particularly in the Mixed batteries, set a standard of bearing and conduct which in my opinion was not equalled by any other women's service.

The administrative services were not only efficient—they were outstanding. Our sick rate was always small though we never had anything like our quota of doctors.

The R.A.O.C. performed herculean tasks with all the new and complicated equipments. The R.A.S.C. set a higher standard of driving than in any other Command. The Signals have

been mentioned more than once for they were superb and were the one essential requisite in all our schemes.

R.E.M.E. produced an inventiveness, coupled with general engineering skill and enthusiasm, which gave us an answer to every difficulty.

The Chaplains department were the first to introduce the "Padre's Hour" into the Army. Much of the excellent discipline was due to them.

Finally, the Commanders and Staffs serving under me were worthy of the troops they led.

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