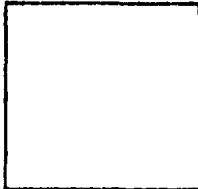


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THE WORK OF NO 2 OPERATIONAL RESEARCH SECTION

WITH 21 ARMY GROUP

JUNE 1944 — JULY 1945

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OPERATIONAL RESEARCH IN N.W. EUROPE

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COMPOSITION
OF
NO. 2 OPERATIONAL RESEARCH SECTION

Lt. Col. P. Johnson R.A.

Major M.H. Swann R.E.M.E.

Major J.F. Fairlie R.C.A. (left in Sept. 1944)

Major D. Hennessey R. Sigs. (left in Sept. 1944)

Major J.G. Wallace R.A.

Major D.F.B. Pike Gen. List.

Major H.A. Sargeant Gen. List.

Capt. G. Mathieson R.A.

Capt. D.N. Royce Int. Corps.

Capt. C.H. Oakley D.W.R.

Attached (from M.R.C.)

Capt. H.B. Wright R.A.M.C.

Capt. R.D. Harkness R.A.M.C.

FOREWORD

by the

SCIENTIFIC ADVISER TO THE ARMY COUNCIL.

No 2 Operational Research Section took part in the campaign with 21 Army Group from D day to the German surrender. When they returned to this Country on 20 July 1945, I directed them to collect and arrange in a permanent form, the records of their work. This involved mainly collating a series of written reports, but it was also a matter of great interest to me and my department to consider to what extent real progress had been made in this entirely new scientific subject, that of attempting to apply our methods to the study of some aspects of warfare.

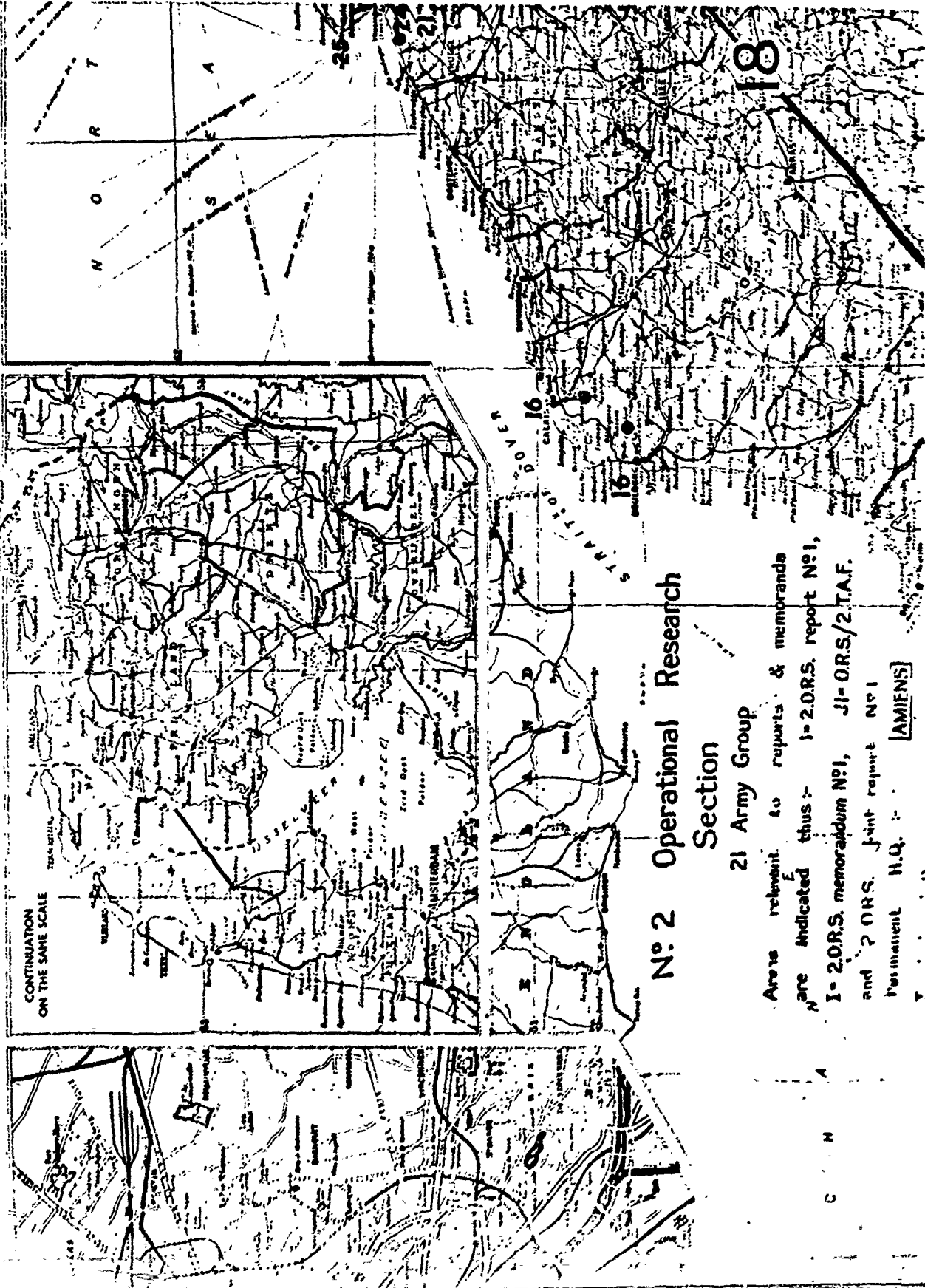
I therefore asked for a history of the work of the section, and for any ideas on the methodology of the research. This was written in the first instance, entirely for internal use in my department, but on reading it I felt that it provided a background for the reports, gave a coherence to the work as a whole that was very valuable, and merited a wider circulation.

I have therefore decided to add this account as an introduction to the reports. I have not edited it in any way, and it remains as it was written - a record of the views and reactions of a group of young soldier-scientists, intended for the eyes of other scientists.

In giving it a wider circulation I must emphasise that in no sense is it an official document, and this is indeed obvious from its informal style, but I hope it will help to convey the atmosphere in which the work, described in the reports, was carried out.

I feel that this account of the work of No. 2 Operational Research Section in North West Europe goes some considerable way to answering the questions "What is Operational Research?". What does it do? How does it do it? Much of what is recorded here is pioneer work, in the sense that nothing quite like it had previously been attempted. I believe that nobody, reading these reports, can fail to agree that they represent a great stride forward in the objective study of war, and the factual recording of what takes place in battle.

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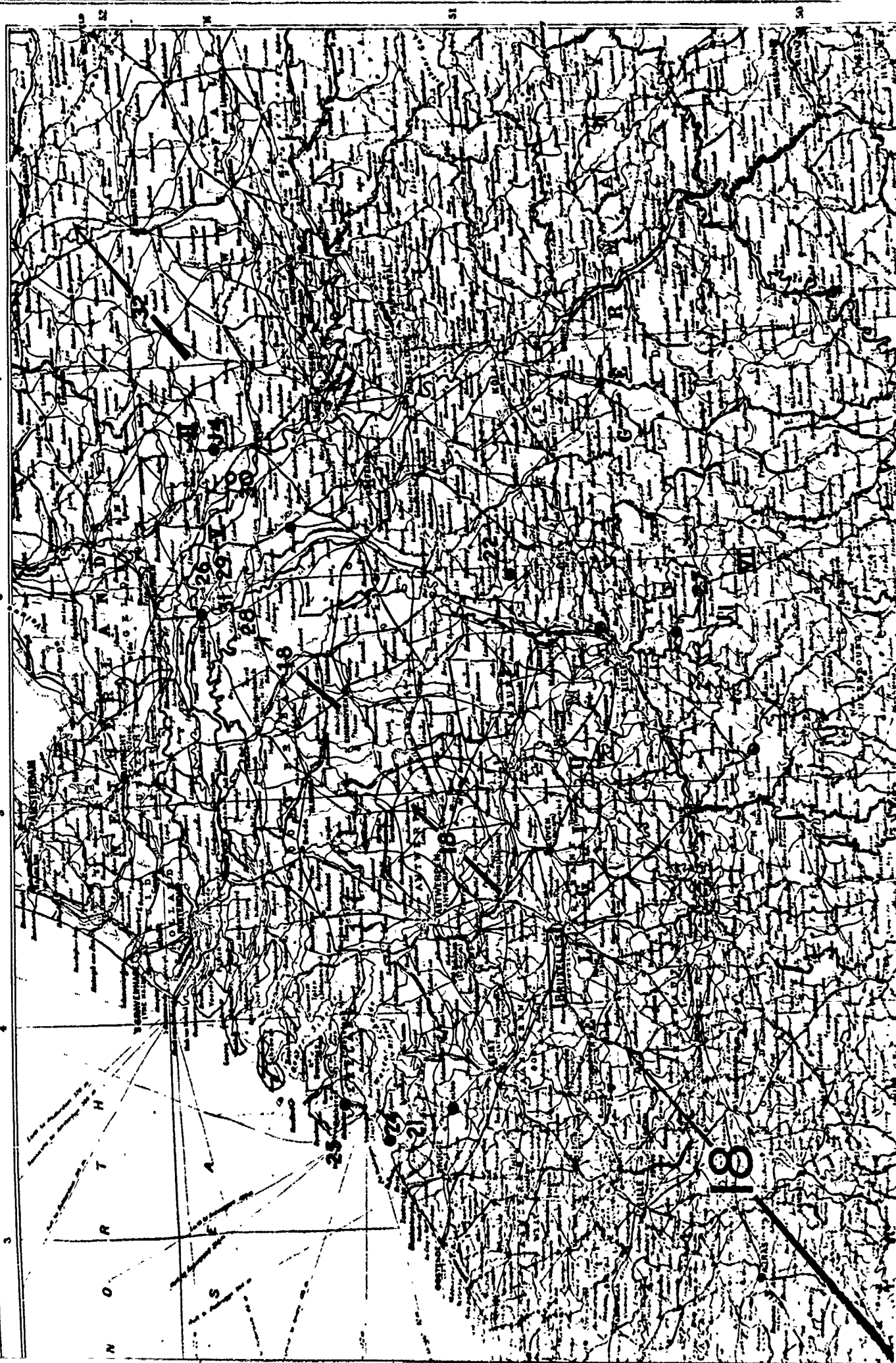
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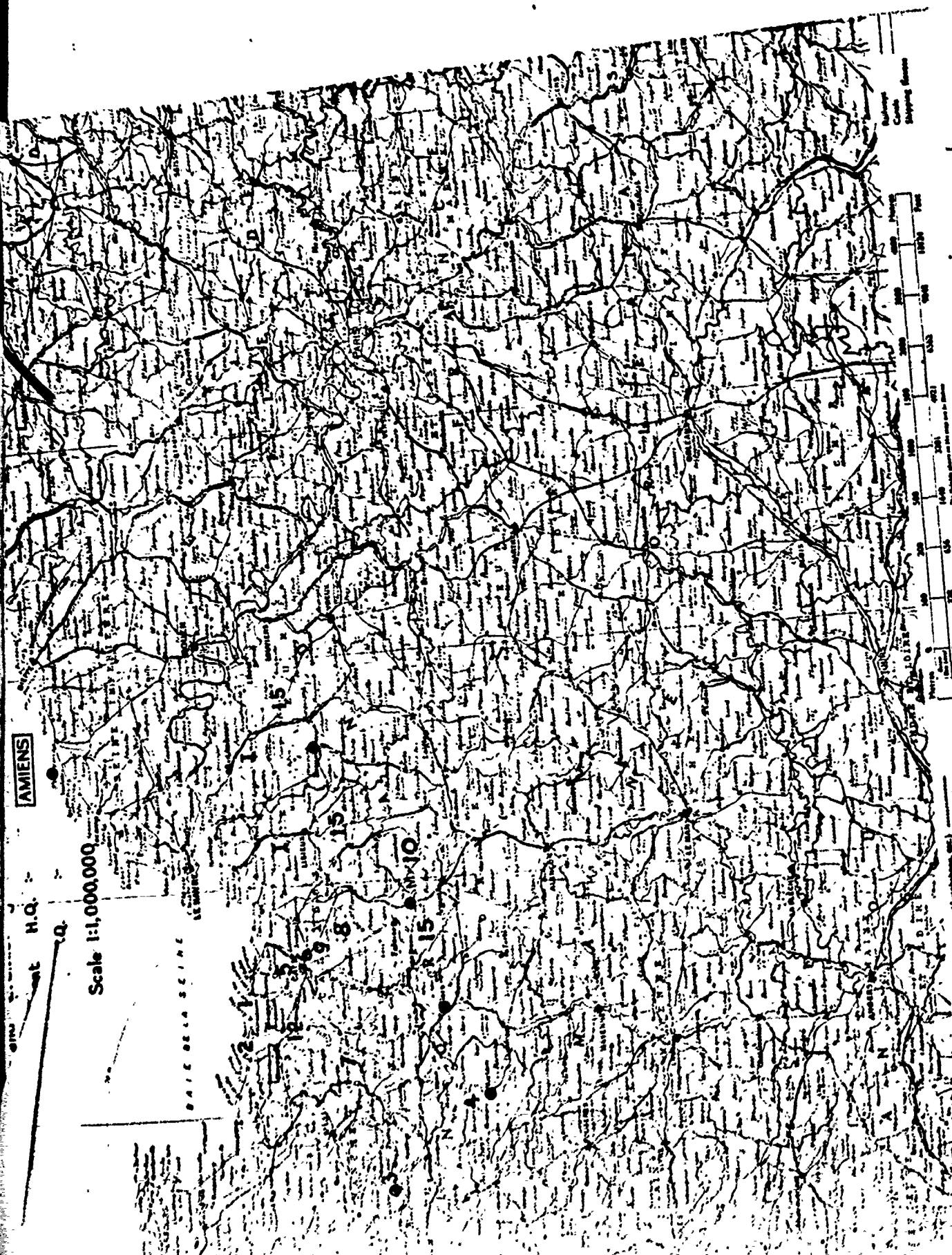
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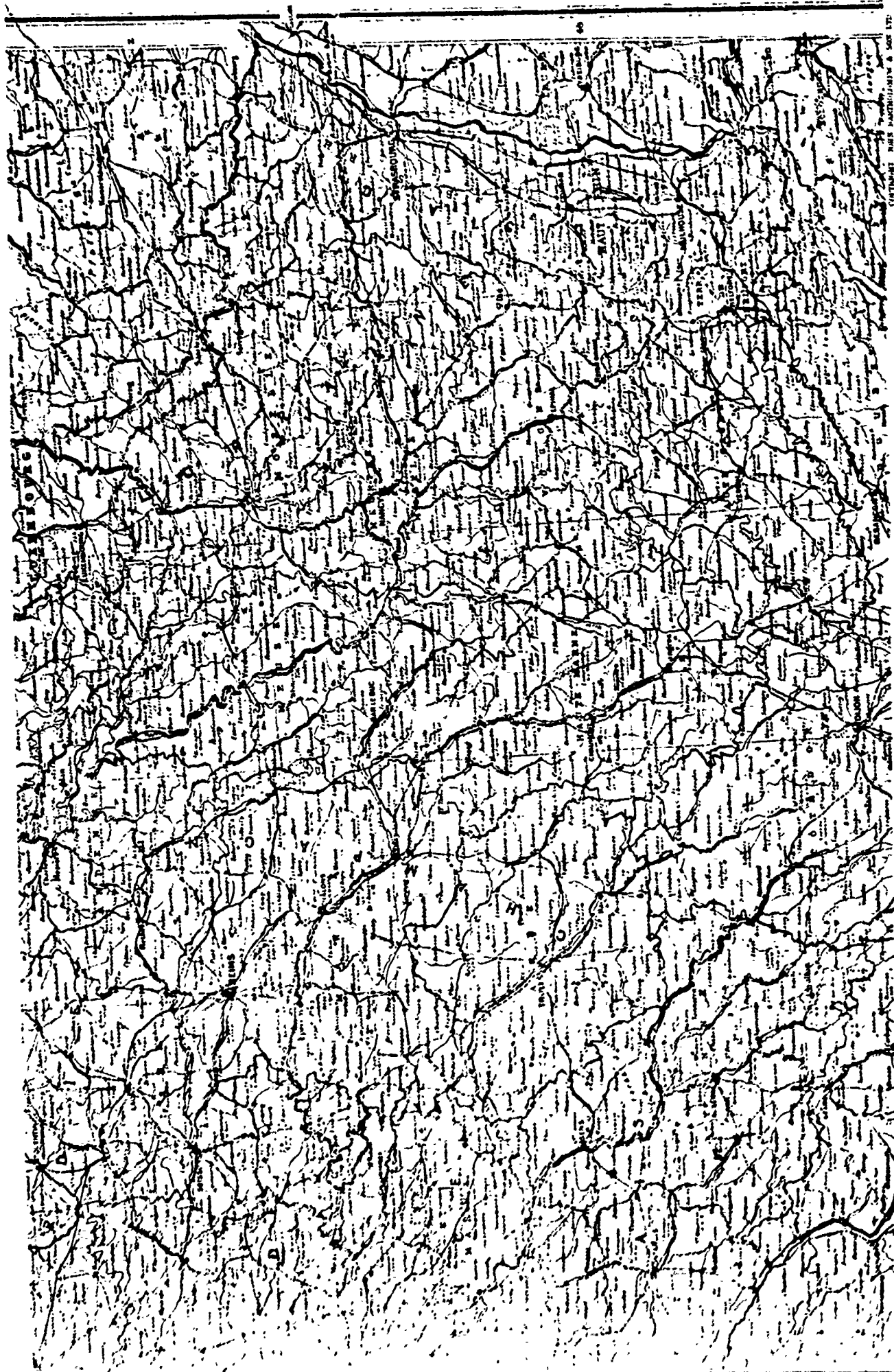




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INTRODUCTION.

§1. The importance of methods.

Long before the war it was evident that science would have much to contribute to the development of military equipment, and it was no surprise that research found such wide applications to the technically difficult but fundamentally amenable problems of Radar, Anti-aircraft and Fragmentation, to name only a few. These problems offered great possibilities to the well-established methods of the physical sciences. By contrast, the complexities of military tactics proved for a long time intractable, since even the smallest battle is a bewildering compound of variables, and new methods had therefore to be worked out before there could be any hope of results. In spite of these difficulties, each of the six Operation Research Sections set up at one time or another with the Field Armies achieved a considerable measure of success. But where the future is concerned, it is not so much the results they achieved, however valuable, as the methods they used, that will matter. For the superficial details of battle may be altered in a moment by the introduction of a new weapon, while the underlying principles of warfare scarcely change from one century to the next.

It is for this reason that we have put together the complete work of one Operational Research Section, that with the Army Group in North-West Europe, in a single volume. In it are the forty-odd reports written by the Section between June 1944 and June 1945, arranged roughly in subjects. To give them a coherence they do not of themselves possess, we have prefaced the reports with a short history of the Section, domestic as well as scientific, followed by appendices on the sources of information from which we drew in our work - records, interrogation and the battlefield itself. Some of the reports are already out of date, and more will become so in time; but whether out of date or not, there can be discerned in them the means we used and the outlook we brought to bear in our attempts at an analysis of warfare.

§2. Lt.-Col. Johnson lands on D Day; the Special Observer Party.

The history of the section, from the date of its joining 21 Army Group to D-day, has been traced elsewhere. Though much work was done by Lt.-Col. Johnson on Beach Reconnaissance and Radar, and by Major Honnassy on Signals, it was mainly a period of preparation: acquaintances had to be made, staff had to be acquired, vehicles and stores had to be drawn. By D-day, when the rest of the section was still busy with last minute arrangements in England, Lt.-Col. Johnson was nearing the Normandy coast in the capacity of Radar advisor to the assault Anti-aircraft brigade, with which he spent three weeks watching the performance of the multiplicity of apparatus that had been squeezed into the narrow confines of the bridgehead.

The next officer to leave England was Major J.F. Fairlie, Royal Canadian Artillery, who travelled as a member of the Special Observer Party, formed at the last minute to study the different types of attack on the coast defences. The party spent an uncomfortable fortnight, without batmen or drivers, digging their own slit-trenches and eating 24-hour ration packs, during which time they examined in detail all the emplacements and gun-positions in the British sector. It was a slow and tedious job, for in many cases mines and boobytraps had not been lifted, and the defences were elaborate. Some information on the accuracy of bombing and shelling emerged from the investigation, and the effect of different projectiles on German emplacements was determined: but for the most part the results were negative. Whatever induced the Germans to give in, it was not physical destruction of their fortifications, for of this there was little or none, despite the huge naval and air bombardments.

The Special Observer Party was the outcome of earlier studies of the attack on fortifications, such as Pantellaria; but like earlier investigations, the work was concerned only with physical effects. Although the far greater importance of morale effects had long before been realized in theory, this aspect was not within the terms of reference of the SOP, nor did we ourselves seriously attempt such work until nearly two months later. To assess the morale effect of a bombardment was, after all, to attempt an utterly new analysis; though there were many who had suggested doing it, there was no one who had ever tried.

§3. The arrival of the Advance Party.

The section began to take shape on D + 17, a week later than was originally intended, when the advance party landed in Normandy. It consisted of Major Swann and Major Sargeant, with a 15-cwt truck, a jeep, a motor-cycle and two drivers. The crossing was an unusual one; for the LCT, that was carrying us and a number of other small units, lost its convoy, wandered far off its course, was saved from going right into the Atlantic by taking a line on a passing V1, and finally made landfall on the extreme western edge of the American sector. Together with the Weapons Technical Staff Advance Party, we drove to Main HQ 2nd Army at Creully, where we were to live until the arrival of HQ 21 Army Group. The first night was spent, as far as we were concerned, in a furious thunderstorm and with no more shelter than a leaking tarpaulin. Tents were impossible to obtain and we lived under the same tarpaulin for five weeks or more. The next day we found Lt.-Col. Johnson, who had to leave for England immediately to attend conferences, and Major Fairlie, who continued to work with the Special Observer Party until he also returned to England to write his reports (Numbers 1 and 2).

The arrival of the section in Normandy by small instalments, was not of our choosing. But as a part of Army Group Headquarters, we would not normally have crossed until nearly two months after D day, so that we were glad of the various other opportunities that were offered to us of getting over earlier. Although, if the section had come over as a whole in the first few days, we should have got going correspondingly earlier, the loss was not so serious as might seem. Each arrival passed on his experience to the next, so that we wasted little time on the elements of finding our way around.

We lived now, and for the next six weeks, with the Weapons Technical Staff, feeding in their mess and enjoying all the advantages of their larger organization. But if our domestic arrangements were settled, our plans for the future were far from clear. Our small encampment was underneath an avenue of firs, which led down to the Chateau on the edge of Creully, round which the Main Headquarters of Second Army was scattered. The obvious start therefore seemed to be in the Headquarters itself, but a little investigation, though it met with every courtesy, gave us no more idea of what we might do nor where we might start. The next move then was to the forward areas, to gain if possible some idea of what fighting looked like and to find out for ourselves where our particular way of doing things could fit in.

§4. First visits and first ideas.

The first visit to the battle-front was Major Sargeant's, to an Armoured Regiment on a fairly quiet sector near Tilly-sur-Seuilles; it ended in a reconnaissance in an Armoured Car and a narrowly evaded ambush. The second visit was Major Swann's, to an infantry battalion which had just captured the village of Chaux; this visit too was an exciting one, in which a small German counter-attack with tanks developed.

Neither visit resulted in inspiration, but both gave a first glimpse, even though it was only a shadowy one, of what is a battle. These two were only the first of many visits to forward troops, in the course of which we accumulated a mass of new experiences. In those days the bridgehead was so small and Second Army Headquarters so near the front, that we could easily drive down to the battle area in half-an-hour, spend a day there, and come back in the evening, to bathe in the meandering river Seulles, search for Calvados liqueur in Crouilly and discuss at length the great problem before us.

By degrees our ideas crystallised, and a number of projects stood out as being worth some concentrated effort. Of the many that we turned over, the chief were: the location of enemy mortars, which were causing appalling casualties and proving almost impossible to deal with; the distribution of hits and penetrations in our own and the enemy's tank casualties, and the influence of this on tactics; the performance and the best method of use of the PIAT; the problem of dust on the roads, and particularly on airstrips (the dust in Normandy was extraordinary, and was wearing out certain types of aero engines at an alarming rate); and lastly the problem of mud, which in the rainy spells was causing great difficulties in the little lanes and tracks that had to be used as supply routes. The blessing of Second Army on those grandiose schemes was obtained, but in the end only the first two projects were ever completed. Dust was taken over by the Air Forces; mud, after looking hopeful, fell through because it became apparent that the ways of the Army were too rough and ready and liable to change in those hectic early days, to allow of any intricate planning of where roads should go; and the performance of the PIAT, which though it was often fired, seldom actually hit an enemy tank, turned into a series of planned trials which were run by the Weapons Technical Staff.

Two projects however remained: the Mortar Location and the Tank Casualty surveys. It is significant that neither were purely technical problems; nor on the other hand were they analyses of the whole or a large part of a battle. They were indeed midway between the technical and the operational; it was possible to isolate them, although the conditions of the battle were all-important. Both surveys necessitated much collection of information, and they were not finally published until the beginning of August. The mortar location report (Number 11) served as a factual basis for the planning of a Counter-Mortar organisation within 21 Army Group, while the Tank Casualty report (Number 12) was welcomed as one of the first papers ever to provide accurate data on how armour should be distributed on tanks fighting in close country. The two reports, though they were not finished until after some of our more ambitious efforts had been started, represent a significant phase in the Section's development.

85. Heavy bombing at Caen: the foundation of much of our work.

Meanwhile, almost by chance, the pattern was drawn for many of the subsequent investigations of the section. On the night of July 7th, Bomber Command attacked the northern outskirts of Caen, as the prelude to the first of a series of great battles in which Heavy bombing was used in close support of the Army, in an attempt to speed up the slow and bitter fighting to expand the Bridgehead. The unending stream of huge black aircraft flying over were certainly awe-inspiring and, visible as they were to almost everyone in the beach-head, they created a huge impression. But the battle that subsequently developed was as tough and hard as any, and it occurred to us to wonder what this immense effort had in fact achieved. Conflicting stories abounded,

and neither the RAF nor the Army seemed to have any clear idea. Without any directive from above and, with the object more than anything else of satisfying our own curiosity, we set to work to find out what had really happened. The three of us, Lt.-Col. Johnson, Major Swann and Major Sargenaut, spent several days looking over the ruins of Caen, talking to troops who had taken part and to Frenchmen who had been in Caen at the time, examining air photographs and defence overprints, and attempting to reconstruct and assess the battle.

The report (Number 5) was received with some interest at Second Army. Although we did not know it at the time, it was received with even greater interest by Brigadier Schonland, Scientific Adviser to 21 Army Group. But to our minds it was not satisfactory, since its conclusions were, probably of necessity, indefinite and negative. In it we had made no serious attempt to study morale effects, we had not considered the possibilities of prisoner-of-war interrogation and we had paid quite insufficient attention to its effect on the progress of our own troops. The report was, in fact, little better than a study of the plain physical effects of the bombing. The real value of this laborious and sad survey into the ruins of a French town only became apparent later, when we realised how much incidental experience and information we had gained and when we were asked to carry out, as a direct result of this work, many more such analyses. This report was in truth the foundation for the greatest part of the section's subsequent work.

About a fortnight after the great battle for the northern half of Caen, came Operation "Goodwood", one of the biggest set-piece attacks ever mounted by 21 Army Group, designed to break out south-east of Caen. Three armoured and four infantry divisions took part, while Bomber Command, 2nd TAF and the VIIIth and IXth U.S. Air Forces carried out a huge bombing programme. On the very day of the operation, an urgent telegram came from Brigadier Schonland, asking us to report on this, and all subsequent Heavy bombing operations, on the lines of our first effort at Caen. The Report (Number 6) had all the defects of our first report on Caen and a number more, since we started too late, the battle was too big for the small numbers of the section, and many of the bombed areas were still in enemy hands at the end. Out of this failure, however, we realised the essentials of success. In all the analyses that we carried out subsequently, we started in good time, studied the operation orders, watched the course of the battle and spared no effort to make them complete.

§6. The reasons for Operational Research.

The lack of knowledge of what had really happened in battle, that prompted our first investigation of the bombing of Caen, turned out to be the root cause of almost all the work we subsequently did. This ignorance was not of the sort that might, for instance, prompt such a question as: how can factory chimneys be knocked down by air or artillery? Though we were sometimes given such problems, they were usually referred to technical experts in the theatre or at home. Rather was it ignorance of a less technical and more fundamental nature, which arose from the vastness and impersonality of modern warfare, where the end-results of a particular course of action are quite remote from the initiators; where, for instance, the results of air attack on an enemy position can only be judged by whether the subsequent ground attack succeeded, when in fact it may have succeeded for a dozen other reasons. In consequence, our work developed into the search for means to reconstruct and analyse particular battles. Once the missing elements of the battle had been supplied, suggestions for improvement followed; and, for instance, the real value of a particular air attack had been determined, it was not difficult to say whether another type of attack would have been better.

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It might be argued that a set of highly-trained scientists were hardly necessary for such a job; certainly it must be admitted that technical scientific knowledge was seldom if ever needed. But of the many reports on battles, made by military observers, there were few if any, that by the careful collection of facts, and by reasoning from them, attempted to fill in the vital gaps in our understanding of warfare. The truth is probably that Operational Research does not demand scientists, but that it is greatly helped by scientific training; no doubt this is why few but scientists have ever succeeded in its particular analytical approach. For Operational Research is much more than the straight-forward collection of facts and the writing of histories; it must continually seek out all the sources of information, especially the least obvious, and, by sound reasoning from the facts, provide a new understanding of its particular problem.

87. Arrival of Major Pike: the Study of air attacks.

Soon after Operation Goodwood, Major Pike arrived with a further jeep and driver to join the advance party at Creully. He came in advance of the rest of the Section, as a result of arrangements made by Brigadier Schonland with the Air branch of 21 Army Group and with 2nd TAF, to study the effects of fighter and fighter-bomber support against the enemy. Here again it was lack of knowledge which prompted the work, and indeed, so great was the lack of knowledge of the effects of air attack, that a very large proportion of the Section's efforts, possibly an undue proportion, was devoted to this one subject.

Major Pike's first report, (Number 3) concerned an air attack on a German column. It was only a small incident, but typical of many, and the first case of its kind ever to be fully examined and documented. It should perhaps be compared with the bombing report on Caen, as a thorough investigation of the physical aspects of an action. His next report (Number 4) went considerably further; it concerned the effect of rocket-firing Typhoons in breaking up the German armoured counter-attack at Mortain, shortly after the American break-out from the bridgehead at Avranches. The report caused much controversy, conflicting as it did with other reports made by the RAF, and argument over it continued for a long while after. The conflict with the actual observed facts of the RAF reports is however not great, and as the only full and detailed survey made on the ground, this report should stand as the authoritative historical record. The truth of the matter is that rockets knocked out a number of tanks, caused great confusion amongst the enemy and, without any doubt, speeded the collapse of the counter-attack. Most of the destroyed tanks however, which were somewhat arbitrarily ascribed to the RAF, were knocked out by American artillery and by infantry-men with Bazookas. It was at Mortain, it may be noted, that we tried examining the battle field from an aeroplane for knocked out tanks; the experiment was not however a great success.

88. Re-organisation of the Section.

Towards the end of July, Main Headquarters 21 Army Group came to Normandy, and set up near Tronquay, west of Bayeux. The Section moved at the same time to an orchard in the nearby village of Noron la Poterie. Up till now we had been living on the Weapons Technical Staff, but it was apparent that we could not do so much longer, particularly as the rear party was expected at any time. A re-organisation had become essential.

Before D Day the Section had consisted of five officers, three drivers, a sergeant clerk, one jeep and two fifteen-cwt trucks. The establishment of an O.R.S. was however in the process of being enlarged

to embrace three more officers, an extra jeep and staff car, and a corresponding increase in other ranks. It was soon evident that even this would be insufficient for the section to be fully mobile and self-supporting, and for the officers to travel whenever they wanted to forward areas. In the first few days we learnt that only in a jeep was our type of "swanning" practicable: no other vehicle began to compare in speed, manoeuvrability in traffic, mud-riding capacity, and, most important of all for the immensely long journeys we later undertook, reliability. On his return from U.K. therefore, Lt.-Col. Johnson set about reorganising the section. An extra jeep was obtained from the now disbanded Special Observer Party, and the 21 Army Group War Establishments Committee drew up amendments to the War Establishment and G.1098, giving the Section a three-ton lorry, more drivers and general duty men, a cook, and all the essential equipment of an independent unit. The new organisation was adequate, though not lavish, as regards Other Ranks; but the transport was still insufficient, and it was often felt that two jeeps in place of the two 15 cwt trucks would have been an advantage. The latter were unreliable, cumbersome and, having only two-wheel drive, quite unsuitable for forward areas. They were in fact seldom used, and one of them was later exchanged for two jeep trailers. The other, after a colourful history of breakdowns, finally collapsed in the Ruhr and was left there.

The re-organisation, though soon agreed on paper, was not completed immediately. The section became once and for all independent in the middle of August, but was not up to strength in every respect until the beginning of September. The work of re-organisation fell entirely on Captain Oakley, the administrative officer. Officially the establishment of the O.R.S. contained no such appointment, but even before the section left England it had become clear that if the scientific officers were not to be unduly burdened, such a post was essential. Oakley joined the Section in England just before D day, and from that moment took on the entire administration: looking after Other Ranks, maintenance and repair of transport, accommodation, stores and office work. The administrative officer is a *sine qua non* for an independent mobile Section.

89. More Heavy Bombing

The seed of our early work on Heavy bombing burst into flower quite soon afterwards. Between 30th July and 20th August we wrote no less than five reports on Heavy bombing, did some work (unpublished) towards a sixth, produced also the report on Rocket-firing Typhoons at Mortain, and put the finishing touches to the reports on Sherman tank casualties and Mortar Location. It was a period, as can be imagined, of feverish activity, and it reflected perhaps the growing speed of the bridgehead battles, preceding the final tempestuous overflow of our forces into France, Belgium and Holland. Our position by this time was easier, for the rear party consisting of Majors Fairlie and Hennessy as well as Captain Oakley, the administrative officer, had arrived, and the reorganisation and re-equipment of the section was under way. We were helped too by Major Hill, G.S.O.2 to Brigadier Schonland, who worked with the Section now and later to such an extent as almost to be a member of it. Even so, we were seldom as busy as in those long sultry days; with everyone who experienced them they have left an impression of heat, dust, haze, and above all ceaseless activity.

The first of the five reports on Heavy Bombing concerned Operation Bluecoat, an attack between Caumont and Villers Bocage, supported by Bomber Command the VIIIth U.S. Air Force, and timed to coincide with the 3rd U.S. Army's attacks to break out from the bridgehead. Here at last we remedied some of our earlier omissions: we studied the planning and the course of the battle in detail, analysed the casualties suffered by our troops and talked to a number of units taking part. The result was something very much better than we had achieved before; it indicated

quite clearly too, the value of the bombing. The report (Number 7), still however, lacked any corroborative evidence from prisoners of war. 'Bluecoat' was quickly followed by another Operation, 'Totalise', between Caen and Falaise, supported again by Bomber Command and the VIIIth U.S. Air Force. The report (Number 8) followed the general lines of Bluecoat, though it was rather less complete. In the course of Totalise, the VIIIth U.S. Air Force dropped a number of bombs on our own troops; this incident we also investigated, from the point of view only of the destruction caused (Report Number 9).

§10. Reports on Heavy Bombing

Studying these Heavy Bombing attacks was a laborious and depressing affair, and at the time we prayed that we should never have to do any more of it. The dust and the appalling quantities of traffic, which still seemed to outdo the heart of London, made travelling to and fro an exhausting business. Having arrived at the front, we had to probe about in the desolation of one French village after another, often uncomfortably close to mortaring, shelling, and the front line, and search out from their hiding places units who had taken part in the battle. When we returned there were air photographs to be poro: over, and a thousand and one fragments of information to be assembled. It has been suggested that once fresh ground has been broken by the Operational Research Section, and a new method evolved, the work should then be carried on by others. Certainly in the case of these operations, such an arrangement would have enabled us to do far more, and more important perhaps, given us time and energy to develop new ideas.

Satiated as we now felt by field work, we sat down to think, and to write a report (Number 14) on Heavy bombing in Support of the Army which, thought it never went further than 21 Army Group Headquarters, did much to clear our ideas. It had been intended as a simple guide, but was vetoed as being too contentious and outspoken. Lastly, as an application of what we had laid down in our report on Heavy Bombing, we started one evening and worked furiously into the night, making out a plan based on bombing river lines, for blocking the German retreat from the Falaise trap, then fast assuming the shape of a pocket. The plan was never adopted for various reasons, but some weeks later we had the melancholy satisfaction of showing how many Germans escaped from the pocket and proving that a very belated attempt to block on river lines had been quite inadequate. It was our belief at the time that had the Air Forces been employed differently far fewer Germans would have got back across the Seine, and the course of the war might have been greatly changed. But it remains only a speculation, where each must judge for himself.

§11. Examining vehicles from the Pocket to the Seine.

A few days after our attempts to frame a plan for blocking the enemy retreat, the entire Section was ordered down to the "Pocket" to find out what the Air Forces had been able to do to the Germans in this same retreat. That day an advance party went down to find somewhere to live, and the next day every officer, and all but one or two Other Ranks, went down to Flers, a small town placed fairly centrally in what had been the eastern end of the pocket. For the first time the section was fully mobile and fully independent, and it was an enjoyable sensation. The countryside, the liberation spirit of the French, and the absence of destruction all combined to make the change from the suffocating closeness of the bridgehead not merely a change, but a transformation. For the first time we felt that the section had grown up and succeeded; from that moment though we had failures and setbacks, it never occurred to us that we were not a useful, if unusual, part of the Army Group's great effort.

After six days spent at Flers examining every destroyed and abandoned vehicle, during which time the pocket finally closed between Falaise and Argentan, we moved on to the area which, for a good reason, we called the "The Shambles". Everywhere it was littered with destroyed vehicles and equipment, and with dead and decaying corpses of horses and men. The stench, borne on the hot wind of late August, was nowhere absent for mile upon mile. We lived once again at a farm, in the village of Montabard, north of Argentan. And here, thanks to the extraordinary kindness of M. Picard, and his wife and children, we lived delightfully for six days amidst the desolation of death. While M. Picard and all the farmers worked incessantly to burn up the horses and bury the dead, we examined, although in less detail than before, thousands of vehicles.

For days now our only thought had been to escape, even for a few days, from the appalling task of examining vehicles in such an atmosphere for twelve hours a day. Visits to Mont St. Michel, Chartres and Orleans were often proposed, but never carried out. After six days we went on, this time to a chateau in Bornay, where we were royally looked after for the next ten days by a French girl, Mlle. Lillianne Lalloumand. From Bornay we examined all the vehicles between the Shambles and the Seine, visited the crossing places on the Seine, and tried to find out from the local inhabitants what had got across, and lastly, examined all the crossings of the rivers Touques and Risle, where a belated attempt had been made to block the German retreat by bombing bridges and their approaches. Work at Bornay went at a more leisurely speed, and the craving for a holiday gradually spent itself on the delightful country, and the pleasantness of the Chateau, of our Mademoiselle and of social life in the town.

The Army, however, seldom permits a good time to last, and the party started to break up. Major Sargeant was sent off to study the armoured pursuit on the far side of the Seine, then in full swing towards Brussels; Major Hennossey was called away to go to Burma; soon afterwards 21 Army Group moved to Amiens. Captain Oakley brought up the remains of the section from Noron, stayed a night with us at Bornay, and went on. So did the rest of the Army, and we were soon left high and dry by the passing flood, quite out of communication, and finding petrol and food an increasing difficulty. Eventually the dwindling party moved on, much to their regret, through damaged Rouen, to the unpleasant town of Amiens, though not without a detour to the home of Benedictine at Pecamp. In Amiens the section had some sort of existence for about 10 days, although it consisted during that period of little more than Pike, labouring at the mass of results from the Falaise pocket, and Oakley, striving to complete the re-organisation of the section.

§12. The assault on Boulogne and the armoured drive into Holland.

While Major Sargeant was still liberating Brussels and Antwerp with the Guards Armoured Division, and later dashing with them up the thin stalk of territory to Nijmegen, Lt. Col. Johnson, Major Swann, Major Fairlie and Captain Royce went to Boulogne, the second of the big fortresses left high and dry on the Channel coast by the tide of the advance into Belgium and Holland. Royce should perhaps have entered this narrative earlier, but until Boulogne, he was an elusive figure, scarcely belonging to the Section. He had been working as an interrogator on a brief of heavy bombing for the Scientific Adviser and ourselves, when it was suggested that he might join the Section permanently. During the period of the Falaise pocket - Seine investigation, he interrogated for us at prisoner of war cages on a number of matters connected with the work, but it was not till Amiens that he actually joined the Section and it was at Boulogne that he became a vital member of it, as interrogator, general adviser on Intelligence matters, interpreter on

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all occasions, and negotiator for wine and food. Without him we could never have broadened our methods as we did, and our day to day living would have been inestimably poorer.

The party arrived at Boulogne some days before the assault, so that it was possible to prepare in detail with maps and plans, and even to look over the ground. Boulogne was surrounded with hills, and while the battle was actually going on, we succeeded in doing what we had seldom done before - watching from a series of close vantage points. As soon as it had gone some distance, we examined the battlefield for the effect of all sorts of attack on the batteries and fortifications, and Royce interrogated continuously as the prisoners were brought in. When the battle was finally over, we discussed it in detail with the battalions and units taking part. So by degrees, we built up a factual and, to a considerable extent, numerical estimate of the operation, more all-embracing than our earlier efforts at Heavy bombing analyses, though essentially similar. If anything, we tried to do too much, with the result that the sections on artillery and tanks were skimmed. We were troubled too with the loss of Major Fairlie, who fell suddenly sick and had to return to U.K. Though the loss of his knowledge of artillery was later made good, nothing every replaced his unparalleled Canadian sense of humour.

Soon after the assault on Boulogne had ended, that on Calais began. We found it quite impossible, as we had originally intended, to do both so after a quick visit to Brussels to replenish, we returned to Calais as the battle ended, to examine a few points of interest: chief of these were the attacks on gun batteries and the fragmentation bombing.

Major Sargeant's work with the armoured pursuit was the direct outcome of a request from the Major-General R.A.C. and the Brigadier Staff Duties of 21 Army Group. Both felt that there were problems in an armoured drive that would be worth studying, but could not state positively what they were; accordingly it was left to Major Sargeant to do what he could. It was obvious from the speed at which the armour was moving and the small amount of opposition it was meeting, that the limit to the rate of advance was being set by the repair of mechanical breakdowns. Many were being left unmended or, if R.E.M.E did stay to mend them, then the workshops got left a hundred miles or more behind the tanks. To check on all the breakdowns meant travelling over 3000 miles in four weeks, often on roads not fully cleared of enemy; it proved a considerable physical strain and emphasised the importance of a reliable vehicle and an excellent driver. Petrol was often a difficulty, and food as well, though it was possible up to a point to live off the country. The drink was the reverse of the petrol problem; in Brussels and Antwerp it was difficult not to take too much aboard.

§15. Report Writing in Brussels

For a month or more after the reunion of the Section in Brussels, we undertook little or nothing new. It was a period marked by the publication of four of our best reports: each, in a different way, was a fair example of the use of methods we had already tried in Normandy. From the historical point of view, Report 15 "Enemy Casualties in Vehicles and Equipment during the retreat from Normandy to the Seine" deserves to be considered as our best work. Into the making of it went the effort of six of us for three weeks, and of one or two for many weeks more. We examined vehicles individually, we counted them in bulk, we interrogated the local French population, we interrogated prisoners of war, we used the reports of aircraft reconnaissance and we examined air photographs. Accepting the limitations of time, there was probably little more we could have done in assessing physical destruction; but we often wished that we had done more on the effect of the Air Forces in causing panic and confusion amongst the enemy. We could only have achieved this by

more intensive interrogation, and at the time we had not the facilities. Memorandum Number 14, a straightforward account of the interdiction achieved by bombing bridges on two river lines in Normandy, was written at the same time as Report 15.

Report Number 16, on "The effects of ground and air support in the assault on Boulogne" was the most complete attempt we ever made at assessing a battle, although in the end it was complete only as regards the air effort. The report employed all the methods we had tried in Normandy, as well as, for the first time, making extensive use of interrogation and intelligence information. Report Number 17, on tank casualties was the logical expansion of earlier work and a good example of the isolation of a particular subject while yet keeping it in its correct relation to the battle as a whole. The amount of information that it was possible to deduce from the casualty data is remarkable. Lastly came Report Number 18, a new departure for the Section, into matters of organisation. Except for one more Report (Number 30), we never explored further the possibilities of research in this direction. Undoubtedly there was much that we could have done, and in many ways it would have presented fewer difficulties than the work we actually did; for there are no intangible factors involved in it and a great part of the data is already recorded on paper by the military machine. But the problems of organisation appealed to us less than those of the actual fighting and, since we were never told to look into them, we left them alone.

B14. Clearing the Scheldt; work on artillery.

While the Section was writing its reports and, in its off moments, enjoying all that a liberated Brussels could offer, a new and laborious strategy was being forced upon the British armies as a result of the failure to hold the bridge at Arnhem. It consisted for the British in widening, on either side up to the Meuse, the narrow corridor leading to Nijmegen and for the Canadians in clearing the banks of the Scheldt and the islands to the north, so freeing Antwerp as a port for the whole Allied Expeditionary Force. The British task was a slow and tedious one, that involved countless small battles among the fields and dykes of Holland, hampered sometimes by floods, and always by soft ground and inadequate supply routes. The fighting was more or less incessant, with few large battles, and perhaps for this reason, the Section did little work there. There were in fact only two reports of any note (Numbers 19 and 22) that came from this part of the campaign: the first was a study of Infantry Officer casualties (and some of this dated back to Normandy, while much of it consisted of statistics from 2nd Echelon), and the second an investigation of a small attack well to the south, near Geilenkirchen. This was a first attempt to relate weight of artillery bombardment with the effects obtained, using as yardsticks the casualties suffered by our own troops and our own admittedly subjective estimates of the reactions of prisoners of war. The results were quite consistent and the investigation, which had never been intended as more than a reconnaissance of the subject, encouraged us to try again. One incident in the attack caused widespread interest: the exceptionally heavy bombardment on the small village of Baugem, which resulted in almost complete paralysis of enemy resistance.

Except for cumulative work on tank casualties or typhoon rocket attacks, the Section confined itself for the rest of the year to the Canadian sector. In September Major Wallace arrived as a replacement for Major Fairlie, and in October Captain Mathieson came out to help him. For a long time past the accuracy of predicted artillery fire had caused some concern: barrages and concentration had become enormous, and because of mixed ammunition lots, uncalibrated guns

and a number of other defects, it was suspected that they were very inaccurate. Wallace's first work, therefore, was a straightforward analysis of the accuracy of a large predicted shoot in the operation to clear up the Breskens pocket on the south bank of the Scheldt. Choosing the operation was not easy, for it was necessary to find a situation where little if any firing had taken place beforehand, and where the distribution of shells could be examined soon after firing, without any danger of its being confused by subsequent fighting. Such a situation was in the end found, and the subsequent work developed into devising means of determining the distribution of shells on the ground, and then carrying out long calculations in an attempt to analyse out the many variables. Air photographs only showed a proportion of small craters in the wet fields of the Breskens pocket, so that a lot of walking over them became necessary. In the course of writing the report (Number 24), the need of assistants and calculators was felt keenly; but it was finished in the end and proved nothing short of a bombshell; it showed the grossest inaccuracies in many of the concentrations, far greater than had ever been suspected. As a result, the interest of the Brigadier R.A., Canadian Army, was aroused and every attempt was made to improve the situation. The report also aroused the interest of the Accuracy of Predicted Fire Committee in England, as being one of the first comprehensive records from the field. A smaller and purely technical report, on the use of G.I. III for calculating artillery motor telegrams was also written about this time, using some of the data collected incidentally in the main work.

Some weeks later came the assault on Walcheren Island; though it was successful, it was costly, since very few of the coastal guns had been silenced beforehand, or even effectively neutralised during the landings. The Section was ordered to investigate this failure. It was soon apparent that the trouble had been due, fundamentally, to over-optimism about what could be achieved against the fortifications with air and artillery; the weights of bombardment had been inadequate, and the possibility that all the coastal guns might be intact and resist fiercely, was not sufficiently considered. Lt.-Col. Johnson and several others of the section examined many of the batteries and produced a report (Number 25) which was, in effect, only a confirmation of this view. Little emerged that was new, but the work served to emphasise the quantity of bombs needed to achieve destruction or even neutralisation of such formidable gun positions as those on Walcheren.

§15. The Section's mode of working; relations with 21 Army Group Headquarters.

Now that our permanent home was in Brussels we were confronted with a difficulty we had not experienced before. In the early days of Normandy the distances were so small that we could always travel to the front and return in a day. Towards the end it was becoming difficult, but we left the bridgehead for our big survey of the German retreat to the Seine before it became impossible. From now onwards Army Group Headquarters was never less than three or four hours drive from the front line, so that day visits were out of the question. Between the Falaise pocket and the Seine we had always taken over houses for the Section to live in, whenever we were more than one or two on a job; this now became our standard practice. These "Tac HQ's" had many advantages: we could go when and where we liked, untroubled by the frequent moves of an ordinary unit; we did not have to wait around for a particular event, getting in the way of fighting troops; we could have room to work; and we could have as many Other Ranks with us as we wanted, to maintain our vehicles and act as clerks. Living with a unit, the other means of existence, had none of these advantages, though it did have an important one of its own: in no other way could contact be quite so close with staffs or fighting units; and for some investigations this advantage outweighed all the objections.

Living in Brussels also brought us into closer touch with 21 Army Group Headquarters than at any time since we left England. Our position was an unusual one: in the early days in England we had been treated exactly as a staff branch and, as a result largely through the efforts of Lt. Col. Johnson, had been able to build up excellent and friendly relations with the staff. But we were in fact a separate entity and, when the time came to go abroad, it was made clear that we must function as such. The high-up view, as it was put to us much later by Brigadier Herbert BGS(SD) had been at that time one of tolerant indifference: we might be of some use in the field, or we might not; like most hangers-on we were more likely to fall into the second category. Already in Normandy this view was changing, and by the end it had changed to such an extent that Brigadier Herbert, a regular officer, himself said that it was only the O.R.S. that told him what really went on and what really mattered.

Since we were not a Staff Branch, we lived on our own in Brussels, in a house a mile or so from Army Group Headquarters. This meant that we were to a considerable extent cut off from the day to day happenings there, however good our liaison with individuals on the staff. Since however our job was not concerned with day to day events, but with longer term investigations, this was not a serious disadvantage, and the compensating advantages of being separate were very great. We enjoyed a complete freedom from office hours and normal routine, we could come and go as we wanted and we could say what we liked.

The gradual strengthening of the Section's position was due as much to the efforts of Brigadier Schonland, the Scientific Adviser, as to our own. As well as being a personal friend of everyone and always willing to make time for any of us, he became a friend of all the senior officers of the Army Group staff and by degrees he familiarised many of them with what we were doing and how we could help. It was a heavy blow for the Section when he finally left, at the end of October, to go to a high post in South Africa: but the blow was softened when we realised the extent to which he had made our position secure. From that time on we enjoyed the personal attention of Brigadier Herbert in everything to do with our work, Lt.-Col. Johnson was asked to attend the Chief of Staff's morning conference and, from time to time, we were consulted about planning.

Our relations with Brigadier Schonland were cordial and productive in the extreme; but, true to British tradition, they were never regularised. The section came under the Brigadier Staff Duties, and not the Scientific Adviser. Only one concession was made; that the Scientific Adviser should control us in Air matters; in everything else his influence was indirect and unofficial. Throughout, indeed, we benefited from a none too precise definition of our functions and rights. As a result, we were allowed complete freedom in where we went, what units we visited, how we worked, and how we finally presented our results. Whether this freedom was the outcome of an intelligent appreciation from above, that a set of independently-minded men would only work well in such an atmosphere, or whether it was merely an oversight of the military machine, we never know; our freedom at any rate, was not shared by various other odd units appended to the Army Group.

§16. The German Counter-attack in the Ardennes.

About the middle of December, when 21 Army Group was preparing a huge attack southwards from Nimwegen and the Americans an attack northwards to meet us on the Rhine, the Germans launched their bold counter-stroke in the Ardennes. Lt.-Col. Johnson and Major Sergeant were visiting 1st U.S. Army Headquarters in Spa at the time and, caught quite unawares, were all but cut off by the enemy. As the days passed

and Christmas approached, the situation became graver. British divisions were pulled out from the North and placed to cover Namur and Brussels. Army Group Headquarters itself was ready to man the barricades. But the offensive slowed, halted, and then gradually the Germans retreated, fighting hard all the way. For the first 6 days there had been little or no air support because of fog and mist. Then on Christmas day the weather changed, and all the aircraft in the A.E.F. were turned on to the salient. Heavies bombed communications far into Germany as well as towns in the salient; Mediums bombed roads and bridges; Fighters and Fighter-Bombers attacked transport and tanks. At the time there was considerable discussion on how the air effort should be arranged, and to clear up certain points on blocking roads we put together some of our observations in a Memorandum (Number 3), on the interdiction of road communications by bombing. Extraordinary claims of destruction were being made by the Air Forces, and since at the time 1st U.S. and 9th U.S. Army were under 21 Army Group and British Divisions and British aircraft were taking part, we were told at the highest priority to find out what was really happening.

The work in the Ardennes arose from a typically vague instruction. Practically never were we given precise directives for our work; often we were given no directive at all. "See what you can make of air attack in the Falaise pocket", "Have a look at the Assault on Boulogne" or "Follow the armoured drive" were all the direction we ever received for some of the most successful of our reports. This freedom allowed us to develop along the lines for which we were best suited, and more exact instructions could only have been deadening.

Because we had had difficulties and differences of opinion with the R.A.F. in the past, when writing on air matters, we were told to co-operate with the O.R.S. of 2nd T.A.F. on this job and on all subsequent ones that were concerned with the air. Joint efforts are usually difficult, and ours were no exception. But by having members of the Air Force O.R.S. to live with us, and by thrashing out the reports together, we always reached agreement in the end. The joint reports that we produced were doubly valuable because they commanded the attention of both Army and Air Force.

Some days before we were told to look into air claims, Major Wallace, Major Sargeant, and Captain Mathieson had gone down to the Ardennes, first to Leignon at the tip of the salient, and later to Dahlem near Liège, to study anti-tank actions. At Dahlem Major Pike joined them and the search over the snow-clad countryside for knocked-out tanks and vehicles started. Later when the priority of the whole investigation was raised from merely "redhot" to "whitehot", Major Swann, Captain Oakley, and Captain Royce, as well as Wing Commander Graham and S/Ldr. Abel of O.R.S. T.A.F., joined them, and the whole party set up a Headquarters in Wyville. From here the countryside was scoured in real earnest. The difficulties were immense for it was exceptionally cold, often blizzarding. Tanks were so covered with snow they could scarcely be seen from more than a few yards away, and the cause of destruction was almost impossible to determine. Jeeps bellied in the snow and skidded into ditches, chains broke, fingers froze. Slowly and painfully a limited area was covered with a speed and thoroughness that necessarily compared poorly with earlier days in Normandy.

Joint Report Number 1 was then written. Unfortunately there had not been enough anti-tank activity by the R.A.F. to form any real conclusions on their performance. But American fighter-bombers were shown, beyond any doubt, to be indifferent at tank destruction. For every hundred claims, we could find only one tank indubitably destroyed by air: and, though a few cases turned up where perhaps tanks had been abandoned because of air attack, they were doubtful and went only a very little way to making good the discrepancy. Almost the only claim we did substantiate was that of a Royal Tiger well and truly demolished by a direct hit from a 500 lb bomb.

The work on the destruction of tanks in the Ardennes suggested the need for a fuller study of the effect of the Air Forces as a whole in stemming the German thrust. A few days later Captain Royce went down again with a member of O.R.S. 2nd T.A.F., and stayed for a week in several of what had been the big communication centres of the salient. By extensive interrogation of local civilians, they accumulated much information on the extent of the dislocation and the delay imposed by the Air Forces. The results were incorporated into a large O.R.S. T.A.F. report, part of which is included as Memorandum Number 6.

The report on Anti-tank actions (Number 27), since it concerned only American units, was never widely circulated, but it deserves nevertheless to be regarded as a classic of Operational Research. By analysing a large number of small tank/anti-tank actions from the Ardennes salient, in terms of the numbers of anti-tank guns defending, the number of tanks attacking, and the losses on both sides, it was possible to establish a clear numerical superiority for self-propelled over towed guns, and for anti-tank layouts with infantry over those without. The report is a good example of how a commonsense numerical approach to warfare can sometimes settle points that have always been regarded as the preserve of experience and intuition.

§17. The ideal organisation for Operational Research

Working with O.R.S. 2nd T.A.F. brought out clearly the differences between our two organisations, and the merits and defects of both systems. Whereas they were largely decentralised, with officers scattered throughout the Groups, and with only the commanding officer and a staff of computers and clerks at their Headquarters, we were entirely centralised, though with a much smaller clerical staff. The chief merit of the Air Force system was the close contact it promoted with Wings and Groups; its grave defect, to our minds, was its inability to concentrate a number of officers on a single big problem. The Ardennes survey would not for instance have been possible without our centralised organisation. Although this is no place to speculate on the ideal organisation for an O.R.S. with Armies in the field, it can at least be said that a centralised section, equipped much as we were, but better provided with clerical and computing staff, is desirable. But additional officers, attached to smaller formations, to collect information and arrange for the keeping of records, would be a great assistance.

We often felt that we were too few to fulfil our function adequately, and that once fresh ground had been broken, the work might have been taken over by a more orthodox body. Up to a point, the size of an O.R.S. might be increased, but a section of more than a dozen officers would tend to lose the sense of unity and common interest that we found so valuable. Since two independent O.R.S.'s in the same field formation are scarcely feasible, a possible solution is perhaps to divide broadly the functions of the O.R.S. into breaking new ground and carrying on with methods already established. This might resolve itself into a main O.R.S., on the lines of our own, and a subsidiary and subordinate one, to do the more routine jobs. The distinction might be invidious, and the system unworkable; but some solution must be found for the difficulties of the existing organisation, where we had too much work, and especially too much that was merely repetitive, and yet where we found the small, compact and centralised unit to be efficient, and most important of all, pleasant to work in and stimulating to thought. Any system which destroyed the intellectual stimulus would be fatal to this sort of work, and it was our belief at the time that too great an increase in the size of the section would lead to this very result.

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§18. The difficulties of giving Scientific Advice.

The Ardennes offensive delayed the big push southwards from Nijmegen until well into February, so that there was time for us to finish off our Ardennes work and get ready well in advance. In one small point of the planning of this operation, "Veritable", we were asked to help: it was a question of whether the extensive use of aircraft bombs in close support, would so crater the wet ground in that part of the world, as to make it impassable or at least difficult for tanks. The question was a more difficult one than might be imagined, for on examination it became evident that the information on crater sizes was scanty and conflicting. In an endeavour to give an answer to this question, and to resolve the existing confusion, we summarized all the information we could find in a Memorandum (Number 5) on 'Crater bombing in wet ground'.

This particular query was typical of several that were put to us at one time or another. It represents what the ordinary man considers to be the sphere of Scientific Advice; and it is often the case that the scientists are as fitted as any to answer such miscellaneous technical questions. But it is to be regretted if Scientific Advice to a Field Army never gets beyond such details. On the other hand there are considerable difficulties in going further. All the Operational Research Sections, whatever their original aims, have for one reason or another arrived at a system of investigating battles, in the broadest sense, and then writing reports containing, explicitly or implicitly, "Scientific Advice". The investigating is done at all levels, even the lowest; the reports on the other hand have always been made for the highest level. Often our own reports went from Army Group to Armies, Corps and even Divisions, but equally often we felt infuriated and frustrated to find our ideas not adopted because reports had never been circulated, or because they had never been read. Much of the trouble lies in the fundamental paradox of the military system: although at the highest formation there is most likely to be the time and temperament to appreciate O.R.S. reports, the opportunity to act on them is in fact least. Although the last say always rests with the top, as regards ways and means of fighting, their influence is remote and their control far less than they may care to admit. The lower formations have the power to act, but less time and less inclination to think, so that O.R.S. reports tend to be regarded as yet more paper from above, and are treated accordingly. It has been argued that Scientific Advice can be put over by the personal touch; up to a point this is true, though it can scarcely be accepted as a workable system. To spread an idea, if the only means is by social contact between Majors and Captains, would need years.

Time and time again we came up against the inescapable fact that the introduction of new ideas rests solely with a commander, or at least with his immediate deputy. We thus found ourselves trafficking in ideas far above our rank, with report-writing as the only ready means at our disposal of conveying them. And it must be stated once and for all that report-writing is a very poor substitute for a senior officer who can discuss the idea with his equals in Armies, Corps and Divisions. Many of the ideas that emerged from our reports were never adopted, often never even considered, because they were only ideas buried in reports that were never read. The conclusion that must follow from this, is that the investigating body, the O.R.S., can be lowly-ranked, but that it needs a highly-ranked officer, a Scientific Adviser to see that its ideas are tried out. Brigadier Schonland, who could have fulfilled this function for us, left just at the point when we had sufficiently developed our technique to be able to give him valuable information.

§19. The attack southwards from Nijmegen.

For operation "Veritable", we planned a major effort: Lt. Col. Johnson, Major Wallace and Captain Mathieson, with a team of Gurnery instructors were to carry out another Predicted Fire Survey (this at the request of B.R.A. Canadian Army); Major Swann was to cover the morale aspects of the artillery bombardment; Major Pike and some members of O.R.S. T.A.F. were to investigate air support; Captain Royce was to interrogate; Major Sargeant was to follow the armour and the Medical Officers who had just joined us from the Medical Research Council, were to survey casualties to tank personnel. The whole party, at times twelve or fifteen strong, lived for ten days in Nijmegen in a shell-damaged house, and went out every day down the muddy congested roads, through the floods of Kranenberg and on to Cleve, or through Groesbeek and the Reichswald, or down by the Maas to Hook and Genep. The attack was a very large one, heavily supported by all arms, but the defences were strong and well-prepared, and included in the Reichswald a part of the Siegfried line, so that it went slowly. The artillery party, by ground examination and a study of air photographs gradually extracted details of the Counter-battery and predicted fire accuracy (Reports 29 and 31). Major Swann, from casualty figures and from battalions themselves, got an estimate of morale effects (Report 26), while Major Pike produced a report on the Mobile Radar Control Post as a means of blind-bombing for medium bombers, (Report 28, Joint Report No. 2). The three artillery reports followed fairly closely the lines of earlier reports, while the Mobile Radar Control Post report was a straight investigation of bombing accuracies. Though, as regards methods, none of them contained much that was new, the actual results were important. The accuracy of predicted fire report showed once again very serious inaccuracies, while the morale effects report expanded the earlier results from Goilenkirehen and gave a strong indication that the immensely heavy bombardments used in the operation were defeating their own ends. The Mobile Radar Control Post report publicised what we regarded as a valuable and all too little acknowledged means of improving air support.

Though we only studied the first stages of the "Veritable" battle, it went on for some weeks yet, with our armies slowly fighting down towards the Americans, clearing up to the Maas on the right and the Rhine on the left. Then followed a long period of superficial quiet, in which the Rhine crossings were planned. Although Lt.-Col. Johnson was occasionally consulted on the planning, there was little for the section to do; for the most part it was detailed administration that counted, and there we had no part. During this period Major Pike's report on the military value of Rocket firing Typhoons was finally published (Joint No. 3). It was based on a series of investigations of Typhoon attacks on Forward troops and established the operational accuracy and the effect on a variety of military targets. Most interesting perhaps it attempted an assessment of the morale effects of attacks with this weapon, based on observation and prisoner interrogation.

§20. The assault across the Rhine.

Then came the Assault on the Rhine. We planned what we rightly suspected to be a last great effort: Majors Wallace and Pike, Captains Mathieson and Royce, and several of O.R.S. T.A.F. to combine on a large study of the Flak and Counter-flak programme (which included air and artillery); Major Swann and Lt.-Col. Johnson to study the build-up of vehicles and units over the river; Major Sargeant to follow the armour and the Medical team to study again casualties to tank personnel. Yet another Tac H.Q. was set up in a reasonably intact house in Kevelaar some days before the assault and the party set to work.

The arrival of the airborne army was one of the dramatic moments of the war. We watched from a hill by Xanten the seemingly unbroken succession of planes and gliders sailing impeturbably over the Rhine and disappearing into the fog of war fast forming over the battlefield. The same afternoon we went down to the Rhine and watched the Buffaloes, assault boats and rafts fast ferrying over vehicles and troops. To the south, after a little shelling, the crossing went easily, and by the afternoon bridgeheads were secure. The near bank was soothing with moon, and bore an irresistible likeness to Margate on a Bank-Holiday with perspiring figures sitting in the sun waiting to cross. Though there was shelling on the far bank, and even a few landing in the water, nothing fell to disturb the party on the near side. But further north, and in particular opposite Rees, the fight had been harder, and the build-up badly delayed. Although by the time we arrived things were easier, the grim evidence of what had gone before was all too evident. It was opposite Rees that almost the only German jet-plane, or indeed plane of any sort to appear in the Rhine crossing, shrieked down at us, sounding like some monster shell.

A few days later the whole party crossed the Rhine and set up a new Tac HQ next to Main 12 Corps. A few days later still, so fast was the battle now moving, we moved forward again to Dingden, next to 2nd Army Headquarters. All this time the Flak and Counter-Flak party toured the countryside examining gun positions, while others followed the armour. But as time went on, it became increasingly difficult to reach the front from Dingden, and so Major Sargemunt and the Medical Officers left to live with Tank units. Soon after, our Tac H.Q. came to an end and we returned to 21 Army Group, which had now moved to Suchteln just inside Germany. The inevitable report writing followed; Number 30, about the Build-up, and Joint Number 4, about Flak and Counter-Flak. The first of these two represented our second and last essay into matters of organisation and indicated, if it did nothing more, the many problems of traffic control demanding investigation. The second report contained some interesting and unusual statistics on the airborne operation, but was mainly concerned with a study of the immense neutralisation programme. All the methods we had evolved for this sort of study in the past were brought together in this very comprehensive survey.

§21. The end of the Section.

Meanwhile the armoured divisions raced on towards the north German coast, Bremen, Hamburg, Lübeck. It was evident that we should do little more of any immediate value, and it became increasingly doubtful if we should ever do any more at all. As a last gesture, more from curiosity than anything else, Major Swann and Captain Royce went to a Corps Headquarters, preparing to attack some of the northern fortresses, lived with them, and tried to find out whether after all they could not give some direct and immediate "Scientific Advice". Unfortunately, or perhaps fortunately, surrender intervened before the matter was put to the test.

If the Rhine crossing was a climax, the events that followed were anti-climax. The result was only a matter of time, and when surrender finally came, it was no surprise. As an O.R.S. our work was done, and in the months that followed, before we finally broke up, we only finished off reports: Number 32, the Armoured pursuit beyond the Rhine, Number 33, The Panzerfaust and Memorandum Number 2, Bombing behind the Rhine. The first of these reports was more of a series of observations on tactics than a report. The second was a thorough and successful study of the tactics and effects of this unusual German weapon. It was perhaps a fitting last report for the Section, inasmuch as it was a culminating development of the type of work with which we started in Normandy, Mortar location and Sherman tank casualties.

The other activities of the Section in this period, visits to newly liberated Denmark and Holland, to Brussels, and to the wine producing reaches of the Rhine, hardly find a place here. They were a pleasant ending to our efforts in the great campaign, but they bore little relation to our work. On July 20th, the section which had already dispersed, was formally disbanded.

§22. The reasons, the means and the results of Operational Research.

Between June 6th 1944 and July 20th 1945, the Section wrote about forty reports, all but a few of which are included in this volume. So varied are the subjects they deal with that we have had to divide the book into four parts and fourteen chapters; but the reasons for writing the reports, the methods of work involved, and the results we hoped to achieve by them were much the same throughout. We have touched on them already; rather than discuss them again in abstract terms, let us come down to the particular and discuss them against the background of some work we did on artillery fire support.

The enormous artillery support programmes of the operations of North West Europe were one of the most notable features of the fighting. Because they involved such a large effort and were in themselves so complicated, they were much studied. Fighting soldiers and Observers wrote about them from many aspects, drawing on their own experience, on their observations, on discussion with the units involved, and on the Operation Orders and plans. As a result of all this study, artillery programmes grew in elaboration and efficiency. Hundreds of guns could be fired on a perfectly timed schedule or directed at a moment's notice on to a particular target. But in the struggle to get the best artillery support, the armies had concentrated on the means of bringing down the high explosive rather than on the means of overpowering the enemy with that high explosive. In consequence, though the mechanics of laying a concentration were fully understood, there was nothing to indicate whether the concentrations of Operation A or of Operation B were the more effective, and there was practically no information on what the stupendous quantities of artillery actually did. Some favoured quick heavy concentrations, others preferred prolonged light ones; on one thing however all were agreed, that the more shells were fired off, the greater was the chance of success. In consequence barrages got bigger and bigger, guns were out faster and more transport was needed, for carrying ammunition. Whereas in the last war battles tended to wait on the accumulation of sufficient expendable manpower, now they tended to wait on the building up of vast stocks of ammunition. These then were our underlying reasons for attempting to investigate fire support.

Our means of investigation included those of the military Observer - watching the battle, discussing with units, and studying the orders and plans - but they went further; to these three we added the interrogation of prisoners, the detailed examination of the battlefield and the study of records such as medical casualty returns, ammunition expenditure sheets and counter-battery logs. If an enemy position held out long after the rest, it might have gone unrecorded in an ordinary report, or at best have been given a brief mention; whereas we should have documented it to the extent of interrogating the prisoners from the particular position to determine why they resisted, working out the duration and intensity of fire on the position in question, and determining the number and type of casualties suffered in attacking it. The more fact that, in every piece of work we undertook, we examined to the full many aspects of every incident, gave us not only fuller direct information, but enabled us to reason from our facts on new lines. It was this reasoning on new lines that led to the unusual conclusions we were sometimes able to draw.

In the case of artillery fire support, the conclusions were simple enough and quite clear; they are mostly to be found in Part II Chapter 8. The results of acting on these conclusions are not difficult to foresee. The more economical use of fire power must mean either more effect for the same weight, which in turn means less resistance, fewer casualties and faster advances, or else it must mean the same effect for less weight which in turn means more shells for elsewhere on the front, or less transport, a smaller L of C and less wear on the roads. The advantages and the economies multiply outwards in every direction.

§23. The need for Operational Research in the future.

Modern warfare is vast, complicated and impersonal; most of it is fought at a distance. A complicated series of weapons are being used in a complicated way; inevitably the inter-relations and effects of these weapons will be complicated and imperfectly understood. The army of today is moreover a huge society and, as with any great society, there is inevitably uncertainty at the top as to what plans and orders really imply when they are carried out at the bottom. As long as there are these uncertainties the army cannot achieve its objects effectively and economically. These then are the reasons for Operational Research. Enough has been done to show that the means of Operational Research can sometimes go further to clearing up these uncertainties than practical experience or casual observation, not because the means are in any way different or even new, but simply because they involve studying many aspects of an incident rather than only one and so reasoning out now and more fundamental lessons. And lastly, enough has been done to show that the results of Operational Research can be valuable and can affect the battle.

Our own country is a small one; the armies we can put into the field are small; unlike the Americans and Russians we can afford no wastage. But in this and every war, more size has been shown to matter less than fighting spirit, skill and equipment. If the British armies are to be strong they must excel in these three very points; it is to the second, and to a lesser extent to the third point that Operational Research has much to contribute. May we, as a few scientists who have tried to establish in this war a new method, express the hope that, should this country ever again be faced with the disaster of war, Operational Research will contribute to that superabundance of skill and excellence of equipment which will be so vital to offset our lack of numbers.

APPENDIX 'A'

DOCUMENTS AND RECORDS USED BY NO. 2 O.R.B.

A. BEFORE AN OPERATION.

1. Defence Overprints are 1:25,000 and 1:12,500 maps overprinted with the latest Intelligence information on the location and nature of the enemy's defence installations, based on the interpretation of aerial photographs and various forms of reconnaissance. They form a useful guide to the battlefield afterwards.
2. Operation Instructions are detailed plans for the conduct of the battle, issued by Corps and Div H.Q. For security reasons their distribution is strictly limited before D day.
3. Air Plan. This is drawn up by the appropriate R.A.F. H.Q. and shows targets and times of attacks before the battle as well as the responsibilities of tactical aircraft during it.
4. Order of Battle is a top secret document to which amendments are issued almost daily. This shows exactly which units are under command of the various Corps and Divisions.
5. Artillery Operation Orders are generally issued from Corps H.Q.
6. Artillery Planning Instructions as above. Both these documents supplement the Corps Ops Instructions with full details of the artillery set-up.
7. Artillery Fire Plan has a useful map showing where barrages and concentrations are to be aimed.
8. Counter Battery Intelligence Summaries, issued daily by the C.B.O., give information about the activity of hostile artillery together with locations of new positions.
9. Hostile Battery Location List is brought up to date by frequent amendments and gives 6 or 8 figure map references for all enemy batteries that have been located by various means. Many will be found to have been unoccupied alternative positions.
10. Div and Corps Intelligence Summaries are prepared by I.Os to give their H.Q. all available information about the enemy in their sector of the front. They provide identification of enemy units and tell of their strength and morale.

B. DURING AND AFTER AN OPERATION.

1. Cositintrops. Combined Situation and Intelligence Reports, available daily at Army Group. They record the positions of our own formations down to Brigade level.
2. Ops Logs are issued at various levels and give the battle situation in varying degrees of detail. They have to be collected soon after issue or they are liable to be burnt.
3. Westels. War Office Situation Teletypes. Copies of these are held at Army Group for considerable periods and, although they deal with no formations lower than Brigades, they are useful checks when no other source of information is available.

4. Air Force Ops Flashes are teleprints from Wings or Squadrons giving full details of attacks made by planes of the Tactical Air Force.

5. Air Force Daily Log. 2nd T.A.F. produced a daily record of all their operations giving time, number and type of aircraft, load and a brief statement about the target and results. It should be noted that map references are not 100% reliable and often a string of place-names is followed by a statement to the effect that 3 tanks and 5 M.T. were destroyed, such informations being quite useless to the ground investigators.

6. Air Ministry War Room Air Staff Operation Summaries are known as "pink 'uns". They give numbers of aircraft, weight of bombs and pilots' claims for all the air forces all over the world. Published daily, they are a most fruitful source of information when dealing with weights of attack but give no details as to size of bombs or their fuses.

7. Hostile Battery History Sheets can be obtained from the C.B.O. They give the date, method and accuracy of location of each battery together with information about weights of counter-battery fire put down on it and some idea of the duration of its activity.

8. Gun History Sheets come from Battery H.Q. and record, among other things, the number of equivalent full charges fired and the state of calibration.

9. Ammunition Expenditure Returns. It is usually best to consult the G.P.O. or the No. 1 of the gun for details of rounds fired in a particular engagement.

10. Artillery Meteorological Data can be obtained from the Met party associated with the operation but it is necessary to arrange with them beforehand for the preservation of all their records. If Rawin ascents are made, data can be obtained from the G.L. team.

11. Divisional R.A. Log, kept by the C.R.A., records any extra barrages or harassing fire over and above the original plan.

12. R.E.M.E. Recovery Section Tank Casualty Location Lists show where all knocked-out tanks are situated though they tend to exclude "brow-ups" which are not worth recovering.

13. R.E.M.E. Workshop Tank Repair Records provide information about the type of damage sustained by the various tanks that have been recovered.

14. P.O.W. Intelligence Summaries are issued periodically from various H.Q. and cover all manner of subjects on which information has been gathered by interrogators.

15. Shellreps sent to the C.B.O., record the arrival of hostile shells with some idea of the direction from which they came.

16. 2nd Echelon Casualty Returns give the daily numbers of killed, wounded and missing in each unit.

17. Divisional Medical Returns are consolidated by the A.D.M.S. from all C.O.S. and F.D.S. reports. They usually indicate the weapon responsible for the death or wound.

18. Div and Corps Intelligence Summaries, referred to in Section A above, can give useful information of the enemy's reaction to the operation.

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19. Aerial Photographs can be used to find where bombs, shells and rockets landed. In good weather many sorties are flown and it is then possible, by comparing photos taken before and after a bombardment, to distinguish new craters from old.

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APPENDIX 'B'

Notes on the Examination of a Battlefield.

1. CRATERS.

(a) Except when filled with water, craters will usually yield clues as to their origin in the form of fragments. Learning from experience one soon becomes expert at distinguishing fragments of a 60 lb S.A.P. Rocket Projectile from those of a shell etc. The age of a crater is harder to determine because one is not often on the scene early enough to recognise that easily distinguished appearance of newly disturbed earth; the sight of vegetation growing in a crater is usually a good indication of age, but in damp soil and with hot weather one can be deceived in this.

(b) Bomb craters.

There are so many variables concerned in the determination of crater sizes that no reliable guide can be given (see Memorandum No. 8, in Chapter V). The very large and very small bombs make craters that can be recognised but the intermediate sizes present difficulties. However, armed with the knowledge that a target has been attacked with 500 and 1000 lb bombs of the same type and fusing, it is usually possible to distinguish the two sets of craters by their relative size. Craters in roadways will generally be filled in by the time the ground investigators arrive, but one can make a fair estimate of the size of the crater by inspection of the disturbed surface. Bomb craters in shallow water show up quite well on aerial photographs.

(c) Shell craters.

These are usually very shallow and pear-shaped, with a very characteristic "butterfly-wing" pattern in the spoil; these "wings" are thrown forward along the line of flight. The only notable exceptions among shell craters are those of the super-heavyweights which are round, 2 or 3 feet deep and without butterfly-wings; this is especially so in wet soil where even mediums tend to make this type of crater.

(d) Mortar craters.

Mortar bombs make hardly more than a scar on the surface; usually almost round and very shallow, these are about 18" in diameter. The larger German mortar bombs make craters comparable with those of field artillery shells.

(e) Rocket craters. (60 lb SAP/HE Aircraft Rocket)

Although with different types of soil and different angles of dive a variety of shapes and sizes have been encountered, the most usual type of crater is oval, some 8' by 5' and about 18" deep. Digging in the crater will generally reveal characteristic fragments but this is often unnecessary because of the presence, in or near the crater, of the easily recognised rocket motor and/or fins. The motor resembles a 3 foot length of drain pipe (3½" diam).

(f) Land rockets. ("Mattress")

The craters are similar to those of the aircraft rocket but the motor tends to split into long thin strips like the peel of an outside banana; these strips will be found protruding from the crater.

(g) Air cannon and M.G. scars.

A metalled road that has been strafed shows very definite poek marks. Where strafing occurs in grassland holes as large as 6" in diameter can often be seen.

2. EXAMINING VEHICLES.

(a) Where a retreat has taken place one has always to be on the lookout for vehicles destroyed by the enemy to prevent them falling into our hands. This is usually indicated by the presence of the metal cases in which the German demolition charges are carried and by the fact that the centre of destruction is located in a standard part of the vehicle, under the engine hatches of a tank, for example. Vehicles that were destroyed on roads are generally pushed off by bulldozers and one has to try to estimate the position at the time of the kill and to assess what was original damage and what was done by the bulldozer.

(b) Multiple damage.

Cases will be found where more than one weapon has done damage to a vehicle and then one has to resort to deductive reasoning and the interrogation of local civilians or to class the damage as "Unknown causes". This problem is aggravated by the tendency of the troops to use knocked out vehicles as practice targets. Knowledge of the course of the battle will serve to show whether a F.I.T or Bazooka hit was the cause of destruction or the work of an enthusiastic marksman at a later date.

(c) Cannon and M.G. hits.

When small holes are found in the roof, bonnet or upper surfaces of mudguards it is generally safe to assume that the vehicle has been strafed but, as pilots are apt to fire at "dead" vehicles, other possible causes of damage must be sought as well. Bullet holes in the sides may be caused by the Machine gun of an A.F.V. but are often the results of musketry practice.

(d) Fragments of shells and bombs.

Such fragments make jagged holes in the sides of vehicles. It is generally advisable to go to the crater and see whether fragments from it could have struck the vehicle, always remembering that if it were in motion at the time of the burst it would have moved some distance before coming to rest.

(e) Direct hits by bombs and rockets.

As neither bombs nor rockets are ever used singly, except in the case of mechanical hang-ups, one should look around for the other one of a pair; it should not be many yards away.

(f) Fires in vehicles.

Vehicles that have been hit by any form of projectile tend to take fire and this causes extra damage due to bursting petrol tanks and exploding ammunition. The appearance of the vegetation in the immediate vicinity will usually give a good indication of when the fire took place.

(g) Dead bodies.

The presence of dead bodies in a knocked-out vehicle is a sure sign that it was not destroyed by the crew. An examination of

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their situation and attitude may yield useful information if one applies the Sherlock Holmes technique; in fact, this technique is used so often in battlefield investigation that one can say that the famous detective would have been a first class Operational Researcher.

3. EXAMINING GUN POSITIONS.

(a) All types of gun positions have been examined, ranging from the shallow pit dug for the 20 mm LAA gun to the reinforced concrete casemates of the heavy coastal guns. They fall into two classes, those apparently made by the troops in the field (varying enormously according to the circumstances) and those made by conscripted labour (prepared long before the battle and built to standard specifications).

(b) Finding gun positions.

They are easy to find when built in the open as they are more built up than excavated. Quite large positions were, however, nearly missed when they were hidden along the edge of a wood but the prominent barrel of the abandoned gun usually caught the eye.

(c) Unoccupied sites.

When a gun site is overrun or the troop is forced to retreat, some evidence of occupation is invariably left; empty cases, clothes, papers, empty tins and cigarette packets. But, when no such evidence is found, one should examine the ground for tracks before stating that the site had definitely been unoccupied.

(d) Dummy sites.

These were often so well devised that they deceived the eye until one approached quite near. Wooden poles were used to simulate gun barrels.

(e) Damaged guns.

Guns still on site when the positions were investigated were either intact, suggesting surrender or rapid retreat, destroyed by the crew, indicated by standard damage (breach blocks blown, muzzles split or, in the case of A.A. guns, mountings demolished) or destroyed by some weapon of ours.

(f) Signs of activity.

Empty cartridge cases tell their own story. The number of unused rounds found on site is often of interest as cases have occurred where positions were overrun because the ammunition was exhausted. All records, documents and personal papers such as letters and diaries are well worth scrutiny. Identification of the unit from such sources can be tied up with the P.W. interrogation. Graves, with or without dates on them, and dead bodies all yield valuable information. Wheel tracks through or purposely avoiding recent craters suggest withdrawal after shelling had begun.

4. TANK TRACKS.

(a) A knowledge of the appearance of the impressions made by the tracks of all types of A.P.Vs., both British and German, allows one to reconstruct the course of events to a very considerable extent.

(b) The depth of the impressions made by such tracks and indications of skidding and bellying enable the investigator to assess the effects of the tank-carrying capacity of the soil on the course of the battle.

§19. The attack southwards from Nijmegen.

For operation "Veritable", we planned a major effort: Lt. Col. Johnson, Major Wallace and Captain Mathieson, with a team of Gunnery Instructors were to carry out another Predicted Fire Survey (this at the request of B.R.A. Canadian Army); Major Swann was to cover the morale aspects of the artillery bombardment; Major Pike and some members of O.R.S. T.A.F. were to investigate air support; Captain Royce was to interrogate; Major Sargeant was to follow the armour and the Medical Officers who had just joined us from the Medical Research Council, were to survey casualties to tank personnel. The whole party, at times twelve or fifteen strong, lived for ten days in Nijmegen in a shell-damaged house, and went out every day down the muddy congested roads, through the floods of Kranenberg and on to Cleve, or through Groesbeek and the Reichswald, or down by the Maas to Mook and Genep. The attack was a very large one, heavily supported by all arms, but the defences were strong and well-prepared, and included in the Reichswald a part of the Siegfried line, so that it went slowly. The artillery party, by ground examination and a study of air photographs gradually extracted details of the Counter-battery and predicted fire accuracy (Reports 29 and 31). Major Swann, from casualty figures and from battalions themselves, got an estimate of morale effects (Report 26), while Major Pike produced a report on the Mobile Radar Control Post as a means of blind-bombing for medium bombers, (Report 28, Joint Report No. 2). The three artillery reports followed fairly closely the lines of earlier reports, while the Mobile Radar Control Post report was a straight investigation of bombing accuracies. Though, as regards methods, none of them contained much that was new, the actual results were important. The accuracy of predicted fire report showed once again very serious inaccuracies, while the morale effects report expanded the earlier results from Geilenkirchen and gave a strong indication that the immensely heavy bombardments used in the operation were defeating their own ends. The Mobile Radar Control Post report publicised what we regarded as a valuable and all too little acknowledged means of improving air support.

Though we only studied the first stages of the "Veritable" battle, it went on for some weeks yet, with our armies slowly fighting down towards the Americans, clearing up to the Maas on the right and the Rhine on the left. Then followed a long period of superficial quiet, in which the Rhine crossings were planned. Although Lt.-Col. Johnson was occasionally consulted on the planning, there was little for the section to do; for the most part it was detailed administration that counted, and there we had no part. During this period Major Pike's report on the military value of Rocket firing Typhoons was finally published (Joint No. 3). It was based on a series of investigations of Typhoon attacks on Forward troops and established the operational accuracy and the effect on a variety of military targets. Most interesting perhaps it attempted an assessment of the morale effects of attacks with this weapon, based on observation and prisoner interrogation.

§20. The assault across the Rhine.

Then came the Assault on the Rhine. We planned what we rightly suspected to be a last great effort: Majors Wallace and Pike, Captains Mathieson and Royce, and several of O.R.S. T.A.F. to combine on a large study of the Flak and Counter-flak programme (which included air and artillery); Major Swann and Lt.-Col. Johnson to study the build-up of vehicles and units over the river; Major Sargeant to follow the armour and the Medical team to study again casualties to tank personnel. Yet another Tac H.Q. was set up in a reasonably intact house in Kovelber some days before the assault and the party set to work.

The arrival of the airborne army was one of the dramatic moments of the war. We watched from a hill by Xanten the seemingly unbroken succession of planes and gliders sailing impeturbably over the Rhine and disappearing into the fog of war fast forming over the battlefield. The same afternoon we went down to the Rhine and watched the Buffaloes, assault boats and rafts fast ferrying over vehicles and troops. To the south, after a little shelling, the crossing went easily, and by the afternoon bridgeheads were secure. The near bank was seething with men, and bore an irresistible likeness to Margate on a Bank-Holiday with perspiring figures sitting in the sun waiting to cross. Though there was shelling on the far bank, and even a few landing in the water, nothing fell to disturb the party on the near side. But further north, and in particular opposite Roos, the fight had been harder, and the build-up badly delayed. Although by the time we arrived things were easier, the grim evidence of what had gone before was all too evident. It was opposite Roos that almost the only German jet-plane, or indeed plane of any sort to appear in the Rhine crossing, shrieked down at us, sounding like some monster shell.

A few days later the whole party crossed the Rhine and set up a new Tac Hq next to Main 12 Corps. A few days later still, so fast was the battle now moving, we moved forward again to Dingden, next to 2nd Army Headquarters. All this time the Flak and Counter-Flak party toured the countryside examining gun positions, while others followed the armour. But as time went on, it became increasingly difficult to reach the front from Dingden, and so Major Sargeant and the Medical Officers left to live with Tank units. Soon after, our Tac H.Q. came to an end and we returned to 21 Army Group, which had now moved to Suchteln just inside Germany. The inevitable report writing followed; Number 30, about the Build-up, and Joint Number 4, about Flak and Counter-Flak. The first of these two represented our second and last essay into matters of organisation and indicated, if it did nothing more, the many problems of traffic control demanding investigation. The second report contained some interesting and unusual statistics on the airborne operation, but was mainly concerned with a study of the immense neutralisation programme. All the methods we had evolved for this sort of study in the past were brought together in this very comprehensive survey.

§21. The end of the Section.

Meanwhile the armoured divisions raced on towards the north German coast, Bremen, Hamburg, Lübeck. It was evident that we should do little more of any immediate value, and it became increasingly doubtful if we should ever do any more at all. As a last gesture, more from curiosity than anything else, Major Swann and Captain Royce went to a Corps Headquarters, preparing to attack some of the northern fortresses, lived with them, and tried to find out whether after all they could not give some direct and immediate "Scientific Advice". Unfortunately, or perhaps fortunately, surrender intervened before the matter was put to the test.

If the Rhine crossing was a climax, the events that followed were anti-climax. The result was only a matter of time, and when surrender finally came, it was no surprise. As an O.R.S. our work was done, and in the months that followed, before we finally broke up, we only finished off reports: Number 32, the Armoured pursuit beyond the Rhine, Number 33, The Panzerfaust and Memorandum Number 2, Bombing behind the Rhine. The first of these reports was more of a series of observations on tactics than a report. The second was a thorough and successful study of the tactics and effects of this unusual German weapon. It was perhaps a fitting last report for the Section, inasmuch as it was a culminating development of the type of work with which we started in Normandy, Mortar location and Sherman tank casualties.

APPENDIX 'D'

THE ADMINISTRATION OF OPERATIONAL RESEARCH SECTION.

Whilst the Section was an integral part of H.Q. 21 Army Group, the day to day administration was very little different from that of any ordinary unit of comparable size. It was not until late August when the Section went off out into the blues to live on its own that new problems had to be faced.

Then the non-commissioned personnel had to undertake tasks that do not usually fall to their lot. Driver batman had not only to drive and to "bat" but had to do far more of the repair and maintenance of their vehicles than is usual for men in their position. They had also to be able to cook as they often went off for days with their officers and, from a box of rations and a petrol cooker were expected to produce 3 meals a day or starve. In many cases they had to assist their officers in the examination of gun-pits, bomb craters and the like.

Parties frequently returned to Section H.Q. in the afternoon and announced that they were due to set off again at 0900 hrs next morning. This meant that the vehicles had to be overhauled, lamps and cookers repaired or replaced, rations for several days packed up and a hundred and one odd details attended to. It was essential, therefore, to have at the base the requisite personnel to deal with such emergencies. The M.T. mechanic and the Corporal between them saw to it that these things went smoothly.

With such a fluid section as this it was impossible to predict how many people would be present at H.Q. at any given time and though officers in the field tried to send messages warning of their arrival the bodies usually preceded the paper by several hours and complicated the feeding problem.

With each move of Section H.Q. and with the setting up of each Tac H.Q., the Administrative officer had his work cut out to visit the proposed area, obtain accommodation and return to organise the move.

The Clerical staff, at one time only a Sergeant typist and a non-typing clerk, was later augmented by the acquisition (surplus to establishment) of a second typist. The production of the many reports and memoranda (an average of one every 8 days) was a big task, as each involved several drafts including tables of figures and calculations and the language was generally somewhat above the heads of the typists.

The life of the section was such that for days and even weeks some men would be working at full pressure and then a brief respite follow. Although every opportunity was taken to give the men time off, we had often to refuse allocations of vacancies for short leave in Paris as there was no one free to go. The men were all hand-picked and responded magnificently to the somewhat unorthodox discipline of the Section. That the corporal, who was a Jack of all Trades, kept this unusual body of men going smoothly was a credit to himself and of inestimable value to the Section.

The strength of No. 2 Operational Research Section was as follows:-

1 Sergeant (typist)	1 Humber Staff car
1 Corporal (i/c discipline etc)	3 Jeeps & 2 trailers
1 M.T. mechanic	1 Bedford 3-ton lorry
1 cook	1 15 cwt truck
5 Driver-batman	2 Motor cycles
2 clerks	
2 general duties men.	

APPENDIX 'E'

List of Reports and Memoranda.

No.	Title
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A. 2 O.R.S. REPORTS

- | | |
|----|--|
| 1 | Self Propelled Artillery in the Assault |
| 2 | Royal Marine Artillery in Operation "NEPTUNE" |
| 3 | Investigation of an Attack on a German Column near
La Boleine |
| 4 | Air Attacks on Enemy Tanks and M.T. in the Mortain
area, August 1944 |
| 5 | Bombing of Caen, 7th July 1944 (of CHARNWOOD) |
| 6 | Bombing in operation GOODWOOD |
| 7 | Bombing in operation BLUECOAT |
| 8 | Bombing in operation TOTALISE |
| 9 | Effect of 90 lb Fragmentation Bombs |
| 10 | Suggested Plan to block German Retreat from Argentan
and Falaise |
| 11 | Location of Enemy Mortars |
| 12 | Analysis of 75 mm Sherman Tank Casualties, 6th June -
10th July 1944 |
| 14 | Heavy Bombing in Support of the Army |
| 15 | Enemy Casualties in Vehicles and Equipment in the
Retreat from Normandy to the Seine |
| 16 | Air and Ground Support in the Assault on Boulogne |
| 17 | Analysis of German Tank Casualties in France 6th June -
31st August 1944 |
| 18 | Tank Casualties during the Exploitation Phase after
crossing the Seine |
| 19 | Infantry officer Casualties |
| 21 | G.L.III in Forecasting Wind for Artillery Meteor |
| 22 | Effect of Artillery Fire on Enemy Forward Defensive
Positions in the Attack on Geilenkirchen (30 Corps) |
| 24 | Accuracy of Predicted Shooting - operation SWITCHBACK |
| 25 | Effect of Various Forms of Fire Support on the Western
Defences of Valcheren |
| 26 | Fire Support Operation VERITABLE - Effect on Forward
Defensive Positions |
| 27 | Anti-Tank guns in the Ardennes |
| 28 | Use of Mobile Radar Control Posts for Air Support of the
Army |
| 29 | Effect of Counter-Battery Fire in operation VERITABLE |
| 30 | Speed of Build-up in the Assault Crossing of the Rhine |
| 31 | Accuracy of Predicted Fire in operation VERITABLE |
| 32 | Armoured Pursuit after Crossing the Rhine |
| 33 | Use of the Panzerfaust in the N.W. European Campaign |

B. JOINT REPORTS (2 O.R.S. and ORS/TAF)

- | | |
|---|--|
| 1 | Air attack on Enemy Armour in the Ardennes |
| 3 | Rocket-firing Typhoons in Close Support of Military
Operations |
| 4 | German Flak and Allied Counter-flak Measures in operation
VARSITY |

REF.

No.

Title

C. 2 C.R.S. MEMORANDA

- 1 Greater Bombing of River Lines in Normandy
- 2 Bombing of Communication Centres prior to operations
PLUNDER
- 3 Interdiction of Road Communications by Bombing
- 4 American Incendiary Bombs
- 5 Effects of Bombing on Wet Ground
- 6 Contribution of the Air Forces to Stopping the Enemy
Thrust in the Ardennes, December 1944
- 7 Morale Effects of Artillery
- 8 Unloading of Gliders in operation OVERLORD

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PART I

AIR SUPPORT

CONTENTS

- Chapter 1: Heavy Bombing of Enemy Forward Defences.
- Chapter 2: Heavy Bombing behind the lines for Interdiction.
- Chapter 3: Fighter and Fighter-bomber attacks on Tanks and M.T.
- Chapter 4: Fighter and Fighter-bomber attacks on Forward Troops.
- Chapter 5: Miscellaneous Air Matters.

CHAPTER 1.

HEAVY BOMBING OF ENEMY FORWARD DEFENCES

CONTENTS

Heavy Bombing in Operation CHARNWOOD	(Report No. 5)
Bombing in Operation GOODWOOD	(Report No. 6)
Bombing in Operation BLUECOAT	(Report No. 7)
Operation TOTALISE	(Report No. 8)
Heavy Bombing in Support of the Army	(Report No. 14)
Air and Ground Support in the Assault on Boulogne	(Report No. 16)

REPORT NO. 5.

Heavy Bombing in Operation CHARNWOOD.

I. INTRODUCTION.

1. From an examination of the ground and of air photographs, and from information provided by CSI(a), SECOND ARMY after the operation, an estimate has been made of the effect of the bombing of CAEN on 7th July, 1944. This has been further supplemented from accounts of escaped BRITISH prisoners who were in the town at the time.

The report that follows is divided into four sections:-

SECTION II	-	Damage inflicted.
" III	-	Effect on morale.
" IV	-	Effect on fighting in CAEN.
" V	-	Conclusions.

One map and 4 air photographs are included as an Appendix. Photographs of damage, taken on the ground, will be submitted as an addendum in due course.

2. In an examination of this type, it is not easy to obtain details of other than purely physical effects. Measured in terms of these effects alone, it might appear that this aerial bombardment was of only limited success, but the bald fact must in no circumstances be overlooked, that it was a prelude to a completely successful operation culminating in the capture of the town.

II. DAMAGE INFLECTED.

1. The bombing attack on CAEN consisted of two separate raids. The first involved 300 aircraft with M R 030694 as an aiming point: bombs from this attack were intended to cover the northern suburbs of CAEN. The second involved 160 aircraft, aiming at M R 011695, an area of open fields. These two distinct target areas, one town and the other country, are described separately.

2. Each bomber carried 5 tons, and it appears from the craters that a mixture of 500 lb and 1000 lb bombs, fused .025 seconds delay, were used. Definite information on these points is not available here.

A. FIELDS NORTH WEST OF CAEN.

1. Description.

This area consists of smoothly undulating fields of grass and wheat, intersected by various roads and tracks. The bombs were reasonably closely spaced, the centre of the pattern being about 200 to 300 yards east of the aiming point. The circle containing 9/10ths of the bombs has been estimated roughly and is shown thus "-----" on the map and on air photographs 1 and 2. There was very little east of this circle, and only a few sticks north and south, but to the west and south west, there was a certain amount of spill into the area of ST GERMAIN LA BLANCHE HERBE.

2. Enemy material and personnel in the area.

There were not many German troops in this area. CSI(a), SECOND ARMY state that 26 SS REGT (INFANTRY) were based on ST GERMAIN LA BLANCHE HERBE and that 2nd and 3rd Btys of 155 ARTY REGT of 21 PZ DIV were in the area north west of CAEN. These batteries were much depleted, and probably consisted of only 200 men and 15 to 20 10.5 cm German SP guns and 12 cm Russian tractor-drawn guns with perhaps 40 vehicles. In addition there were various unidentified Flick units in the neighbourhood.

The defence overprint of 2nd July, 1944, showed the following:-

(a) 2 communication trenches	1 & 2 on map
(b) Underground headquarters	3 " "
(c) 1 small 4.75 cm, 3 4.75 cm and 9 small 4.75 cm guns along the track at	6 " "
(d) 67 SP guns	4 " "
(e) 2 or 3 guns	5 " "

This information appears to have been substantially correct.

3. Effect on enemy material and personnel.

The effect of the bombing on the enemy is best shown by considering each item shown on the defence overprint:-

(a) Communication trenches. These were well fitted out underground office quarters. They were outside the main area of the bombs and could not therefore be expected to have suffered damage except by chance.

(b) Underground Headquarters. These consisted of very extensive underground offices and quarters, surrounded by wire. These also were outside the main area of bombing but there were a few bombs within the enclosure. Again the extent of damage to the actual earthworks was small and in fact none was damaged.

(c) Anti and AA guns. In this area there were numerous slit trench sleeping holes, larger dugouts and shallow gun pits of various sizes. The site might have contained as many as 100 men. The equipment remaining was a damaged 60 mm Flak gun, and a wrecked and quite unrecognisable vehicle. There were piles of 20 mm shell cases, indicating that there had been guns of this calibre there. It seems likely that the other guns and vehicles were salvaged after the bombing. About 48 hours elapsed before the CANADIANS occupied this particular area, so that salvage would have been possible. There were no dead left behind. The density of bombs varied from nil to about 15 per acre.

(d) 67 SP guns. This area contained sleeping holes and larger dugouts, a few wrecked by bombing. The site might have held 50 men, but no dead were found. There were also 4 severely damaged wheeled vehicles, one damaged semi-tracked vehicle and 1 damaged motor cycle. The ground was heavily marked with tracks, and it is probable that there had in fact been a number of SP guns in the area, which, together with such vehicles as remained serviceable, had been removed at some time after the bombing. The density of bombs varied from about 10 to 15 per acre.

(e) 2 or 37 guns. This area contained the usual slit trench sleeping holes as well as one larger semi-tracked personnel carrier with trailer, not badly damaged, and two severely damaged small semi-tracked vehicles. Two dead Germans had been left partially buried in a crater. This site might have held 2 or 3 guns and 20 to 30 men. The density of bombs varied from nil to about 10 per acre.

4. Effect on roads and tracks.

There was only one proper road in the actual area of the bombing; this is shown on the Map at 7. It was about 5 to 6 yards wide, sunk to as much as 6 feet in some places. It had received 13 hits which partially or wholly blocked it to wheeled and tracked vehicles. The craters were however quite easily filled in by bulldozers within 36 hours of the area being occupied by Allied forces. The blockage of this road did not seriously affect either side as detours were easily made in the surrounding fields. The tracks shown at 8 and 9, although running through the most heavily bombed area (15 bombs per acre) were easily negotiable by making detours round the craters. The roads and tracks outside the main bombing area, although in a few cases they were strewn with a little debris, were in no way affected as regards taking traffic.

B. NORTHERN CLEN.

1. Description.

The principal area bombed in NORTHERN CLEN is shown thus _____ on the Map, and is illustrated in Air Photographs Nos. 3 and 4, taken before and after the bombing. It is not possible to estimate at all exactly an area containing 9/10ths of the bombs. This was a suburban area, with widely varying densities of houses. The principal type of building was a lightly built, detached suburban villa of two or three stories. The great majority of these were totally wrecked, and those left standing were very seriously damaged. The Southern part of the area just included a part of the main town, where there were stone buildings (not detached) of 4 to 5 stories.

The density of bombs in this area was about 35 per acre in the centre, falling off to about 10 per acre towards the edge.

In addition to the concentration in the suburban area there was some spill into the heavily built-up areas in the South, where particularly heavy devastation was caused. This is shown at 10 on the Map.

Some bombs were also spilt to the north, east and west of the main area, but their effect was of no great significance.

In the suburban areas the streets were on the average about 12 yards wide, except for the main entrance roads, which were sometimes as wide as 20 yards. In the town, the streets varied between boulevards of 100 yards across to side streets of only 10 yards.

2. Enemy material and personnel.

The number of Germans in the area was small. OSI(a), SECOND ARMY, state that the North part of CAEN contained only rear elements of a battalion of 31 GAF REGIMENT and of 12 SS DIVISION, probably less than 100 men altogether. It is known that there were some German casualties, but no estimate can be made of the numbers. Only three dead Germans were found during the examination of the area, but others may have been buried in the rubble.

The defence overprint of 2nd July, 1944, showed only an MT park in the North of CAEN. Although this particular area was heavily cratered, no vehicle remains were found, indicating probably that they had been moved before the bombing, it is otherwise inconceivable that relics would not have been found.

3. Effects on roads in suburban area.

The effect of the bombing was to produce a complete obstruction to all wheeled vehicles entering the town from the North, along the direct routes of the Grandes Communications Nos. 22 and 79, 7 and 60 (see Map). It is just possible that tracked vehicles could have found a way through, although this was not in fact tried. The obstruction was due almost entirely to craters, which were so close as to leave no space for detours. The obstruction due to wrecked buildings was only incidental in the centre of the area, although in the Southern, more heavily built up area, it contributed to some extent. The density of bombs in this area varied between 10 and 50 per acre.

The first attempt to clear a route through consisted in sending a bulldozer from 11 to 12 on the Map, in the afternoon of 9th July. The bulldozer succeeded in smoothing a path through the suburban area, suitable for tracked vehicles, as far as the point (12) where it was held up by a large crater with half wrecked buildings on one side and a vertical descent into the moat of the Chateau on the other.

4. Effect on roads in town areas.

The extent of the obstruction in the town itself is shown diagrammatically on the Map. The obstruction was due partly to craters, but mainly to large masses of masonry, as much as 10 feet high, brought down from stone buildings. The height of the obstructions depended on the height of the buildings and the width of the streets, but as a rough estimate, complete obstruction resulted when the height of the building was equal to or greater than the width of the street. In many instances, the masses of masonry were so great that bulldozing would be quite ineffective, and removal of masonry the only method of clearing.

This degree of obstruction, which was far greater than that in the suburban areas was produced by a very much smaller density of bombs, less than 5 per acre.

III. EFFECT ON MORALE.

Little evidence could be obtained of the effect of the bombing on German morale, which is unfortunate, as this may well have been its greatest contribution. No P.W. were captured who had actually been in the bombing. The P.W. outside the area agreed that it was most frightening while it lasted, but it was not possible to find out whether this effect was lasting. The 31 GAF Regiment, who held positions north of CAEN, were isolated and received no food or ammunition after the bombing, but in fact they resisted for considerably longer than troops to the East or West.

There is no doubt that our own troops were greatly encouraged both by seeing the impressive stream of bombers flying overhead and also by knowing that the bombs were dropping in the area where they were to fight the next day.

IV. EFFECT ON THE FIGHTING IN AND ABOUT CAEN.

1. The direct effects of the bombing of CAEN on the subsequent fighting in the area can only have been small in view of the small number of troops in the area. Such troops as there were must necessarily have been seriously disorganised.

2. The 31 GAF Regiment, who were holding North of Caen, did not get any supplies of food, petrol or ammunition through after the bombing. Although in fact these forces held out for some days longer than those in the East and West approaches to CAEN, it may only have been that the forces East and West were able to retire, while those North were not.

6.

3. The opinions of both 9 CDM and 9 BR Brigades, who entered CAEN from West and East respectively, were that the bombing in and just North of CAEN could only have made the Town more difficult to take, since it denied much of it to all but infantry on foot, while leaving plenty of cover for snipers, restricting the number of entrances to be held, and leaving intact a lateral route through the Town.

V. CONCLUSIONS.

The following points, though not fully proven, stand out from a consideration of this attack:-

1. Planning a heavy bomber attack.

The possibility of spill from the main target area must be allowed for. When this falls in a heavily built up area, it can produce unforeseen results in the way of obstructions.

2. Blocking roads.

(a) Open country. A density of bombs up to 15 per acre over a considerable area did not block the roads. In wet weather, or in heavily ditched or wooded country, when detours are difficult or impossible, such blocking might result.

(b) Suburban areas. Blocking was achieved with a very high density of bombs (up to 35 per acre). Subsequent clearing by bulldozers was possible.

(c) Town areas. Blocking resulted from quite a small density of bombs (less than 5 per acre) and was very much more difficult to clear because of huge masses of fallen masonry.

3. Destroying guns.

Only 1 of 15 - 20 guns in the NW area was left behind, so that the remainder were presumably undamaged or sufficiently intact to be salvaged. Nearly 48 hours elapsed before our troops occupied this area so that salvage would have been possible. It is well known that guns are relatively invulnerable, but greater success should have been achieved by the use of instantaneous instead of delay fuses.

4. Destroying vehicles.

10 out of about 40 vehicles were left behind seriously damaged. A considerably higher proportion still could have been destroyed had instantaneous fuses been used. In this connection it should be noticed that most of the remaining vehicles were heavily smashed, but with few fragment strikes, indicating that they had only been destroyed when they were within or at least very near the area of an individual crater.

Soft transport is undoubtedly one of the army's most vulnerable points to this form of attack.

5. General.

The material effects produced by this bombing attack do not appear to be sufficient to account for the marked success of the operation it preceded. It is thought that the value of this form of attack is largely in the disorganisation and morale effects that it produces.

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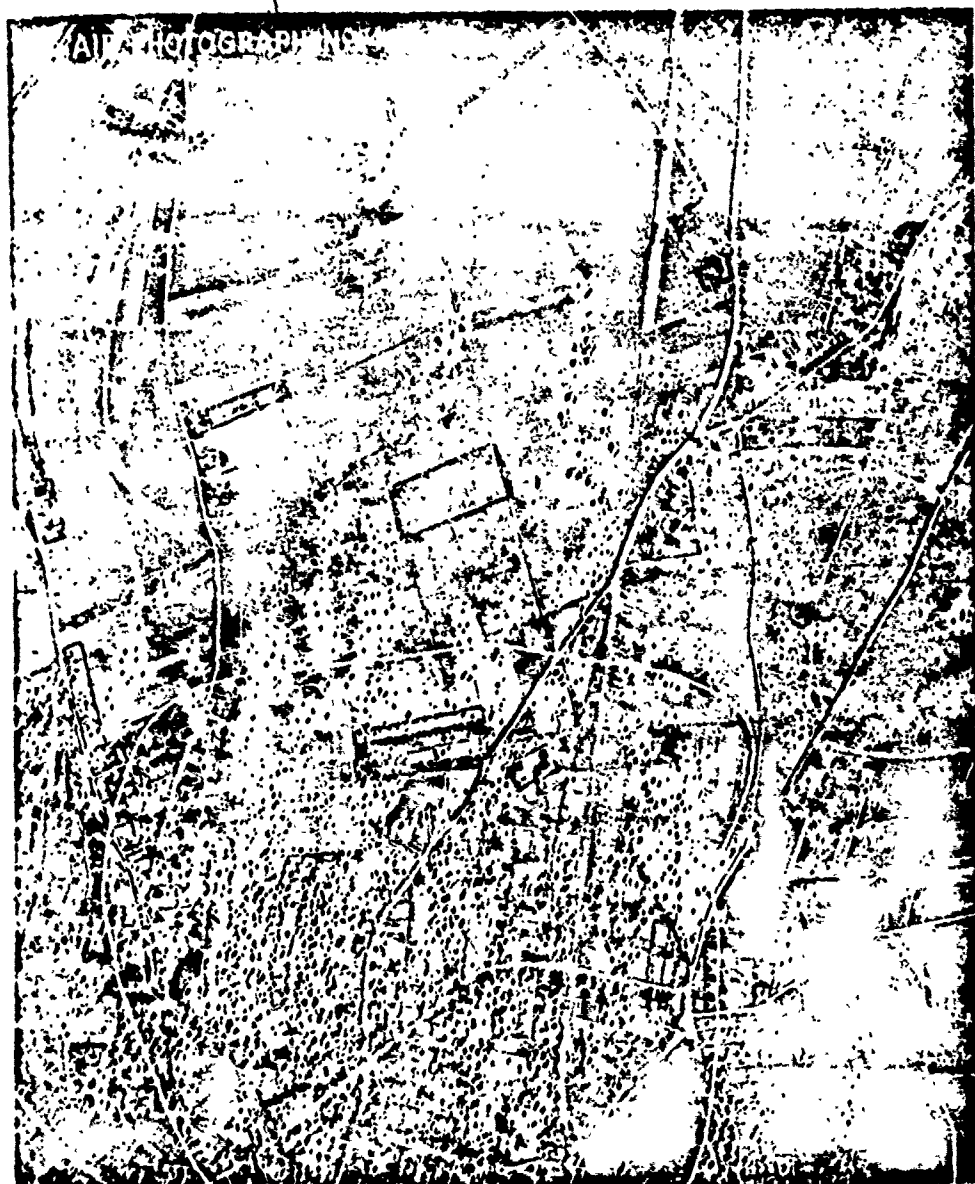
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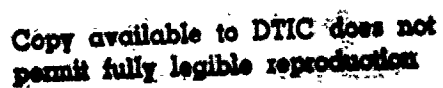
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REPORT NO. 6.

Bombing in Operation GOODWOOD.I. INTRODUCTION.

The primary object of this examination was to ascertain if possible the effect of fragmentation bombs which were dropped by Medium bombers, but a few observations on the effects of the Heavy night bombers were also made.

Unfortunately the number of bombs and bombers allotted to each task, the precise types of bombs used, aiming points and other necessary details have not been forthcoming. The ground has been so much cut up by shell-fire also, that without the guidance that this information should have provided, it has been virtually impossible to interpret air photographs or decide which areas were worthy of examination. Information is therefore incomplete and conclusions should be accepted with reserve. Examination of the area covered by the Heavy day bombers was not practicable.

An extensive tactical report on air support has nearly been completed by G (Plans) 2nd Army and will include the findings of G (I). No attempt has been made to duplicate this work, save that an Appendix is attached dealing specifically with the effect on armour.

II. EFFECTS PRODUCED IN AREAS COVERED BY MEDIUM BOMBERS.1. Obstruction.

No road was found to contain a crater that would have obstructed either a tracked or a wheeled vehicle, though the latter would have been slowed up by the uneven surfaces. The same was also true of the fields, where it was clear that the majority of craters were due to shells.

The streets in the villages of Giberville, Cuverville and Demouville had been somewhat obstructed by debris, but were largely cleared by the time they were examined. The amount of debris seen made it unlikely that tanks would ever have been obstructed; in any case these villages were readily by-passed and there was no reason to suppose that the debris was more than might have been expected from the volume of shell-fire on these areas.

2. Material effects.

Woods and walls in and about the villages of Cuverville and Demouville were examined for fragment strikes. In all cases where the strikes were of recent origin and could definitely be associated with a particular crater, this was a shell crater. Five cases of circular craters approximately 15 feet diameter by 1 ft. 6 ins. deep with a small extra depression in the centre, showed no signs of strikes on walls and trees nearby, the wall being in one instance only 10 ft. from the centre of the crater. Two of these craters were close together in a small yard, surrounded by buildings. One of these, a lightly built small stone house, which was estimated to have been four yards from the centre of the nearer crater, was practically demolished and considerable damage was done to other buildings around. There is no certainty that these shallow craters were in fact due to bombs as the target areas in question had also been shelled by heavy artillery, but the craters due to the latter were readily identified as such.

One 88 mm and two 75 mm anti-tank guns were found in the area. One of the former had been abandoned with only a few fragment strikes on it, while the remainder had been knocked out by shells. There was no evidence that bombs had fallen near them. Places where equipment might have been expected according to the defence overprint yielded no result; all traces of movement had been totally obliterated by heavy rain by the time they were examined.

3. Conclusions.

(a) An area covered by medium bombers with loads as carried in this operation, will not cause any appreciable obstruction to subsequent movement.

(b) There is a suspicion that the fragmentation of the bombs, or at least the direction of the fragments, was not satisfactory. The evidence is too confused and insufficient to justify more than a suspicion, but it might be worthwhile carrying out an experiment under controlled conditions on soft ground to settle the matter.

III. HEAVY NIGHT BOMBERS.1. Factory area (Concentration A).

The density of craters appeared to be about 7 per acre, with mainly 1000 lb bombs to the north near the factories and 500 lb bombs in the residential area to the south.

2.

The writer witnessed this bombing from a point approximately 3000 yds north of the most northerly factory, and formed the opinion that its effect on anyone in the area must have been thoroughly demoralizing.

The factory buildings themselves were very badly damaged though not flattened, and from the amount of debris it did not appear that anyone in them would have remained unharmed. Specific points in the area where resistance was momentarily offered were on the fringe, namely around 075707 and 082692, from which an anti-tank gun or guns knocked out four tanks. But resistance was also offered in the factory itself, around 076698; however, it is thought that this must have been by troops who had subsequently fallen back.

In the residential area towards the south, the majority of buildings were either demolished or badly damaged and, had they been held, resistance must have been seriously disorganized.

Obstruction due to the cratering was very serious in the northern part of the area, and most roads were made impossible to all vehicles, a condition which is understood to be accepted where this type of bombing is used. In the residential area where the small bombs were used, most roads had been made passable by 4 days after the attack, apparently without much difficulty.

2. Eastern area (Concentration II).

A high concentration (about 12 bombs per acre) of what appeared to be 1000 lb bombs made the village of Sennerville impossible to all traffic, but it was not difficult to by-pass. In particular there was a large crater and 10 feet of debris blocking the main street.

3. Conclusions.

Where demolition in built-up areas is required, it can be obtained with less subsequent obstruction and greater ease of clearance by 500 than by 1000 lb bombs, but large factory buildings require the more drastic treatment. If the object is to obstruct enemy traffic movements, the larger bomb is to be preferred.

IV. GENERAL CONCLUSIONS.

In an Operation such as GOODWOOD in which so much other fire-power was used apart from bombing, it is very difficult to assess the contribution made by the bombing, but there was a definite indication that, at least temporarily, opposition in the bombed areas was not severe. There is also evidence that within a matter of hours opposition can stiffen, but whether by recovery of those in the area or by reinforcement from those outside is not clear.

Evidence for this conclusion is slender, but it is hoped that the G (Plans) report will provide greater detail.

APPENDIX A.

OPERATION "GOODWOOD"

Effect of Bombing in Assisting Tank Units.

INTRODUCTION.

The southern British thrust on July 18th and 19th in operation "Goodwood" was carried out primarily by tanks using the tactics of "fire and movement" - i.e. some tanks moving forward while others at rest give supporting fire. Wartime experience has shown that such supporting tanks should be placed hull-down behind a crest, and in the present attack our units were instructed to adopt such tactics.

OBJECT.

The object of this appendix is to estimate how far bombing assisted our armoured forces in their attack beyond Caen on July 18th and 19th.

DISCUSSION.

In European terrain A/T guns, before they fire, can normally be so camouflaged as not to be seen by tanks; in these circumstances such guns usually held their fire, even down



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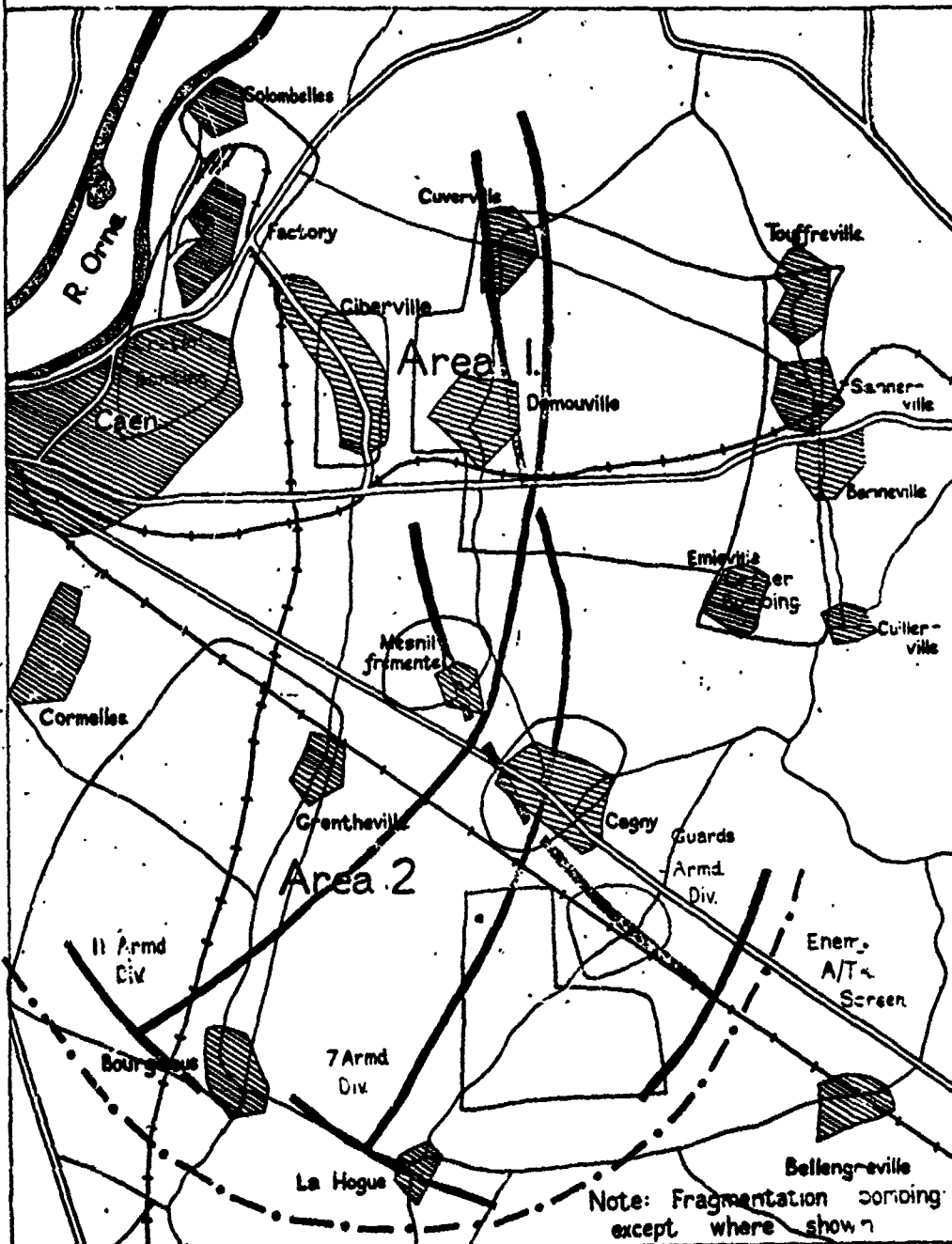
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Map to illustrate Heavy Bombing in operation Goodwood

Scale 1:50000



to ranges of 200 - 300 yards, till they are certain of a hit. With suc. opposition at what points in operation "Goodwood" was difficulty to be expected for our armoured units and how far did bombing assist them?

When using the tactics of fire and movement, where our supporting tanks are far away, say 2000 yards, it will take at least on average of 15 rounds HE before a direct hit on a dug-in A/T gun is scored; even when several tanks are firing this will take sufficient time for 4 or 5 of our attacking tanks to be hit. Where, however, supporting fire is at 800 yards or less, one of our supporting tanks should score a direct hit on their first round. If the enemy guns are unable to penetrate the frontal armour of our tanks long range support will not be altogether impossible. For operation "Goodwood", however, our tanks lacked such armour and, where terrain made long range support necessary, some other way of neutralising German A/T guns was necessary - in this case, presumably bombing.

The attached map shows, what a study of the actual terrain proves far more clearly, that though the early part of the armoured attack was over ground with undulations which were fairly close together, yet the ground for the final move gave no adequate crest cover for about 4000 yards; therefore it was in this last stretch that most help was needed.

In judging the assistance given by bombing to our Armoured units it is simplest to divide the total area into two sections:-

Area 1. The area where ordinary tank tactics might by themselves be expected to succeed, i.e. where the crests are reasonably close together.

Area 2. The area where ordinary tank tactics might by themselves be expected to fail, i.e. where the crests are far apart.

AREA 1.

The 11th Armd. Div. over-ran this area with comparative ease in about 6 hours except for the final length close to Caen. They said they were not checked by crests and were unanimous that the bombing had been of the greatest assistance in frightening and dazing the A/T gun crews. In the area of Caen far more resistance was met and in order to push ahead this area was avoided by a movement to the west.

Later the 11th and Guard's Armd. Divs. met this same resistance and suffered casualties before overcoming it. There is no data as to whether the guns were in position before the bombing or were later reinforcements.

On this limited evidence there can be no final judgment as to the amount of help provided by the bombing. On the material side it was probably small; of the 3 A/T guns found, all had been knocked out by HE and not by bombing. On the morale side, several tank crews claimed that they discovered A/T crews still in their slit trenches and that they destroyed them by throwing in grenades. This is probably true since slit trenches were found roughly filled in by infantry who said they had done so to cover German bodies so mutilated they could not be moved. The fact that A/T crews were sitting in their slit trenches and not turning their guns towards support but not proof to the claim that bombing had dazed them since they might have been there through fear of tank HE or in the hopes of avoiding detection.

Summing up, it is considered probable that the bombing assisted our tanks traverse area 1 although it is possible that ordinary tank tactics would have succeeded equally; possibly, though judging from other tank attacks over similar terrain in Normandy, unlikely.

AREA 2.

In this area the 11th Armd. Div. suffered particularly, though both the 7th and Guard's Armd. Divs. suffered heavily also. The 11th Armd. Div. did not arrive in this area till about 10 hours after the bombing, while the other two divisions were even later, by which time the psychological effect had probably worn off or reinforcements had arrived. A further attack was made next day without success.

On the evidence it is impossible to say whether the bombing was of assistance in area 2 beyond the statement that, if it did assist, it was insufficient to overcome the natural disadvantages of the terrain. All personnel interviewed, officers and men, were unanimous in their desire for more bombing support. Almost all wished for waves of bombing, each wave briefly preceding in time their own advance; they insisted that area 2 should not have been bombed till they were ready to attack it.

APPENDIX B

OPERATION GOODWOOD - 18TH JULY, 1944.

(Based on reports by Scientific Adviser, 21 Army Group; No. 2 O.R.S.; D.L.T. Air Ministry, and various liaison officers).

1. The bombing plan for this operation is shown on the attached map, which contains details which will not be repeated here.

2. Bombing by the heavies. Areas A, B, C, D and E, were extremely well concentrated and all targets except C were well covered. Examination of the ground at Colombelles showed that in the factory area the roads though badly cratered could be by-passed by tracked vehicles. The road through Sannerville was completely blocked by craters and rubble. The ground at Cagry where special instantaneous fuzes were used has not yet been studied.

3. Bombing by the mediums in Area G was not completely effective in Cuverville and Demouville though the use of small fragmentation bombs avoided the creation of choke points in these villages. 11 Armoured Division reported active resistance in both areas with heavy machine gun and mortar fire. Later examination of a copse S.E. of Cuverville disclosed little or no bombing of what, judging from the shell craters, must have been a strongly held position. Judging from the ground in Area G the medium bombing was devoted too much to the villages and too little to the copses around and in between.

4. Fighter bombers on Troarn were not able to neutralise effectively the large area occupied by the enemy there and medium or heavy bombing would have been better.

5. Safety distance of 2000 yards was used at Colombelles (A). No bombs fell among our own troops. Two sticks fell on the Western bank of the Orne and one near the sapper bridge at Blainville (X), 2000 to 2500 yards from the edge of area A.

6. Damage to enemy equipment. A complete survey has not been made but at Cuillerville (Area D) 13 tanks, Tigers, Panthers and Mk. IV's, and 7 S.P. guns, were found in No Mans Land amongst a mass of cars, signal trucks, lorries and motor-cycles, while others are visible through binoculars and are buried in craters. This area held a battalion of 21 Panzer Division.

Along the Colombelles - Giberville road were direct hits by 1000 lb bombs upon infantry and anti-tank positions in the edge of the wheat and a good number of damaged 75 mm guns and enemy dead were found.

In the Colombelles factory area a battalion of 16 G.A.F. Division was destroyed and several hundred prisoners taken, including the battalion commander.

7. Moral and psychological effects; enemy opposition. 70% of the prisoners were stone-dead hours after capture and could not be interrogated. On the Northern edge of the village and factory area of Colombelles, however, the enemy resisted strongly where he had not been bombed and the factory area itself was not occupied until the evening. The 2nd Army report gives many details of breakdown in morale.

Opposition was also encountered in Sannerville from machine guns and snipers. This was overcome by 1200 hours. Troarn, which had been attacked by fighter bombers, was strongly held and could not be captured.

In spite of the bombing of Cagry, anti-tank guns and tanks were met there at 1200 hours.

8. The timing of the attacks on the Southernmost targets was such that too long an interval elapsed between the bombing and the appearance of our troops. It is considered that if these areas, including Cagry had been attacked one or two hours after the others, instead of at nearly the same time, enemy resistance would have been much less. As the open country provided good going, these Southern areas, E, I, K as well as N could probably have had delayed bombing on the road junctions in the villages.

The tactical development of the battle indicated the desirability of a bombing timetable which is progressive so that targets in depth are bombed just before the assault upon them.

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REPORT NO. 7.

Bombing in Operation BLUECOAT.I. INTRODUCTION.

Operation Bluecoat consisted of an attack on 30th July, 1944, by 8 and 30 Corps. The initial break-in was to be made by 15 (Scottish) Division of 8 Corps and 43 Division of 30 Corps, and this was then to be exploited by armour. Normal artillery support was arranged for the operation and the heavy bombing was to be superimposed on the plan if the weather was suitable.

In investigating the operation, we have attempted to go further than a mere examination of damage and obstruction, and have tried to estimate the extent to which the bombing actually helped the attacking troops. In this case it has only been possible, for various reasons, to draw rather tentative conclusions but the same method might be tried again, since it is only in this way that the tactical value of heavy bombing can really be measured.

II. THE TARGET AREAS.

In the first instance a number of areas were selected by Second Army as being probable areas of tactical importance. These are shown on the diagram at Appendix A ringed with a continuous black line. It will be seen that most of these areas contain either high ground or villages and other likely points of resistance.

This request by Second Army was not met in full by the Air Forces, and the target areas finally agreed upon are shown on the diagram ringed with a broken line.

The weather at the time of the first bombing was bad, with low cloud. Nevertheless, the bombing was carried out and the amounts reported as dropped in the various areas are given below:-

Areas A, B and C. Weights of attack on the different areas are not available. The total of bombs dropped on the three areas was:

468 x 500 lb GP
3581 x 250 lb Frag
16 x 250 lb ?
2419 x 100 lb Frag

of these 50% were fused instantaneous, and 50% 8-11 secs delay.

Total weight 706 tons.

Area D1. 58 x 500 lb MC
1288 x 500 lb GP (Fused instantaneous)

Total weight 300 tons.

Area D2. 827 x 500 lb MC
500 x 500 lb GP (Fused instantaneous)

Total weight 296 tons.

Area E1. Nothing is mentioned of this area, and the ground showed no craters.

Area E2. 710 x 500 lb MC
2427 x 500 lb GP
140 x 500 lb U.S.

of these 70% were fused .025 secs delay and 30% instantaneous.

Area F1. Nothing is mentioned of this area, although it had definitely been hit by a few bombs.

Area G. This area was not bombed.

A further area, in square 7252, is reported to have received 124 x 500 lb. This area is not among those originally asked for nor those agreed to, but it was confirmed on the ground that some bombs were dropped in the vicinity.

It is understood that ORS AEP has made a report on the accuracy of the bombing and this point has not therefore been considered.

III. ENEMY DISPOSITIONS.

Little detailed intelligence on enemy dispositions was available at the time of the attack. It was known that the front opposite 15 and 43 Divisions was held by 326 Infantry Division and the approximate areas of Regiments and Battalions were also known. A defence overprint of the area was produced but this was mostly unconfirmed and known to be inaccurate. It does show guns to a total of approximately the number to be expected in a German Infantry Division, but several of these locations were subsequently examined, and some gave no evidence at all of having contained anything.

In the course of the operation, a piece of carbon paper, showing a rough trace of enemy dispositions was captured. This was later confirmed in respect of several of its locations.

Appendix A shows the sum total of what is now known of enemy dispositions at the time of the bombing, from defence overprint, the carbon paper trace and other sources.

IV. THE MATERIAL EFFECTS OF THE BOMBING.

A 1 and 2. These areas were accurately bombed.

2 single guns and a site of 3 possible 88 mm guns were shown on the defence overprint in the vicinity of these areas. No trace could be found of the 2 single guns, although there were a few sleeping holes round the edges of the fields in question. The holes showed no signs of having been recently occupied.

The 3 gun site was discovered, although it had apparently contained only 3 20 mm guns. Numerous sleeping holes, and some vehicle pits were also found round the guns. There were signs that this site had been occupied more recently than the other two but there was no evidence of it having been evacuated hurriedly or in a state of disorganisation. It seems likely in fact that it had been evacuated before the bombing.

Sleeping holes were found in various other fields and orchards, but in every case they seemed not to have been occupied recently. No damaged equipment was found.

B. This area did not appear to have had many bombs and, what there were, were widely scattered.

The defence overprint showed one site of 3 guns in this area. This was identified in a field with vehicle pits and sleeping holes round the edges. There were no bomb craters anywhere near. There were, however, shell craters in the field and, whether because of this or the progress of the battle, the site had evidently been left in some haste although there was no sign of any actual destruction.

On the high ground near ring contour 220 there were slit trenches and anti-tank gun pits. There were a few bomb craters around, but no signs of damaged equipment.

C. The bombs in this area appeared to be rather scattered.

The area was bombed in the afternoon of the operation and, as the battle had by then progressed considerably, there is no indication of what was in the area. It was not possible to examine the whole area in detail, but no evidence was found of the bombing having caused any material effects. The tank crews who arrived first on the objective confirmed that they saw no equipment knocked out and no enemy killed by the bombing.

D 1 and 2. Both areas had been fairly accurately bombed, although the bombs on D 1 were more concentrated than D 2.

Nothing was shown on these areas on the defence overprint, although a number of sleeping holes which had evidently been occupied were discovered. There were no signs of destruction of the enemy.

E 1. Practically no bombs had fallen in this area and there was no damage to buildings in Arroye sur Seuilas. Beyond a motor cycle and sidecar combination possibly knocked out by a fragmentation bomb, there was no evidence of destruction either to enemy personnel or equipment.

E 2. Brugere and surroundings were heavily and accurately bombed with delay and instantaneously fused bombs. 3 of the 5 exits to the village, being fairly narrow sunken lanes, were completely blocked to traffic by craters. Brugere was known to contain part of the Reserve Battalion of 751 Regiment and ample evidence of this was discovered. The area contained numerous weapon pits and slit trench sleeping holes, with miscellaneous small

equipment strewn about. At least two sleeping holes were completely destroyed by delay fuzed bombs. There can be little doubt that the troops in this area were seriously disorganised for a time by the bombing but, as the battle did not in fact move up to this area until nearly two days later, they presumably had time to recover.

F 1 and 2. The first of these areas had not been bombed. Nothing was shown on the defence overprint for the second area and no signs of the enemy or of destruction to his equipment or personnel were discovered, although a number of bombs had fallen in the area.

G. This area received no bombs and was not therefore examined.

Summing up, it can be said that, in spite of the accurate placing of about 2000 tons of bombs on the various areas, the resulting damage to enemy equipment and personnel was very slight, for the sole reason that the amount of equipment and personnel in the areas was itself small.

V. FRAGMENTATION AND CRATERING.

In Areas A, B and C, bombed by the IXth Air Force, there were two main types of crater to be found. Some were deep and conical, and of rather variable size, up to about 45 ft. diameter. These were made by bombs fused 8-11 secs delay. In a few instances the bombs had penetrated so deep before exploding that they had only produced a camouflat. The other type of crater, that produced by the 90 lb Fragmentation bomb, was only a few inches deep, of irregular shape and about 3-4 ft in diameter. Further out from the centre was an area of ground much broken up by fragments, and further out still, radiating in all directions from the centre, were the fragment tracks. In several instances the disposition of strikes could be observed on the walls of nearby houses or on trees, and in all cases the main fragment zone had kept very close to the ground.

In the Bomber Command areas, there were large craters, presumably made by 500 lb bombs fused .025 secs delay, as well as a variety of shallow craters. Some of these were about 2 ft. deep and 5 - 10 ft. across, sometimes with and sometimes without fragment tracks on the grass. These were often difficult to distinguish from heavy shell craters. The other very characteristic type of crater consisted of a 'saucer' about 10 - 15 ft. across and 9 ins. deep, with a further small depression in the centre. The grass was always blasted away for a distance around, but fragment tracks were never visible, and when it was possible to observe strikes on houses or trees, they appeared to be few and high. This phenomenon was pointed out in an earlier report, and seems to merit expert attention. In no case did the fragmentation bombs in the British areas appear to be so effective as in the American areas.

VI. EFFECT OF THE BOMBING ON THE COURSE OF THE BATTLE.

43 and 50 Divisions.

Operation Bluecoat did not proceed according to plan on the left flank. 43 and 50 Divisions were held up all through the day of 30th July quite a short way in front of the start line, and they did not reach the bombed areas until 2 - 3 days later. Although the bombing on Areas D, E, F and G, and in particular E 2 (which fell on part of a reserve battalion) might have influenced the battle had these areas been reached rapidly, in fact it is doubtful whether the course of the battle was affected at all.

11 Armoured Division.

The attack of 11 Armoured Division, protecting the right flank of 15 Division, went well. The objectives of this attack were not bombed and it is not therefore considered in any detail. The left flank of the attack did however pass through the Area A and progressed considerably faster than the attack on the right flank. This must however be attributed mainly if not entirely to the fact that there was considerable opposition at Cussy on the right flank which held up the advance for several hours.

15 Division.

15 Division with 6 Guards Tank Brigade in support started attacking at 0700 hours and in two hours had reached the first objectives of Sept Vents and Lutain Wood. They met considerable opposition and the two battalions attacking suffered about 80 casualties each. The first bombing (Areas A, B, D, E, F, and G) took place between 0900 and 1000 hours and the second phase of the attack started immediately afterwards.

This consisted of an attack by 4 Grenadier Guards tanks and 10 MLI on the village of Nervieux, and by 3 Scots Guards tanks and 2 MLI and 3M on the high ground near Les Loges. Both attacks were supported by a timed artillery programme and both were somewhat held up by AP mines. In both cases the tanks went in front and reached the objectives about 1200 hours, while the infantry arrived shortly afterwards. Infantry casualties were much lighter than in the first phase, and it is interesting to note that the battalion attacking on to the bombed area suffered only 20 casualties as opposed to the 35 casualties suffered by the other battalion.

The last objective, Point 309, was to be bombed between 1600 and 1700 hours and the final attack could not start until the bombing was completed. This involved waiting for some hours on the second line of objectives, in the course of which 12 of the Scots Guards tanks were knocked out in a bunch by two long 88 mm SP assault guns, and the enemy was presumably given time to reorganise. However, when the attack did start after the bombing, it went well and the timed artillery programme which was to have been put down, was cancelled as being unnecessary. 4 Coldstream Guards tanks arrived on the objective about 1800 hours and the infantry about an hour later. The ease of this attack may well be partly due to the bombing of the objective. Casualties in the attacking infantry battalion (2 Gls H) were only 35.

The attack also went well for the tanks. Casualties due to enemy action were:-

Scots Guards	26
Coldstream Guards	10
Grenadier Guards	12

of these 12 were due to mines, so that only 38 were due directly to enemy guns. Owing to changes in the Brigade R.E.M.E. staff directly after the action it has not been possible to pinpoint these casualties, but it has, however, been mentioned that 12 of the Scots Guards casualties were caused by two 88 mm Assault guns during the wait on the second line of objectives.

These casualties are low in comparison with other attacks in Normandy. This was no doubt due partly to the country, which was considered favourable for Churchill's, but may have been due also to the bombing. Various tank crews reported finding anti-tank gunners still in their trenches and not firing. In general the tank crews taking part were in favour of the bombing, but were very critical of the long wait imposed on them half way through the attack.

The general course of the 15 Division attack is shown at Appendix A.

VI. CONCLUSIONS.

It was the opinion of some of the troops taking part that the fierce fighting on the first two objectives went a long way to breaking enemy resistance and so disorganising him that he was unable subsequently to offer any serious resistance. While no doubt this is partially true, the amount of equipment abandoned in Sept Vents and Lutain Wood suggests that the majority of the two forward battalions involved got away in some order. The relative ease of the second phase of the attack must be attributed partly also to the timed artillery programme, of which there was none in the first phase. Tank co-operation was undoubtedly excellent and further assisted the attack. But, as already pointed out, it is suggestive that the battalion attacking under comparable conditions on to the bombed objectives suffered considerably fewer casualties. Again, in the last phase, in spite of the absence of artillery support and the long pause on the second objectives, the casualties were light.

While there is no evidence that the bombing was at all decisive and while there are endless accidents of war which make any firm conclusions from such limited evidence impossible, there is at least some indication that the bombing helped in getting the troops on to the objective, in spite of the very slight material effect and the fact that the attacks did not actually reach the objectives until 2 or 3 hours afterwards.

How exactly the bombing brought this about, either in the present attack or in others is not clear, but is evident that the many psychological factors usually referred to as morale effects were responsible. There is no reliable POW information on this attack which throws any light on the point.

OPERATION BLAUFRONT, 30TH JULY.

(Summary of investigation by No. 2 O.R.s.)

1. The general layout of the operation, with details of enemy dispositions etc., is shown on the diagram attached. The final details of bomb weights and natures and the areas bombed have not yet been obtained from AEF. The remarks on the bombed areas shown are based on a quick general survey of the ground and require confirmation and extension.

2. Material effects of the bombing.

Examination of the areas showed little sign of abandoned enemy equipment. Brayers (Area E II), which definitely contained part of the reserve battalion of 751 Regt was severely damaged and 3 of the 5 exits from the village were completely blocked to traffic.

There was in fact little enemy equipment or personnel in the areas bombed.

3. Effect of bombing on the course of the battle.

There is no evidence that the bombing was decisive but there is some indication that it helped in getting troops on to their objective. Various tank crews reported finding A/Tk gunners still in their trenches and not firing.

4. Timing of final phase.

Tank crews were critical of the long wait imposed on them between Phase II and Phase III before the final objective was bombed, during which 12 tanks were knocked out and the enemy given time to reorganise. The attack in Phase III, however, went well, and the timed artillery programme was cancelled as unnecessary. This may well be partly due to the bombing programme.

5. Area bombing requests by the Army.

The attached map shows large areas A, B, C, D, E and F, which the Army asked to be bombed. The Air Forces were unable to meet these requirements and the final agreed bombing is shown.

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REPORT NO. 8.

OPERATION "TOTALISE".

R.A.F. Heavy Bombing on night 7/8th August 1944.

457 Lancasters and 184 Halifaxes, 641 planes in all, took part in this bombardment. Between then they dropped 6935 bombs (1000 lb and 500 lb bombs of various types) of a total weight of 3458 tons. All were fitted with 025 sec delay fuses.

The five targets which are dealt with separately below were:-

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| 1. FONTENAY-LE-MARMION | U 035583 |
| 2. LE MOQUE | U 095606 |
| 3. MAY-SUR-ORNE | U 021593 |
| 4. SECQUEVILLE-LA-CAMPAGNE | U 097593 |
| 5. Track crossing at | U 103583 |

1. FONTENAY-LE-MARMION.

This target was bombed by 135 Lancasters dropping 828 tons, which total was made up in the following manner:-

563	1000 lb H.C.
11	1000 lb G.P.
1093	1000 lb U.S.A.
260	500 lb H.C.
299	500 lb G.P.

No bombs fell on the village itself; there were a few in the fields to the east, but the great concentration was straddled across the little hamlet of LE VAL which lies half a mile to the west of the target.

LE VAL was completely wiped out but there was no sign of enemy equipment destroyed or men killed by the bombing. Debris and craters made the roads through LE VAL quite impassable.

The bombing was finished at about midnight and the first Canadians forced their way into the village of FONTENAY-LE-MARMION at 0100 hours; they had occupied it by 0200 hours. Well dug in on the north side of the village were Germans who appeared to be unaffected by the bombing, for they put up very stiff resistance to the advance of the battalion of Camerons, which suffered heavy casualties.

P.O.W. reports state that, when bombs started to fall on MAY-SUR-ORNE some ten or fifteen minutes before the attack on FONTENAY-LE-MARMION, the tanks and M.T. which were in the latter were pulled out and the troops in the trenches to the north were told to hold on as a counter attack would be launched in the morning. This did in fact occur and the village was heavily shelled between 0900 and 1000 hours by tanks mounting 88 mm guns (according to the Camerons).

Officers of the Camerons mentioned that the flares, which were fired to indicate the target, had faded just before the bombing started, which might account for the inaccuracy. It was also stated that, as a result of the bombing, the air was so thick with dust that it was very difficult to see.

2. LE MOQUE.

This target was bombed by 95 Halifaxes and 4 Lancasters which dropped 467 tons, the total being made up in the following manner:-

232	1000 lb H.C.
102	1000 lb G.P.
524	1000 lb U.S.A.
209	500 lb H.C.
166	500 lb G.P.
4	500 lb U.S.A.

LE MOQUE was struck fairly and squarely by a great weight of bombs though there was some spill-over into the fields on the west side. Not a single building had more than 6 feet of wall standing and the roads were not only impassable but quite unrecognisable. There did not appear to have been any enemy equipment or personnel in the village at the time of the bombing.

No attempt was made to enter LA HOGUE during the day which followed the bombing but on the next day (9th August) a battalion of the 51st Division approached it and had to bypass it to the south.

3. MAY-SUR-ORNE.

This target was attacked by 89 Halifaxes and 3 Lancasters, dropping 424 tons of bombs; this total was made up in the following manner:-

778	1000 lb H.C.
13	1000 lb G.P.
50	500 lb H.C.
271	500 lb G.P.

MAY-SUR-ORNE appeared to have received only a slight attack; some bombs had obviously fallen in fields near ST MARTIN DE FONTENAY to the north of the target but even so the number of craters observed was nowhere near 1112 which was the number of bombs said to have been used in this attack. Air photographs of BRETTEVILLE-SUR-LOIZE taken on 7th and 9th August show that at some time between these dates a large weight of bombs had fallen there and it is tentatively suggested that this town was bombed by a number of the planes which were intended to attack MAY-SUR-ORNE.

Damage inflicted on the enemy in MAY-SUR-ORNE was negligible. As soon as the bombing ceased, a battalion of the F.M.R. (Canadians) advanced from ST ANDRE but, when they had reached a point some 100 yards south of ST MARTIN DE FONTENAY, they were held up by very determined machine gun fire from MAY-SUR-ORNE; this caused a number of casualties and the advance was not resumed until flame-throwing Churchills had cleared the road after daybreak.

The following points were made by officers who were concerned in the attack. The flares had just faded out when the bombers arrived. Some bombs fell short among the men who were waiting to advance; this caused some confusion and did not improve their morale. It was suggested that, whereas in daylight attacks our forward troops are able to see the planes unload their bombs or fire their rockets on the enemy, at night they do not see any such heartening spectacle but merely hear the bombs descend and wonder where the next one will fall.

4. SECQUEVILLE-LA-CAMPAGNE.

This target was attacked by 110 Lancasters with 637 tons of bombs which consisted of the following:-

12	1000 lb H.C.
1180	1000 lb U.S.A.
244	500 lb H.C.
224	500 lb G.P.
4	500 lb U.S.A.

SECQUEVILLE-LA-CAMPAGNE did not appear to have been very badly damaged by bombing but there was a large number of craters in the fields to the north-east of the village. Hardly a hundred bombs could have fallen in SECQUEVILLE itself. There were no signs of enemy personnel or equipment destroyed by the bombing.

5. Track Crossing.

This area was attacked by 205 Lancasters which dropped 1100 tons of bombs; the total being made up of the following:-

1379	1000 lb H.C.
722	1000 lb U.S.A.
264	500 lb H.C.
483	500 lb G.P.

The open scrubland which was the target in this case was very heavily pitted with bomb craters. As it was still very close to the enemy at the time of the writer's visit no detailed examination was undertaken but, as the Defence Overprint only showed two guns in the area, it is unlikely that any great loss could have been inflicted on the enemy.

CONCLUSION.

It should be pointed out that, in the case of targets 2, 4, and 5, it was hoped that the bombardment of these points on the left flank of the main axis of the attack would reduce the chance of a counter attack from that direction. No such counter attack did in fact develop.

NOTE: The following paragraph is NOT approved by G-2, AD, 21 A-6p.

In the case of targets 1 and 3 the villages to be bombed were also objectives for the ground forces and the bombing appears to have been of no assistance to them in taking these points. An interesting comparison can be made between three parallel attacks by three Canadian Battalions, the S.S.R. on ROCQUANCOURT, the Camerons on FONTENAY-LE-MARTIN, and the F.M.R. on MAY-EUR-ORNE. The last two were bombed and they proved difficult to take; the first was not bombed but the infantry were assisted by an artillery barrage and reached their objective more easily. The casualty figures bear this out, for the S.S.R. only lost 6 officers and 35 other ranks whilst the Camerons lost 8 officers and 108 other ranks, and the F.M.R. halted their attack half way when they had lost 3 officers and 45 other ranks.

1. INTRODUCTION

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(c) greater, similar must be achieved, or a size and space that houses detour: such

REPORT NO. 14.

Heavy Bombing in Support of The Army.I. INTRODUCTION.

In the past few weeks O.R.S. has studied in some detail four major operations involving heavy bombing:- CHARNWOOD, GOODWOOD, BLUESCOAT, and TOTALISE. The basis of the investigations has always been a careful examination of the ground and of the course of the battle. The opinions formed as a result of this approach do not entirely accord with those of PW nor of our own troops, at present the most prolific sources of information, but it is felt that the two must be balanced against each other if a true picture is to be formed of what bombing really achieves. It is felt also that before bombing can be successfully applied to any tactical situation, its real effects must be known with at least a measure of exactness. The aim therefore of this work has been to find out as accurately as possible what bombing does do, and only then to suggest how it can best be used in support of the army.

In the operations studied heavy bombing has been used to assist the first stages of the break-in and the treatment which follows is primarily concerned with such stages. However, some of the results may well be applied to other stages of military operations.

The effects of bombing are several and interrelated. For ease in description, however, three major effects are considered separately: obstruction, destruction, and demoralisation. All three aim ultimately at the same thing: so to disorganise the enemy that he cannot resist or attack effectively. Those three effects are described as they appeared in the thirty or so separate target areas involved in the four operations.

II. EFFECT OF HEAVY BOMBING.

Broadly speaking, the pattern on the ground of an attack on one target by British heavy bombers is much the same size whatever the weight of attack. Nine-tenths or more of bombs usually fall within a circle of 1,000 yds diameter, so that there are very few "wide shots." It does however quite often happen that the centre of the pattern is wrongly placed, and it is this risk rather than the occasional wide shot which imposes a considerable safety distance.

Given that the heavy bomber pattern is a 1,000 yard circle, it is clearly uneconomical to use this form of attack on point targets, or on widely dispersed targets; it should be confined to genuine area targets. The nature of the effect produced is then determined by the type of bomb employed, and the intensity of the effect by the number of bombs dropped.

1. The obstructive effect of heavy bombing.

Only the larger bombs, fitted with delay fuses can be considered really effective in obstructing enemy movement. This they may achieve by the size of the crater they produce (up to 45 ft diameter and 12 ft deep for the 1000 lb bomb fused .025 seconds delay) or by knocking down buildings to form heaps of rubble.

This means broadly speaking that towns and well built up areas are readily blocked, while in the open country a greater weight of bombs is needed, depending mainly on closeness of the country and the ease with which the obstruction can be by-passed. Present knowledge on obstruction with deep cratering bombs based on the limited experience of the operations studied can be conveniently summarised under headings of the type of town or country.

(a) In heavily built-up areas. Complete blockage over a whole 100 yd circle can be accomplished with about 5 bombs per acre, or about a 50 bomber raid (British). This, like any blockage, can be cleared in time, but it is likely to be a complete obstacle for several days to any wheeled or tracked vehicle.

(b) In less heavily built-up areas such as villages, the weight of bombs needed to cause a similar blockage is rather greater, up to about 10 bombs per acre, or a 100 bomber raid. In both these instances it should be realised that the blocking is achieved primarily with masonry, and only secondarily with craters.

(c) In open suburban areas the density of bombs needed for blockage is much greater, since there is no great amount of masonry available to assist. In this case, blockage must be achieved by means of craters almost entirely, and this necessitates as many as 40 per acre, or a 400 bomber raid. This figure is however liable to be considerably modified by the size and spacing of individual houses. In general, a suburb approximates to open country, in that houses are widely spaced, the ground is levelled, and there are no continuous obstacles to detour such as banks or ditches. Vehicles can therefore easily detour through gardens. A density

of 40 bombs per acre, however, ensures that craters are almost overlapping, and makes any detours impossible even for tracked vehicles. A rather lower density would obstruct wheeled vehicles. This type of block is not such a permanent one, and can be overcome with bulldozers in 1-2 days.

(d) In level open country the density of bombs quoted above is required in order that craters may almost overlap, thereby making small detours impossible. In general however larger detours to avoid the bombed area completely are possible, and obstruction bombing in open country cannot in general be considered worth attempting.

(e) In close country blocking is easier to effect. The density required is largely dependent on how close the country is, but given woods, trees, orchards, parks, ditches and streams, it will seldom be possible for wheeled transport to move off roads and tracks. A density of 10 - 15 bombs per acre (equivalent to a 100 - 150 bomber raid) will produce at least 15 craters on any road in the area, and thereby produce a very adequate block. To block tracked vehicles may need greater densities than this.

2. Destructive effect on heavy bombing.

In spite of reports by POW and our own troops, the actual amount of damage caused to enemy personnel and equipment by heavy bombing in the four operations in question has been small. Numerous reports of very heavy damage have been received, but a close examination of the ground very soon afterwards has almost always shown the damage and casualties due directly to bombing to be very slight. This is a disappointing conclusion, but it should not be taken as an indication of the ineffectiveness of bombs, but rather of the fact that there was little in the area to be bombed. The enemy always practices a very high degree of dispersion, so that there is not likely to be much in a 1000 yd circle, and there is no doubt that in several of the areas bombed there were no enemy at all. It is clear therefore that damage to the enemy can only be considered in relation to his dispositions, and this point is discussed later.

(c) Effect of different bombs.

It is necessary to summarise first, however, the little that is known of the destructive power of various types of bombs. The destruction caused, as already mentioned, has been slight and, of this, very little gives any clear indication of the true destructive power of bombs.

The evidence of trials in England is sketchy. The lethal effect of bombs on personnel in the open is known reasonably well, but this is only of academic interest since the enemy invariably digs in well, and must be assumed to take shelter while bombing is in progress. The lethal effects of bombs against dug-in troops are not known with any high degree of accuracy but a rough idea of the relative efficiencies for different bombs and fuses can be obtained by consideration of crater sizes, blast and debris effects. The values so obtained are set out in the following table, the efficiency of the 100 lb G.P. bomb being taken as 1.

<u>Bomb</u>	<u>Instantaneous Fuse</u>	<u>Delay Fuse</u>
100 lb	1	-
250 lb	2	4 - 10
500 lb	3	6 - 20
1000 lb	4	8 - 30

While in normal sandy ground, delay fused bombs are about twice as effective as instantaneously fused, in certain grounds, and in particular in clay, they throw large quantities of heavy debris about and may be 5 - 7 times as effective. The substantial roof covers of most German shelters will however reduce the value of this debris very considerably.

While, therefore, delay fused bombs are more effective than instantaneously fused, they are not much more effective, and when cratering is inadvisable, the latter could be used without great loss of effect.

The effect on vehicles is also shown roughly in the table below. The table assumes ten vehicles to be parked in a field 100 yds square and gives the number that would be knocked out, seriously damaged, or destroyed by five bombs falling in the field.

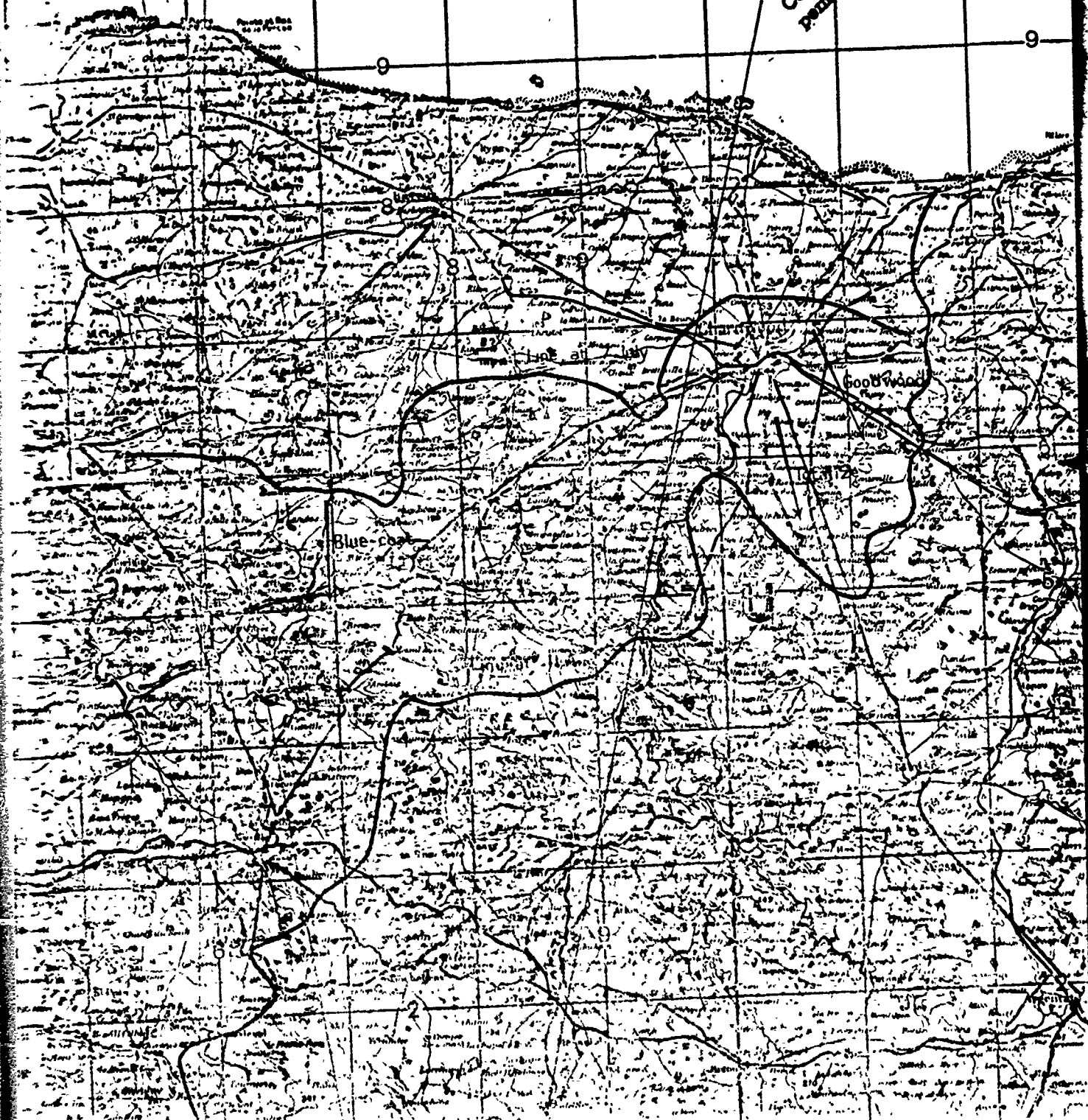
<u>Bomb</u>	<u>Instantaneous Fuse</u>	<u>Delay Fuse</u>
100 lb	3	- (The figures for instan-
250 lb	5	- (taneous fuses refer only
500 lb	7	- (to vehicles not dug in, while
1000 lb	9	- (with Delay Fuses digging in
		(makes no difference.

Map to show heavy bombing
attacks in Normandy

Scale 1:250,000.

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For the same number of guns in a similar field, with five bombs dropped in it, the figures for instantaneous fuzes should be divided by about 10 - 20, while the delay figures remain unchanged.

These figures again should be treated only as a general indication. They do indicate that against vehicles not dug in instantaneously fuzed bombs are about ten times better than delay fuzed bombs, while against guns there is little to choose. It should however be noted that there is evidence that the 90 lb bomb is as good as or better than heavier bombs with instantaneous fuzes.

The evidence available for actual bombings of the enemy is exceedingly scanty, but such as there is roughly bears out these figures.

(b) Dispositions of the enemy and vulnerability to attack.

Real information on enemy dispositions is scanty. Enemy formations are often fixed up and seldom up to strength, so that it is impossible to argue from them densities on the ground. But from a general knowledge of enemy tactics and from APIS information, some evidence can be found.

1. Administration Areas.

Starting from the rear, there are first the Services and Administration Areas. These are all well concealed, usually in woods and very little is known in detail of how they are dispersed nor in general of where they are located. There is reason to suppose that much of the transport of the fighting troops is also kept well back in or near these areas.

A German Infantry Division has about 1000 motor vehicles and 1000 horse-drawn vehicles, and a Panzer Division 3000 M.T., the majority of which are probably to be found in these areas, and they represent, without doubt, the target most vulnerable to bombing attack; this point will be further discussed.

2. Gun Areas.

Gun areas usually extend from about 2 - 4000 yards back to 6 - 8000 yards. An analysis of Defence Overprints, for the gun areas in the first instance north and later south of CAEN, gave similar figures for both areas.

Taking all A.A., A/T. and field guns, the Defence Overprints showed an average figure of 4.3 (N. of CAEN) and 4.5 (S. of CAEN) guns per 1000 yards square. The highest number in both cases was 12 per 1000 yd square. From this it becomes clear why bombing of gun areas has been found so unproductive of physical damage, since a 200 (British) bomber raid on one 1000 yd square (using 500 and 1000 lb bombs with delay fuzes), containing 4 guns (and perhaps 20 vehicles and 80 men) would only be expected to damage 1 gun and 3 vehicles. Instantaneous bombs, on the other hand, might damage only one gun but probably almost all the vehicles.

Even if the area contained 12 guns, which would be exceptional, the destruction of them and their M.T. would hardly be expected to influence the course of a battle very greatly, and the results are very clearly not commensurate with the effort expended.

3. P.O.D.s.

The German system of defence is in general to hold small strong positions, often centred round but not in a village, with a number of dug-in tanks or S.P. guns, and perhaps 1 or 2 companies of infantry. The size of these strong positions varies greatly but two typical examples taken from the battle south of CAEN are given, one fairly lightly and the other strongly held.

La Hogue.

Size about two 1000 yd squares.

contained:- 2 Field)
2 A/Tk.) guns
3 A.A.)
3 Mortars.
Probably 1 Company.

Total strength: estimated 250 men.

Assessment

Size about four 1000 yd squares.

containing:- 26 S.P. guns, tanks, and 12 guns.
39 Mortars and Nebelwerfers.
Probably 2 Companies.

Total strength: estimated 700 men.

These two areas given densities per 1000 yard square of:-

	Men	Guns	Mortars
LA MOQUE:	125	34	12
ROOQUAN COURT:	175	7	6

It will be seen that in the first of these areas the density of guns on the ground is more or less comparable with a gun area, while the density of men is greater.

In the second the density of guns is high, and of men still higher.

To cover the first area, two aiming points would be needed, to cover the several four aiming points. If 200 bombers were to be allotted to each and covered the first with two 100 bomber raids, and the second with four 50 bomber raids, we might expect the following (using delay fused 500 lb or 1000 lb bombers):

		Total	Destroyed
LA MOQUE:	Men	250	30
	Guns	7	1
	Mortars	3	(4)
ROOQUAN COURT:	Men	700	45
	Guns	26	12
	Mortars	39	2

One might therefore the prospect of destruction in areas actually bombed by us is explained, and the return in casualties and losses for the effort expended is small. There is, however, not the least doubt that this weight of attack would have morale effects out of all proportion to the physical effects, and it is the morale effect which must be utilised if heavy bombing is to prove really useful.

3. Demoralisation produced by bombing.

In its capacity to deliver a weight of projectiles over a protracted period and in its accuracy a heavy bomber compares unfavourably with any medium gun. A large formation of bombers can however deliver a weight in a short period which is out of all comparison with that attainable by any artillery concentration that can at present be contemplated and can also, if required, reach areas beyond artillery range.

There is little doubt that it is primarily the overwhelming concentration in time of a heavy bombing attack that gives it its demoralising effect, though there is at present little evidence as to what is the optimum weight, area, and duration of such an attack to yield the best dividend, or what type of bomb is the most effective. It is considered that further research is badly wanted to elucidate these points.

The main weight of evidence as to the demoralising effect of heavy bombing comes from PW statements; these have related in much detail how terrifying it was, but it is the reaction after the bombing that is of importance in the subsequent attack. The evidence as to the extent and duration of the demoralisation produced by heavy bombing is not yet sufficient for any conclusions to be drawn. On the one hand there are numerous intelligence reports of a high degree of demoralisation and cases such as that in Operation GOODWOOD where 1/16th gunners were found in their trenches (incapable of resistance). On the other hand the evidence from Operations CHARNWOOD, BLUECOAT, and TOTALISE was that enemy resistance was as strong as in the unbombed area and a special PW interrogation carried out at our suggestion disclosed that at least one small batch of enemy troops was in fact able and ready to resist almost immediately after the bombing. The conflict of evidence can be due to a number of causes, but the main cause of success in operation GOODWOOD is probably the fact that the follow-up into the bombed area occurred sooner than in most, if not all, other cases; namely, within about one hour of the bombing.

Until more evidence is available as to how complete demoralisation can be produced, it is suggested that too much reliance should not be placed on its occurrence, but that its effects are most likely to be realised if the follow-up occurs within a hour of the bombing.

III. THE APPLICATION

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III. THE APPLICATION OF HEAVY BOMBING IN SUPPORT OF THE ARMY.

The best application of heavy bombing in support of the Army follows simply and logically from the conclusions of the last section.

1. Of the three effects of heavy bombing, one, morale, is only temporary. It follows that a bombing attack aimed at breaking morale is almost useless if it is not followed up rapidly. Whether in fact this is practicable is not a matter for discussion here, but it is very certain that no bombing attack with demoralization as its primary object should be arranged unless it can in fact be rapidly followed up. This limits such attacks to the enemy's forward positions. By this means it should be possible to walk through them with little or no opposition, and as the prelude to a set attack, it may therefore be valuable.

2. The other two effects of heavy bombing are more permanent, although obstruction may not in fact hinder movement for more than a few days.

It is evident that obstruction can be caused fairly readily in town or close country, less easily in open country. In either case, detours may be possible. This means that blocking is not easy without a considerable effort, placed on a number of carefully chosen points. But blocking on a flank, blocking of supply routes, blocking the lateral movement of reserves or blocking the path in front of a retreating army is definitely possible.

All the necessary knowledge is now existent to plan such an attack with considerable precision, and a reasonable measure of success is only a matter of applying the knowledge.

3. The destructive effect of heavy bombing is the most permanent, but also the most difficult to achieve. It has already been pointed out that bombing for destruction in gun areas is highly uneconomical, and even if achieved, unlikely to influence the battle unless carried out on a vast scale. The same is true in lesser degree of F.D.L's where bombing for morale effect is far more productive.

There remain, however, a few targets which could possibly be profitably bombed for destruction. Of these, ammunition dumps and dense concentrations of troops and equipment need no comment, since they are bombed at present if the opportunity occurs. In any case they cannot form part of the plan of a battle. There is, however, a third target, which has already been mentioned as being particularly vulnerable to attack by instantaneously fused bombs - soft vehicles, not dug-in. A small and rough calculation will show the possibilities of this sort of attack. It has already been mentioned that five 90 lb bombs falling on a 100 yd square field, containing ten soft vehicles, will knock out about three. This is confirmed by a mistaken attack on our own troops. Roughly speaking, therefore, 3 - 4 90 lb bombs in a 100 yard square knock out about 20% of the soft transport in that field, and 300 - 400 bombs uniformly spread over a 1000 yd square will similarly knock out about 20% of all transport in that area, if not dug in. This represents at the most only about 20 tons of 90 lb bombs. 200 to 500 bombers could therefore knock out 20% of all the enemy transport in an area about 3 miles square. Destruction on this scale is clearly capable of being decisive at various stages of a battle.

REPORT NO. 16.

AIR AND GROUND SUPPORT IN THE ASSAULT ON BOULOGNESummary of the Principal Lessons.I. LOCATION OF HOSTILE BATTERIES.

1. The Hostile Battery List contained 48 positions, of which 29 were actually destroyed. Of these, 9 were genuine batteries, 6 contained odd guns, 3 were dummies and 11 were empty. A further 12 batteries were not located before the assault. In a fortress, such as BOULOGNE, there is a limit to the amount that can be got from air photographs and the very closest co-ordination of intelligence, APIS and C.B. information is needed to produce an accurate H.B. list. Without such a list, much air and artillery effort is inevitably wasted.

II. USE OF AIR BEFORE THE ASSAULT.

1. Air attacks before the assault had not done significant damage to Infantry defenses, and broken communication cables had often been re-laid; although they may have lowered enemy morale, the effect does not seem to have been marked. It is therefore suggested that air effort before the assault be considered in terms of destruction to guns, which are limited in number, and virtually irreplaceable.

2. There were altogether 49 air attacks by Mediums, Fighter bombers and R.P. Typhoons. 31 of these, directed at battery positions, were subsequently examined; 7 proved to be attacks on dummy positions and 11 on empty emplacements. Because of this wastage, the total score of guns damaged was poor, but excluding the wasted attacks, 1 rangefinder and 4 guns were put out of action by 800 bombs and 200 rockets, which is well in keeping with known accuracy figures. The destruction of guns is necessarily expensive; some 180 Heavy bombers, or, since they are more accurate, 150 Mediums are required to destroy half the guns of a battery in open emplacements.

III. HEAVY BOMBING DURING THE ASSAULT.

1. The heavy bombing on the first line of objectives did not do much important physical damage, but had a strong morale effect. It was probably largely responsible for the fact that the three Battalions attacking into bombed areas took 1 1/2, 1 and less than 1/2 a day respectively to capture their objectives. Two battalions attacking similar positions that were not bombed took 5 and 3 days respectively. Since the effect is much more moral than physical, it must be followed up very quickly. The one battalion that arrived at its objective within 3/4 hrs of the bombing took it in less than half a day.

2. Target Area 2 for Heavy bombing contained a six gun 88 mm Flak battery, and was attacked altogether by 36 Mediums and 39 Heavy bombers. Only 1 88 mm and 2 of the 3 20 mm were put out of action, and the battery subsequently fired about 2000 shells (in a ground role). Throughout the assault on BOULOGNE, it was evident that, where there were virtually bombproof shelters, the bombing of batteries achieved no more than a transitory neutralisation unless the actual guns were destroyed.

IV. NEUTRALISATION OF HOSTILE BATTERIES DURING THE ASSAULT.

1. The greater part of the 600 casualties suffered by the Canadians at BOULOGNE were caused by shellfire from Hostile Batteries. An essential requirement for assaults of this sort is to be able to decide which batteries are in action and retaliate immediately; the Air O.P. is likely to be one of the best methods.

2. Even when the correct Hostile batteries were located, neutralisation was not entirely successful. One 6 gun 88 mm battery had fired 2000 rounds (in a ground role) in spite of receiving the extraordinary total of nearly 6000 shells within a circle of 300 yds diameter enclosing the guns. PW said they took cover during the very heavy concentrations, but came out and fired during the considerable lulls. Methods of neutralisation need consideration and ingenuity.

3. Neutralisation by R.P. attack was not entirely successful either. While these attacks seldom caused destruction, they were very frightening, but after taking cover PW always came out again and fired their guns. To attain anything more than transitory neutralisation, R.P. attacks need to be repeated, perhaps as often as every 15 minutes, unless of course they are rapidly followed up on the ground.

V. ASSAULT WEAPONS.

1. Many tanks and assault vehicles were lost in bomb craters and others were considerably delayed. Armour, which is blinded by darkness, smoke or dust, is much affected by even a small amount of crater bombing.

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2. Under the conditions prevailing in this operation Flails could NOT be relied on to clear a lane through a minefield; Sappers and Pioneers had also to be available.

3. Potards fired from A.Vs.R.E. had little serious effect on the concrete of pillboxes, and out of more than 20 strikes examined none had hit the front steel plate. Nevertheless, the enemy almost always surrendered. If however A.Vs.R.E. are to achieve any material effect and destroy determined defenders, they must get sufficiently close to hit this plate.

4. Crocodiles can be relied on for immense moral effect against poor troops.

5. Had there been guns capable of damaging Churchill's present, extra fire power would have been needed to assist the approach to pillboxes.

CONTENTS

- I. Introduction.
- II. R.P. Typhoons, Fighter Bombers, and Medium Bombers.
- III. Heavy Bombers.
- IV. Artillery.
- V. Tanks and S.P. Guns.
- VI. Assault Equipment.

- Appendix A. Narrative of the Assault on B.N. 1000.
- B. Table of R.P., F/B, and Medium Bomber Attacks.
 - C. Table of effect of Air and Artillery on various types of pillboxes.
 - D. Note on the composition of the Garrison, P.W. types, morale, and the employment of Psychological Warfare.
 - E. Note on Morale, P.W. types, and the effects of Supporting Arms at CALAIS.

- Map 1. Infantry objectives and air targets.
2. Hostile Batteries.

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AIR AND GROUND SUPPORT IN THE ASSAULT OF MOULONG.

I. INTRODUCTION.

1. The defenses of MOULONG were based on a ring of hills round the town. They were extensive and well prepared with wire, mines and exceptionally heavy concrete emplacements. The garrison numbered about 10,000, but were known to be of poor morale. It was thought that a sudden heavy blow might induce them to give in, and the 8th and 9th Infantry Brigades of 3rd Canadian Infantry Division who assaulted the town were therefore supported by an unusually great concentration of fire power.

2. The attack, however, developed unexpectedly; it took 6 days instead of an anticipated 2, chiefly because of insuperable obstacles and heavy shelling from batteries well back. On the other hand, once the infantry and assault equipment succeeded in getting up to the emplacements, the enemy surrendered, usually with little or no fight. Casualties, due largely to shell fire, were about 12% of the infantry taking part.

3. A full report on the whole operation has been prepared for G (Ops) B, H.Q. 21 Army Group, by Lt.-Col. Rideout. Our investigation has been primarily concerned with the assistance given to infantry by the Supporting Arms and to find out how, if possible, this assistance might be increased.

II. R.P. TYPHOONS, FIGHTER BOMBERS AND MEDIUM BOMBERS.

1. General.

1. Before the Operation the air effort aimed at the destruction of strong points and guns and, while the battle was in progress, the neutralisation and if possible also the destruction of such guns as were causing trouble. During the Operation typhoons were permanently on call, controlled by an F.C.P.

2. An analysis has been made of this air effort, with information collected from a number of sources. (See Appendix B and Map 2). 49 separate attacks were made, involving 570 sorties, in which 2,304 bombs (500 lb fused .025 secs delay) were dropped, and 1028 rockets fired. Almost all the attacks were directed at batteries or positions where guns were alleged to be and, although there was damage to defence works, it was of very secondary importance. The air effort is therefore considered only in terms of destruction of guns. It should be noted that in almost every case the A.A. guns were in open concrete pits 16 ft across and 4 ft deep, while the field guns were in open positions or in pits only 2 ft deep. Although there were a number of covered gun emplacements, these were seldom occupied, presumably because the number of guns in the garrison was limited and restrictions on the field of fire could not be tolerated. A number of Heavy C.D. guns were in covered emplacements, but in only one or two cases were they able to bear on our troops.

3. The attacks were divided as follows:-

<u>Attacks investigated:</u>	Attacks resulting in damage or possible damage to guns	4
	Attacks resulting in NO damage to guns (of these, 11 were on positions that proved subsequently not to contain batteries)	23
	Attacks on dummy batteries	7
<u>Attacks not investigated:</u>	Position of attack not recorded and therefore not investigated	7
	Attack not examined	8

4. Damage to guns was slight:

Bombs	-	1 gun destroyed, 2 guns minor damage.
R.P.	-	1 rangefinder of CD Bty destroyed, 1 gun minor damage (Possible R.P. only).

At first sight this seems a small return for the effort expended, but, considering only the attacks made on actual battery positions, we get the following 'score':-

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1 gun destroyed)	for 840
2 guns minor damage)	bombs.
1 Rangefinder destroyed)	for 216
1 gun possibly destroyed.)	R.P.s.

5. The figure for R.P. damage is good, when it is considered that in trials, 30 rockets are required to hit a tank, which presents a target perhaps 5 times larger in area, and where the attack is unopposed by Flak. The figure for destruction by bombs is reasonable and in keeping with a normal medium bomber pattern. It is clear that the R.A.F. functioned as accurately and effectively as they could be expected to and, when given suitable targets, they produced as much material destruction as might be expected.

6. It will be seen from para. 3 that of the 34 attacks examined, 7 were on dummy batteries, 11 on positions which, while they may have contained odd guns, did not contain batteries and 16 were on genuine battery positions. This wastage of effort raises the whole question of identifying gun positions, which is dealt with in Section IV 2, under "Counter Battery."

2. Air effort before the Assault.

1. Morale effects, though sometimes long term and cumulative, are largely transitory. The time before a set piece attack on strong fixed defences must therefore be considered largely as one of attempted destruction.

2. The 29 attacks made before the battle were directed mainly at batteries, but only succeeded in damaging one gun. While in theory it should make no difference to the total number destroyed, whether the attacks are spread over many targets or concentrated on a few, in fact many of the targets proved not to contain guns and it would have been more effective to have concentrated all this air effort on a few batteries identified for certain. We might then have expected 5 to 10 guns destroyed for the same effort.

3. Although there was very little destruction of guns, it appears from P.W. statements and ground observations that at least the four heaviest attacks (Appendix B, Serials 13, 18, 19, and 27) succeeded in cutting telephone and fire control cables. Cables were partially relaid, but no doubt the efficiency of the batteries for co-ordinated A.A. or C.D. fire would have been reduced. But, in fact, all the batteries used wireless communication with their O.P.s. when telephone cables were cut and their efficiency in a field artillery role was not much impaired. It was indeed noticeable everywhere in the assault on BOULOGNE that even the heaviest bombing, unless it actually destroyed the guns, did not afterwards stop them from firing.

4. In various places destruction was caused to infantry defences. This however could not be considered significant and it is clear that, in their nature, infantry defences are too flexible to be worth attempting to destroy.

5. The destruction of guns is expensive, but it is considered on the evidence of these attacks that nothing else is worth attempting before the assault. The morale effects of bombing are valuable during the assault and the destruction of telephone cables is useful when there is no time to replace them; but before the assault both of these effects are far less significant. It is suggested, therefore, that in future operations a concentrated destructive programme be attempted, with attacks aimed in the first place at batteries located with certainty. The weight of attack needed for varying degrees of destruction is a matter for the R.A.F., but as a rough guide it can be taken, on the basis of the latest accuracy figures, that about 180 Howies or, since they are more accurate, 150 Medians are needed to destroy half the guns of a battery provided they are in open emplacements, whatever the size of the battery; 3 to 4 times these numbers are needed to ensure the destruction of all the guns.

3. Air Effort during the Assault.

1. The destruction of guns is so expensive that it will seldom be possible to achieve it during a battle. On the other hand, the destruction of telephone cables, which needs only 15 - 20 Medians, is valuable and there is great scope for exploiting the great morale value of the "Air", and in particular of Rockets. Their high morale value was once more confirmed in this Operation, where several P.W. commented that they were exceptionally terrifying, although usually inaccurate. Morale effects, however, tend to be transitory, and R.P. attacks must be followed up rapidly on the ground or repeated at intervals.

2. In this Operation there was, as far as is known, no case of an R.P. attack being called for on a target which might subsequently have been quickly overrun. In almost all the cases where R.P. attacks were made on batteries, they were not repeated, with the result that the battery soon started up again. It should be a matter of course for any target attacked by R.P. to receive repeat attacks unless it is overrun by ground forces.

III. HEAVY BOMBING.1. Target Areas.

The heavy bomber effort consisted of attacks on five different target areas, shown on Map 1. The attack on Target Area 1 (the MONT LAMBERT, ST MARTIN, MARLBOROUGH defenses) was the prelude to the whole battle, and troops crossed their start lines as the last bomb fell. Areas 2, 3, 4, and 5 were objectives for the later stages of the attack. They were bombed between 1 and 3 hours after the end of the first attack. The total weight of bombs was 3340 tons, distributed as follows:-

Area	Approx. Weight of bombs (tons)	Number of bombs
1	1850	4711
2	210	546
3	240	634
4	505	1316
5	505	1334

2. Destructive Effect.

1. The effect of bombs on German concrete emplacements has already been investigated (Report to 21 Army Group on the bombing of targets in the British Sector, NORMANDY, by Major F.W. Anderson), and no new points emerged in this attack. Only direct hits stand any chance of destroying the normal pillboxes and the stronger emplacements (8 ft concrete roof) are proof even against these.

2. Of 20 P.W. interrogated from various bombed areas, only three reported casualties due to bombing (a total of 11); the rest claimed that they suffered no casualties. All mentioned that telephone cables had been cut, but that wireless continued to work. On MONT LAMBERT it was noticed that temporary telephone lines had been laid on the ground. Various PW mentioned that the cratering made it easy for our infantry to approach unobserved. One Captain said that, although there was little important damage, the various effects of the bombing made control and cohesion difficult.

3. Morale Effects.

1. Everybody in the bombed areas was severely shaken and those of poor morale beforehand became worse. Those of better morale all said that the effect was only temporary and that they regained heart. A few said that the large quantity of artillery prevented them recovering from the effects of the bombing.

2. All PW went for shelter during the bombing and made no attempt to man their weapons until after it was over.

4. Assistance given to the Infantry by the Heavy bombing.

1. Target Areas 2, 3, 4 and 5 were captured so long after the bombing that no safe conclusions can be drawn as to the extent to which the bombing helped the Infantry. Target Area 1 was however followed up rapidly.

2. The extent of Target Area 1 and the objectives and axes of the various battalions are shown on Map 1. The table below shows the progress of the various Units in this phase of the battle:-

Battalion	Objective	Time taken to clear objective	Casualties suffered in clearing objective	Whether Bombed
N.W.S.R.	MT. LAMBERT	1 1/2 days	approx 60	Yes
S.D. & G.	ST. MARTIN (S of rd)	less than 1 day	approx 4	Yes
R.O.R.	ST. MARTIN (N of rd)	1 day	0	Yes
R. de Chaud	BON SECOURS	5 days	58	No
N.S.F.	LA TREBORERIE	3 days	54	No

3. Assessing the help given by the bombing is very difficult. The battalions attacking into bombed areas were all enthusiastic about it, especially the S.I. & G. who overran most of their objective within an hour of the last bomb falling. The table above is somewhat misleading, however, since the time taken to clear the objectives depended on various factors besides the enemy opposition, such as extent of mines and

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obstacles, cover available, etc. Nor were the casualties sustained a full indication of the enemy resistance on the objective, since many were caused by shell-fire from batteries outside the bombed area. Nevertheless, the figures do give a quantitative indication which is often wanting of the assistance given by bombing.

4. The importance of a quick follow-up was once apparent. The S.D. & Co. arrived on their objective within 3/4 hrs of the bombing, and took the whole area in less than half a day.

5. Effect on 88 Bty at TURBINGEN (Target Area 2).

1. The Heavy attack was superimposed on a medium attack of 36 planes made the day before. The total number of bombs was about 800. The pattern was, however, rather displaced, and 3 of the 88s were right outside the area of dense bombing. The results of these attacks, shown in Appendix C, were briefly:-

Number of guns in battery	Number damaged or destroyed by bombs	Approx number of rounds fired by 88 during battle (from empties)
6 88 mm	1 88 mm	2000
4 20 mm	2 20 mm	unknown

2. 3 out of 10 guns were damaged. It was unfortunate that it should have been 2 out of the 4 20 mm and only 1 out of the 6 88s. As may be imagined from the number of rounds fired, the battery proved a constant source of trouble until it was finally captured. The remarks under Medium bombers on the destruction of batteries apply equally here.

6. Fragmentation bombing at CALAIS.

The experiment was tried in the Assault on CALAIS of bombing one area with instantaneous fuzes. The results of this attack are described in Appendix E.

IV. ARTILLERY.

1. General.

1. Taking part in the Operation were the artillery of 3 Cdn and 51 (Highland) Divisions, 2 (Cdn) LORL and 9 LORL, and 2 H.A. Regiments, making a total of -

Field Regiments	5	-	120 guns
Medium Regiments	8	-	120 guns
Heavy Regiments	3	-	48 guns
H.A.A. Regiments	2	-	48 guns
			<u>344 guns</u>

2. After a timed programme on enemy F.D.Ls, lasting for about 1 1/2 hours, and expending some 20,000 rounds, regiments were sub-allotted to Artillery Group Commanders at each Brigade, except that the Heavy and H.A.A. Regiments, and from time to time others, were at the disposal of the C.B.O.

3. It became clear at an early stage that the most important aspect of the battle was the destruction and neutralisation of hostile batteries and we have studied this in as much detail as circumstances permitted. There was, however, much firing at hostile batteries by the Artillery allotted to Brigades and of this no records were kept, so that an exact analysis of what fell where has not been attempted.

2. C.B. Programme.

1. The details of the C.B. programme, which were modified several times both before and during the attack, are of no special concern. There was a pre-arranged programme up till half an hour after the end of bombing on Target Area 1, when harassing fire was started under control of Air O.P.s. There were five of these, each netted to a Regiment and covering a zone of the defences. On the first day of the attack, which was fine, they were very effective in locating enemy batteries and bringing fire to bear on them.

2. It had been hoped that the Heavy Bombing of Targets 2, 3, 4 and 5, west of the river, would render hostile batteries in this area inactive. In fact, however, Air O.P.s. spotted batteries active even during the bombing (although presumably not in the actual target areas) and C.B. was therefore carried out in this area actually during the bombing.

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3. The Hostile Battery List contained 48 fixed positions; 19 of these were not examined. Of the remaining 29:-

Genuine battery positions	9
Odd guns	6
Dummy positions	3
No guns present	11
	29

In addition to this, 4 further battery positions were discovered on the ground and 6 further positions were indicated by the Infantry as causing trouble as the attack progressed, or were mentioned by PW but were not examined. Details of all the battery positions, located and unlocated, false and genuine, are given in Map 2. It is thought that altogether there were about 90 enemy guns of 75 mm calibre or greater in BOULOGNE.

4. There were certain discrepancies between the Hostile Battery List and the Defence Overprint. Neither appear to have incorporated certain battery lists issued by G-2 SHAEF although these may have been issued in some other form. The best possible collation of the information then available would have given 15 batteries completely correct and substantially fewer false positions. The lesson to be drawn is that intelligence, APIS, and CB information must be closely co-ordinated to produce the best possible Hostile Battery List.

5. The incompleteness of the Hostile Battery List depended as well on the normal limitations of air photographs in detecting genuine battery positions, which in the case of BOULOGNE were enhanced by the careful preparation and camouflage of the defences. Good quality 1/8000 scale verticals supplemented where possible with 1/4000 compensated verticals of pinpoints will show all there is to be seen from verticals. Low obliques are the only means of detecting positions screened by overhead cover such as camouflaged guns or batteries on the edges of woods. Photographs of all these three types are desirable but their availability must depend on the operational conditions existing during the planning period.

6. There is no doubt also that the enemy pursued a careful and comprehensive policy of sound ranging deception. In such a case as BOULOGNE, sound ranging before the assault cannot be regarded as giving more than an indication of where to search for guns on air photographs.

7. The great importance of co-ordination of all sorts of information about hostile batteries needs no emphasis. Without a substantially correct H.B. list, much air and artillery effort is inevitably wasted.

3. Enemy activity and effects of our C.B.

(a) PW information.

1. A Captain, commander of the Army artillery of the garrison, captured on the second day, claimed that he had not lost any of his guns through C.B. (3 Btys, 4 x 10.5 cm gun hows and 1 Bty, 4 x 10.5 cm guns), and that we appeared not to have pinpointed his positions accurately. His return fire was limited by lack of ammunition and lack of working O.P.s. His line communications, though not his wireless, had been put out by bombing and the large amount of artillery fire made his O.P.s. disinclined to get out in the open.

2. 3 O.R. PW from the 88 mm Flak battery at HONRIVILLE, captured at the end of the third day, claimed that they were frequently shelled heavily for periods of about 15 minutes. Personnel took cover only on the order of the Battery Commander, and then only during the actual shelling, and each gun fired many hundred rounds. Our counter fire did not appear to follow activity on their part. Line communication within the battery was working all the time, as the cables were buried two metres deep.

3. 4 O.R. PW from a 155 mm Bty south of HOCQUET, captured on the 5th day, said that bombing had destroyed one gun and cut telephone communication with the O.P. Artillery fire caused no damage or casualties and mostly fell a considerable distance short of the battery (the position had not been located before the battle). They had fired all their available ammunition (30 rds per gun).

(b) Information from own troops.

1. The whole attack was heavily influenced by enemy shelling, which caused the greater part of the 600 casualties. From Appendix A, the narrative of the battle, it will be seen how frequently forward movement and the mopping up of defences was delayed by shelling.

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2. In spite of the concentrations and 'stomachs' at the immediate disposal of the infantry, no less than 17 batteries were reported back to Division as being particularly troublesome, with requests for air or other action.

3. Discussion with Infantry and Artillery personnel served to confirm once more two well known difficulties; firstly that while an accurate concentration on a well located battery invariably silenced it for the duration of the concentration, the effect seldom lasted for any length of time afterwards; secondly, that in many cases, the battery doing the shelling could only be located approximately, if at all, so that although concentrations were laid on the most likely positions, they were by no means always effective.

(c) Examination of enemy battery positions.

1. An examination of a number of batteries was made, and the results are summarised in the table below. Details of the examination are shown in Appendix C. All guns were in open concrete pits except where specifically stated.

Map Ref.	No. & Type (incl light flank) of Guns	No. & Type put out of action by Arty.	Rds fired by Bty	Estimated rds put on enemy bty (in 300 yd diam circle)
682554	5 88 mm	1 88 mm	1200	3600
677566	2 210 mm 4 105 mm 2 76.2 mm	Nil 1 105 mm Nil	- 300 -	- ? -
663532	6 88 mm	2 88 mm	2000	5700
654924	4 138 mm 1 76.2 mm	1 138 mm Nil	1500 -	? -
660515	6 88 mm	1 88 mm	2000	?
700518	5 88 mm	1 88 mm	200	?

In most cases shell craters were obscured by spoil from bomb craters but, if the two cases that could be counted are typical, the number of rounds put on the batteries was very considerable. In spite of this they were far from silenced.

9. Discussion.

1. The Artillery assembled for the Operation (about 350 guns) was less successful than might have been expected in neutralising hostile batteries, on which some 80,000 shells were expended.

2. The location of enemy guns during a battle has always presented a problem. The Infantry who are being shelled cannot easily make careful observations and are usually out of view of the guns firing on them. Artillery O.P.s, F.O.O.s, Counter Mortar personnel, and Air O.P.s are the only ones in a position to deal with the problem and greater interchange of information between them should be attempted.

3. The neutralisation of a hostile battery once it is located also needs proper thought and ingenuity. The sudden and very heavy concentrations of 10 - 15 minutes used in this Operation were not entirely satisfactory.

4. It is urgently recommended that opportunities be made to study in detail the reactions of some hostile batteries to Counter Battery fire of different types so as to find out with more certainty what methods show most promise.

V. TANKS AND S.P. GUNS.

1. 8 and 9 Brigades were allotted 1 squadron each of tanks from 10 Canadian Armoured Regiment, and 1 troop each of M10s (3" S.P. A/Tk guns).

2. BOULOGNE was unusual in having very few A/Tk guns and, while there were a number of 88s and 75s which could and did function as A/Tk guns, they were nearly all in A.A. battery positions and therefore relatively easy to avoid. Although somewhat cautious at first, when they discovered the small quantity of A/Tk opposition, the Armour took more risks and gave valuable direct M.E. support to the Infantry. A normal complement of A/Tk guns properly sited would have restricted them severely.

3. The great value of tanks and S.P. guns against troops of low morale is shown by a number of incidents. The North Shore Regiment fired a few rounds from M.10s at pillboxes in WHILLIE and the enemy promptly surrendered. A German 2/Lt captured on MONT LAMBERT on the second day surrendered with his men when surrounded by tanks, without apparently any attempt to use the Infantry A/Tx weapons. An Infantry captain from ST. ETIENNE told how his men surrendered at once when they saw tanks coming up at them. No case of tanks actually causing casualties has been discovered.

4. In various instances tanks proved useful in giving covering fire to enable infantry to get up to pillboxes. In a few cases they actually supported the infantry to within a few feet by firing small arms tracer from a flank. It was universally agreed that any form of fire at the allies, either M.E. or S.A.A., was effective in neutralising the weapon inside. This might not have been so with more resolute defenders.

VI. ASSAULT EQUIPMENT (FLAILS, A.Vs.R.E., CROCODILES).

1. General.

1. The assault equipment was allotted variously to battalions as the operation progressed; they were also grouped together in three armoured columns which were to break through quickly when the first objectives were taken and to capture the three bridges intact. As it turned out, because of the delay in getting the first objectives, the columns were late in starting and, by the end of the first day, two of them had not reached their bridges while the third remained to help clear MONT LAMBERT. The two columns moved off early next morning but found their bridges blown. Thereafter these columns were allotted as a whole or in parts to battalions as the operation demanded.

2. Obstruction by bomb craters

1. The craters caused by heavy bombs with delay fuzes constituted a considerable difficulty in this attack for all sorts of armour for, although in daylight a tank will normally see and avoid a crater, at night, or in poor visibility, they can readily fail to do so. A Crab, when flailing, has little chance under any circumstances of avoiding craters. In fact, 3 fell into craters when flailing, and 2 in the dark.

2. A simple calculation shows that in a density of bombs as low as 1 per 4 acres (a normal bombing attack gives a density of at least 5 per acre), a tank which cannot see and avoid a crater stands a 50% chance of falling into one in the course of a 1000 yds run. Alternatively, if the leading tank of a column can be employed as a pathfinder and, when it comes to grief, a second tank takes a new route and continues as leader, then, in a density of five craters per acre, 15 tanks will fall into craters before a safe path over 1000 yds has been found.

3. The indirect effect of craters was considerable. For instance, 4 tanks went up on mines in one bombed area which, but for the craters, might well have had a lane cleared through it by Flails.

3. Flails.

1. Flails were allotted to both Brigades and did much useful work. In the N.S.R.'s attack on LA TRESORERIE, however, they were unable to take the route originally planned, which was under observation from enemy guns, and the gradient of an alternative route proved too steep, so that in the end a lane had to be cleared by Sappers. Similarly, in the N.N.S.R.'s attack on MONT LAMBERT the Infantry in fact arrived on the objective well before the flails had cleared a path. The S.D. & Gs. also had to clear paths by hand for the armoured columns.

2. Although under favourable conditions the Flails functioned effectively, they were often held up by obstacles, and they suffered from a number of breakdowns. Sappers and Pioneers had always to be available and ready to clear lanes instead. These breakdowns and delays usually meant that the A.Vs.R.E. and Crocodiles did not get on to their objectives as soon as they were wanted. A more liberal allotment of flails should overcome these difficulties.

3. A few instances were recorded of flails failing to set off the deeply buried shells and bombs which were widely used by the enemy as improvised mines. Whether in fact the proportion of these mines missed was any greater than the proportion of ordinary mines missed is not certain.

4. A.Vs.R.E.

1. A.Vs.R.E. were used on MONT LAMBERT, MONTRIVILLE, and other fortifications, but very little can be deduced from their employment, since in no case that we have been able to find did they in fact seriously fight a pillbox. In many cases they fired only one or two rounds and the enemy came out and surrendered. PW could not apparently distinguish A.Vs.R.E. from tanks and the majority were induced to surrender by the mere appearance of an armoured vehicle.

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2. The concrete MG emplacements around BOULOGNE were of more or less standard construction, with walls and roofs as much as 8 feet thick. Set 2-3 feet back into the walls was a 1 1/2 - 2" steel plate, which had a hole about 5" x 5" for the machine gun to fire from, and a small vision slit to one side. Both holes could be covered over by sliding plates. The emplacements were of good quality concrete and well reinforced.

3. The effect of one or even several rounds on the concrete is not great and, against a determined defender, it will be necessary to hit the steel plate in order to cause real damage. Of all the Petard strikes examined (20 - 30), none were found on the steel plate.

4. There were very few A/Tk guns in the BOULOGNE area. But, where there were guns capable of damaging A.Vs.R.E. or other assault equipment, it was found that the latter could not cover their own advance up to the emplacement with smoke or small arms fire and that extra fire power was required. This was supplied by M.10s, Tanks, or Infantry with brass.

5. Crocodiles.

1. Crocodiles were greatly in demand and were used on the majority of defended localities. In particular they were used with effect on MONT LAMBERT, LA TRESORERIE and ST. ETIENNE, where in every case the enemy came out and surrendered after one squirt, if not before. In no case, so far as can be ascertained, were any casualties caused.

2. An officer cadet on MONT LAMBERT heard flamethrowers at work and decided to give up; 3 O.R. P.W. said that their company attempted a counter-attack south of the river, but were deterred by seeing flamethrowing tanks, and a Captain of an M.O. Battalion was persuaded, by the "heat of the shots" nearby on the road, to give up rather than risk attack on his pillbox.

APPENDIX A

NARRATIVE OF THE ASSAULT ON BOULOGNE.

(a) Plan.

1. BOULOGNE was well prepared for all round defence. Round the town is a ring of high ground, with FORT DE LA CRECHE, BON SECOURS, and ST MARTIN DE BOULOGNE to the north, the highest ground of all, MONT LAMBERT, in the centre, and HERQUELINQUE, ST. ETIENNE, and MOUQUET to the south. Each of these features was heavily ringed with wire and mines and provided with emplacements, some very heavily concreted, giving crossfire between themselves and the adjoining features. Well to the north, centred on LA TRESORERIE, were more defenses, while inside this main ring are further hills on which the enemy artillery was largely concentrated.

2. It was planned that the attack would start with heavy bombing on a long strip, from MONT LAMBERT to BON SECOURS. As the last bomb fell troops would cross the start line, some 3,000 yds away, and move up as rapidly as possible in order to exploit to the full the damage and confusion caused by the bombing. At the same moment a comprehensive timed artillery programme was to be fired. 9 Canadian Infantry Brigade was to attack in the south, with the Battalion, the North Nova Scotians, directed on MONT LAMBERT, and another, the S.D. & G. Highlanders, on ST. MARTIN DE BOULOGNE. 9 Canadian Infantry Brigade would attack to the north, with the Queen's Own against ST. MARTIN DE BOULOGNE (North of Main Rd), the Regiment de la Chaudiere on HERQUELINQUE, and the North Shore Regiment on LA TRESORERIE. The southern flank of the attack was to be held by the Cameron Highlanders of Ottawa (Machine Gunners) and the northern flank by 7 Recon Regiment. As soon as MONT LAMBERT and ST. MARTIN DE BOULOGNE were captured by 9 Brigade, three armoured columns "A", "B", and "C" were to go straight through to capture the three bridges over the river in BOULOGNE. Infantry would then move over the river, meanwhile certain of the fortifications on the other side would be attacked by heavy bombers. 8 Brigade in the north, after capturing ST MARTIN DE BOULOGNE, HERQUELINQUE, and LA TRESORERIE, would move on to the remaining fortifications near the coast. Every Battalion was to have Flails in support, and the battalions of 9 Brigade in the south were to have in addition Kangaroos, Crocodiles, and Tanks. After the timed programme, which was to last about an hour, the artillery would be on call for a very comprehensive series of prearranged "conos" and "stomachs." Rocket-firing typhoons were also on call. It will be seen that the plan made the fullest use of the available fire power and supporting weapons.

(b) Course of the Battle.

1. The battle started at 0825 hours on Sunday 17th September, 1944. The heavy bombing went according to plan, and the troops crossed the start line on time. But almost immediately

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the bombing stopped enemy shelling started up and slowed down the advance to the first objectives. The N.N.S.Rs. and S.D. & Co. of 9 Brigade were however in Kangaroos and were less troubled therefore than 8 Brigade. These two battalions went as far in the Kangaroos as mines permitted and discussed some distance short of their objectives. The S.D. & Co. captured their part of ST. MARTIN DE BOULOGNE very quickly, but were then heavily shelled and held for most of the rest of the day. The N.N.S.R. on MONT LAMBERT did not get on as well and were held up by shelling and H.Q. fire, until they succeeded in getting up their A.Vs.R.E. and Crocodiles, when they started tackling concrete emplacements one by one. This was a slow business as the Germans were by then putting down fire on their own positions. The clearing up was not in fact finished until half-way through the next day. The H.L.I., the third battalion of 9 Brigade, were held in reserve all this day. On the 8 Brigade sector in the north, events followed a similar pattern. All these battalions progressed slowly because of obstacles and shell fire and by the end of the day were only partway on to the objectives. In the afternoon "A" and "B" armoured columns moved forward. By nightfall "A" column had reached the walled "Citadel" in BOULOGNE and "B" column some distance short of "D" bridge.

2. On the following day, in the afternoon, the N.N.S.Rs, having cleared MONT LAMBERT with the help of "C" armoured column, moved down the slopes of MONT LAMBERT and captured the battery position of CHEMIN VERT, encountering some shelling on the way. Two companies of the S.D. & Co. moved off with "A" and "B" columns to capture the bridges, but found them blown and could only establish themselves on the near bank. The rest of the S.D. & Co, with 2 A.Vs.R.E., attacked the "Citadel". One shot from a Petard and the simultaneous appearance of a platoon inside the "Citadel", smuggled there by means of a secret passage, sufficed to make the enemy surrender. The H.L.I. moved down to "D" bridge and prepared to cross the next morning. On the 8 Brigade sector the Q.O.Rs. moved on to their next objective, the upper part of the town to the north, where they succeeded partially in establishing themselves in the face of considerable shelling from the Harbour area. The R. de Chauds and North Shores spent the day fighting on their objectives and clearing pillboxes with the help of Assault Equipment, considerably hampered once again by shell fire.

3. On 19th September, 1944, the third day, the N.N.S.Rs, in the face of further shelling, established themselves on Bridge "C", meanwhile the H.L.I. made an effective surprise crossing at Bridge "D", repulsed during the night by the Sappers. They were shot across by a strange diversity of weapons - 3" Mortars, 2" Mortars, captured 20 mms, P.I.A.Ts, and L.M.Gs, fired from the houses on the near side of the river. The crossing was effected without a casualty. They then cleared most of the high ground S.W. of the town, and put in an attack on the batteries at HONRIVILLE, which was however called off because of very heavy shelling from all around. The S.D. & Co, starting late in the afternoon, took OUTREAU and made a sudden and successful attack on the 88 mm Battery at TURBINGEN, who were so preoccupied shelling the H.L.I. that they failed to notice the S.D. & Co. forming up. On the Northern Sector, the Q.O.Rs. were still fighting in the high ground in the north of the town and around the cemetery and the R. de Chauds were still clearing their original objective of MARLBOROUGH and the MONUMENT. Once again these battalions were subjected to a lot of shelling. The North Shores, having cleared LA TRESORERIE, managed to get one platoon into WIMEREUX and 2 platoons into WHILLE in the face of considerable opposition, particularly from 20 mm A.A. guns.

4. The following day the S.D. & Co. cleared the Sugar Factories south of the river without event, while the N.N.S.Rs. took ST. ETIENNE and at the end of the day were moving round to NOCQUET. The H.L.I. took the HONRIVILLE battery at a second attempt, and moved down to the HARBOUR area, where one company was heavily shelled and had to retire. North of the town, the Q.O.Rs. and R. de Chauds were still fighting in the same areas, while the North Shores cleared up WHILLE.

On the fifth day, the N.N.S.R. continued their broad sweep and cleared NOCQUET and NINGLES, while the H.L.I. cleared the HARBOUR area. North of the town, the Q.O.Rs. finished off round the cemetery and started up the coast. The R. de Chauds were still fighting round the MONUMENT, while the North Shores attacked WIMEREUX and gained most of the town.

On the 22nd, the last day of the battle, the Q.O.Rs. prepared to attack the last stronghold in the north, FORT DE LA CRECHE. This had been bombed by Medusas on the night before, and the Garrison thought better of the attack and surrendered as it was about to start. In the south the S.D. & Co. and H.L.I. formed up to attack LE PORTEL, and after a local truce this stronghold also surrendered, with the Garrison Commander, General Holm. The last stronghold of all to give in was an 88 mm gun on the end of the breakwater. The post surrendered finally in the afternoon after receiving a note from the captured Garrison commander. So all resistance in BOULOGNE came to an end.



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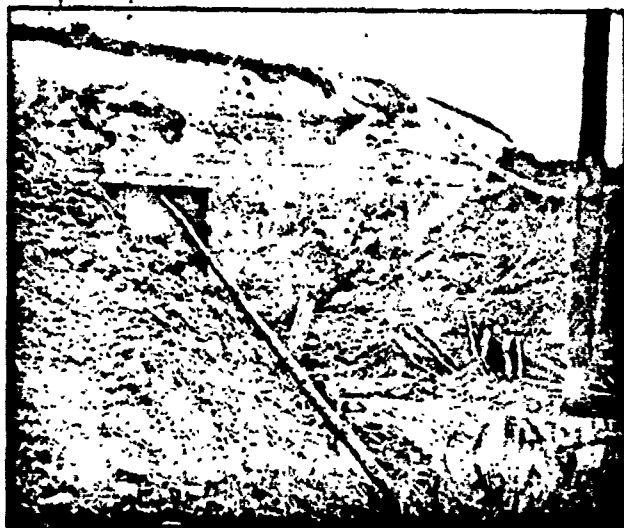
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105 mm. gun on naval mounting, set in concrete,
destroyed by the final bombing attack (Serial 49)
on FORT DE LA CRECHE.



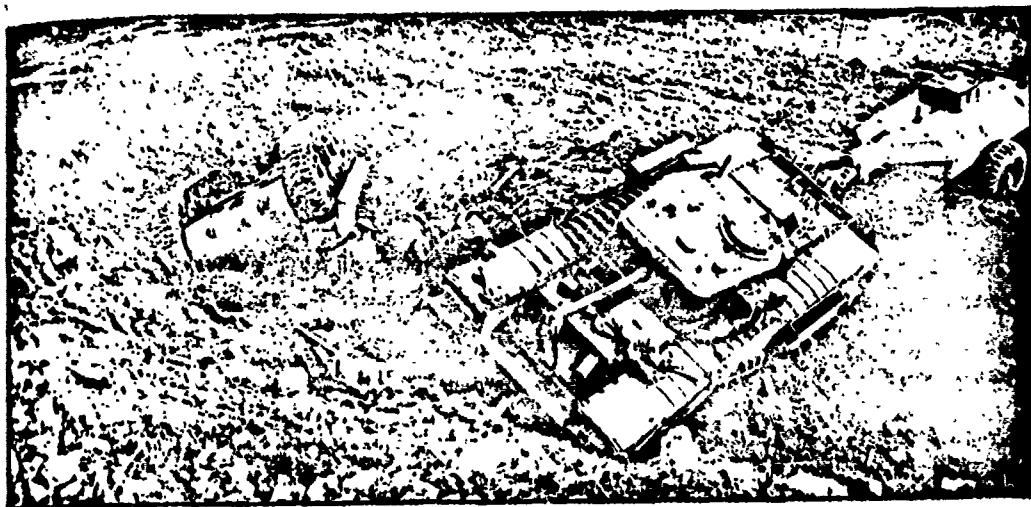
PHOTOGRAPH 2.

Results of 500lb. bomb immediately alongside a concrete emplacement on MONT LAMBERT, showing the negligible destructive effect.



PHOTOGRAPH 3.

Results of a 500lb. bomb on the 4ft. thick roof of a concrete Command Post on MONT LAMBERT. Part of the roof had come down inside.



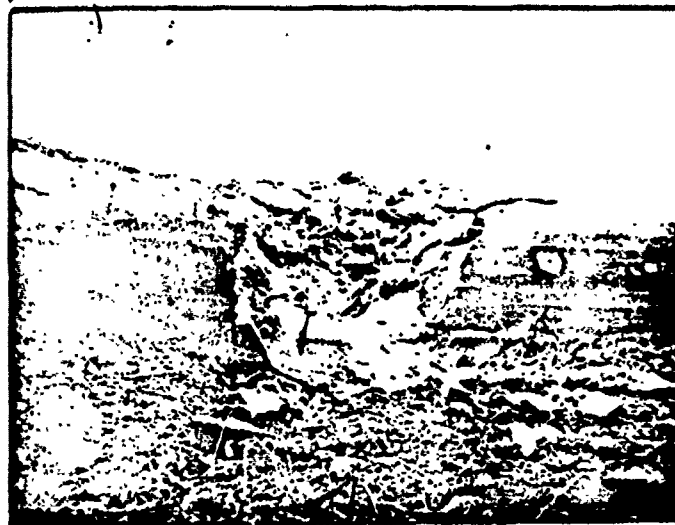
PHOTOGRAPH 4.

Grocodile and Kangaroo stuck in a bomb crater. A Sherman had also driven on to the Kangaroo and stuck, but had been removed before the photograph was taken. All these vehicles had stuck in daylight, but in dust and smoke occasioned by shellfire.



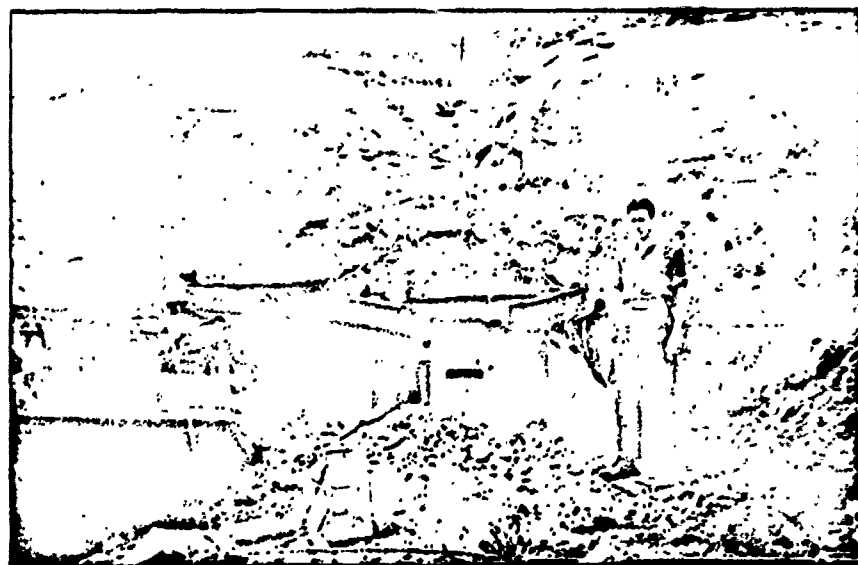
PHOTOGRAPH 5.

Grab belied on the edge of a bomb crater.



PHOTOGRAPH 6.

The effect of a single Petard on the side of a concrete emplacement on MONT LAMBERT.



PHOTOGRAPH 7.

The result of 2 Petard rounds on the face of a Machine Gun pillbox on MONT LAMBERT. There was no visible effect inside. The marks of S.A. fire aimed at the vision slit can be seen.

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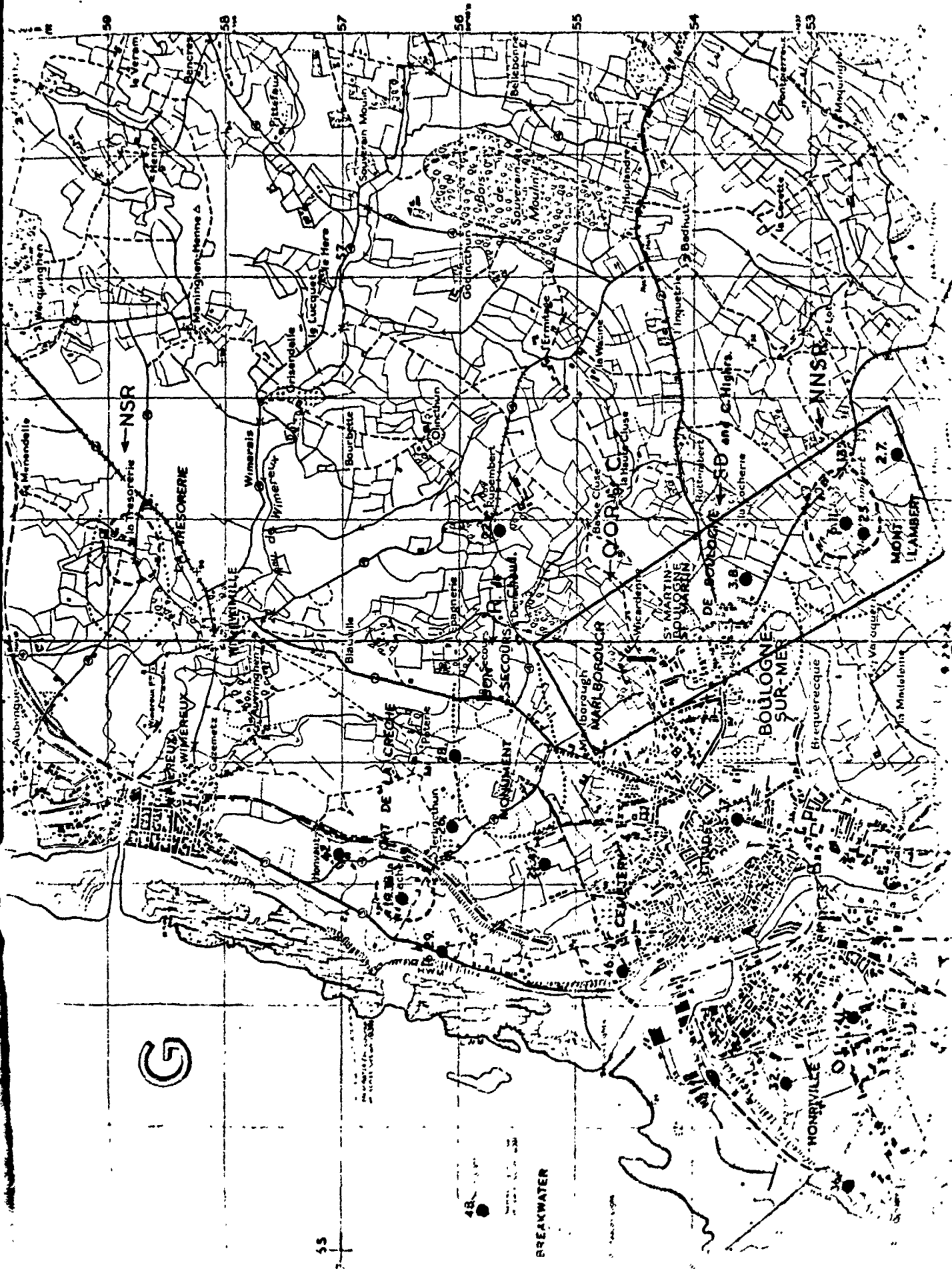
APPENDIX B

REPORTS OF THE BOMBING OF BOULOGNE.

Serial No.	Date	Reference	Place	Type of Target	No. & Type of Bombs	No. & Type of Projectiles	Remarks
1	5 Sep	-	St. MARLOU.	Own position	8 Typhoons	32 R.P.	Position not recorded.
2	"	71523	MT. LAMBERT	Strong point	6 Mitchells	48 500 lb .025	See Serial 7.
3	"	70553	ST. MARTIN	Strong point	12 Mitchells	96 500 lb .025	See Serial 8.
4	"	67742	St. THOMAS	Strong point	16 Mitchells	128 -do-	See Serial 10.
5	"	70949	MILKLAND	Own position	11 Mustangs and 5 Mitchells	83 -do-	See Serial 20.
6	"	71052	MT. LAMBERT	Own position	10 Mustangs	40 -do-	See Serial 11.
7	"	71523	MT. LAMBERT	Strong point	16 Mitchells	128 -do-	Area contained no guns, and no other defense implements.
8	"	70553	ST. MARTIN	Strong point	12 Mitchells	96 -do-	See also Serial 3. Area later attacked by Hercules and impossible to separate effects. 2 P.W. did not mention any damage done by earlier attacks. Infantry positions only.
9	"	700518	CHENIN VERT	88 Bty	6 Mitchells	48 -do-	See Serial 23.
10	"	67742	St. THOMAS	Strong point	5 Mitchells	40 -do-	See also Serial 10. Area later attacked by Hercules, and impossible to separate effects. P.W. (Captain) did not mention any damage done by earlier attacks. Mainly inf. positions.
11	"	71052	MT. LAMBERT	Strong point	18 Mustangs	72 -do-	See also Serial 6. Area contained 3 37 mm Flaks, which were undamaged.
12	"	-	Village of BOULOGNE	-	6 Typhoons	24 R.P.	Position not recorded.
13	"	-	MT. LAMBERT	Strong point	45 Mitchells, 22 Mustangs	162 500 lb .025	Whole area later attacked by Hercules and impossible to distinguish effects. No guns in area, except those referred to in Serials 6 and 11.
14	"	-	BOULOGNE	Own	37 Spitfires	37 -do-	Position not recorded.
15	"	652309	LA. SALLE	Own	4 Typhoons	32 R.P.	See Serial 40. A dummy battery.
16	"	674562	Mr. CRECHE	Own	4 Typhoons	32 R.P.	See Serial 29. A dummy battery.
17	"	-	BOULOGNE	Strong point	24 Spitfires	23 500 lb .025	Position not recorded.
18	"	-	LA. TREBONIE	Strong points	33 Mitchells	265 -do-	Naval Bty and 75 Flak Bty undamaged. P.W. confirmed no damage to fighting equipment. Bombs fell mostly in area of heavy armor to equipments and did little damage.
19	"	677566	FORT DE LA CRECHE	Strong points	24 Mitchells	192 -do-	See Serial 38.
20	"	70949	HERFORDING	Strong point	8 Typhoons	64 R.P.	See also Serial 3. Only 1 20 mm and 2 75s in the area, which were undamaged.
21	"	681554	MR. HERFORD	88 Bty	8 Typhoons	16 500 lb .025	See Serial 47.
22	"	709539	HERFORD	Strong point	8 Typhoons	64 R.P.	Infantry in open field positions. No damage visible and P.W. confirm this.
23	"	700518	CHENIN VERT	Strong points (88 Bty)	8 Typhoons	64 R.P.	See also Serial 9. 88 mm Bty, but no damage attributable to it.
24	"	700518	CHENIN VERT	-do-	11 Spitfires	11 500 lbs .025	Minor damage to ca 50 mm, caused by a mortar immediately afterwards.
25	"	709527	MT. LAMBERT	Strong points	24 Spitfires	21 500 lbs .025	This area later bombed by Hercules, and impossible to distinguish effects. No guns in area.
26	"	681562	TERLINCTHUN	Own	9 Spitfires	9 -do-	Not examined. As far as is known, no guns in the area.
27	"	-	TURBINGEN	88 Battery	36 Mustangs	7 bombs	See Serial 31.
28	"	690561	Mr. TOTERIE	4 Own	7	7 bombs	Not examined. As far as is known no guns in the area.
29	"	674562	Mr. CRECHE	4 Own	7	7 bombs	See also Serial 16. A dummy battery.
30	"	652309	LA. SALLE	Own	4 Typhoons	32 R.P.	See Serial 40. A dummy battery.
31	"	660515	TURBINGEN	88 Bty	4 Typhoons	32 R.P.	See also Serial 27. Later bombed by Hercules, and difficult to distinguish effects. One run of 50 also possible. Area later.
32	"	663532	HERFORD	Own	4 Typhoons	32 R.P.	A dummy battery.
33	"	674562	Mr. CRECHE	Own	4 Typhoons	32 R.P.	Not examined. As far as is known, no battery there.
34	"	652309	LA. SALLE	Own	4 Typhoons	32 R.P.	See Serial 40. A dummy battery.
35	"	689537	MR. SQUIRE	Tps	8 Typhoons	64 R.P.	See Serial 37. Not examined. Target attacked 35 min after alarm requested.
36	"	689537	HERFORD	Own	4 Typhoons	32 R.P.	Naval Bty. 88mm Flak, but no guns, and no other defense implements. Target attacked 40 minutes after being requested.
37	"	689537	MR. SQUIRE	Tps	4 Typhoons	32 R.P.	See also Serial 36. Not examined.
38	"	-	HERFORD	Strong point	16 Typhoons	128 500 lb .025	See also Serial 3. Area later attacked by Hercules, and impossible to separate effects. P.W. (Captain) did not mention any damage done by earlier attacks. Mainly inf. positions.

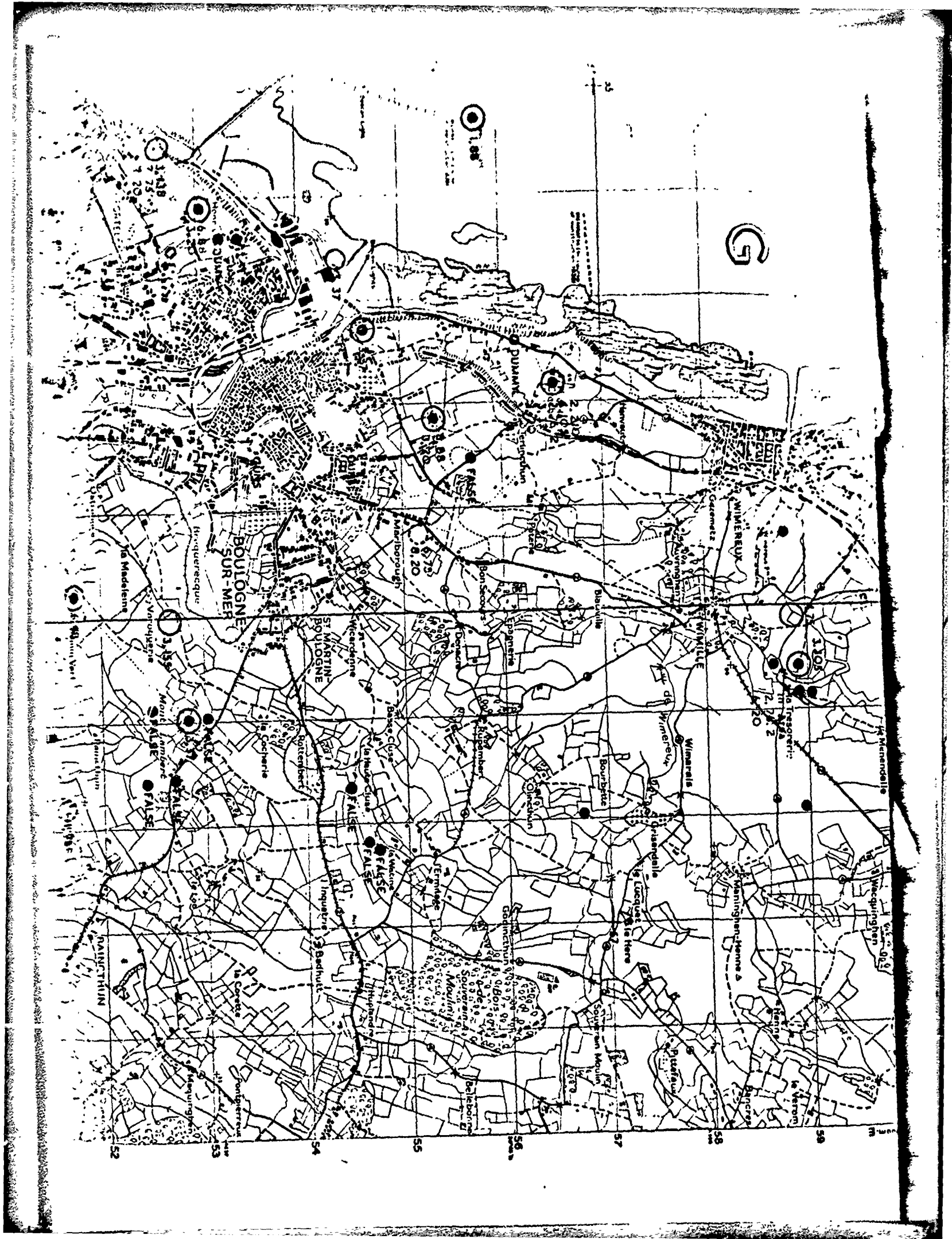
Serial No.	Date	Reference	Place	Type of Target	No. & Type of Planes	No. & Type of Projectiles	Remarks
39	17 Sep	686528	Mr. LA TROMPERIE	Gun	8 Typhoons	64 R.P.	Not examined.
40	17 "	686509	LA SULLE	Gun	4 Typhoons	32 R.P.	See also Serials 15, 30, and 34, where this target attacked. A dummy battery.
41	17 "	686526	COUTEAU	X-rds	4 Typhoons	32 R.P.	Not examined.
42	17 "	686571	NORMVILLE	Gun	8 Typhoons	64 R.P.	Not examined.
43	17 "	-	BOULOGNE	Gun	4 Typhoons	32 R.P.	Position not recorded.
44	17 "	-	BOULOGNE	Def. Posn.	8 Typhoons	64 R.P.	Position not recorded.
45	17 "	-	BOULOGNE	Def. Posn.	6 Typhoons	64 R.P.	Position not recorded.
46	20 "	675947	Mth Harbor	Gun	4 Typhoons	32 R.P.	3 37 mm Flak guns in the area. Not damaged by R.P.
47	20 "	681554	Mr. MONTGOMERY	88 Battery	4 Typhoons	32 R.P.	See also Serial 21. 88 Bty. Not damaged by R.P.
48	20 "	-	Breakwater	Gun	4 Typhoons	24 R.P.	Single 88 mm. gun. Not damaged. and active shortly after.
49	21 "	-	PT. DE LA CROIX	Gun & Strong Points	46 Mitchells 16 Bostons	432 500 lbs J25	Naval Battery. 1 10-5 destroyed and 1 10-5 minor damage by bombs.

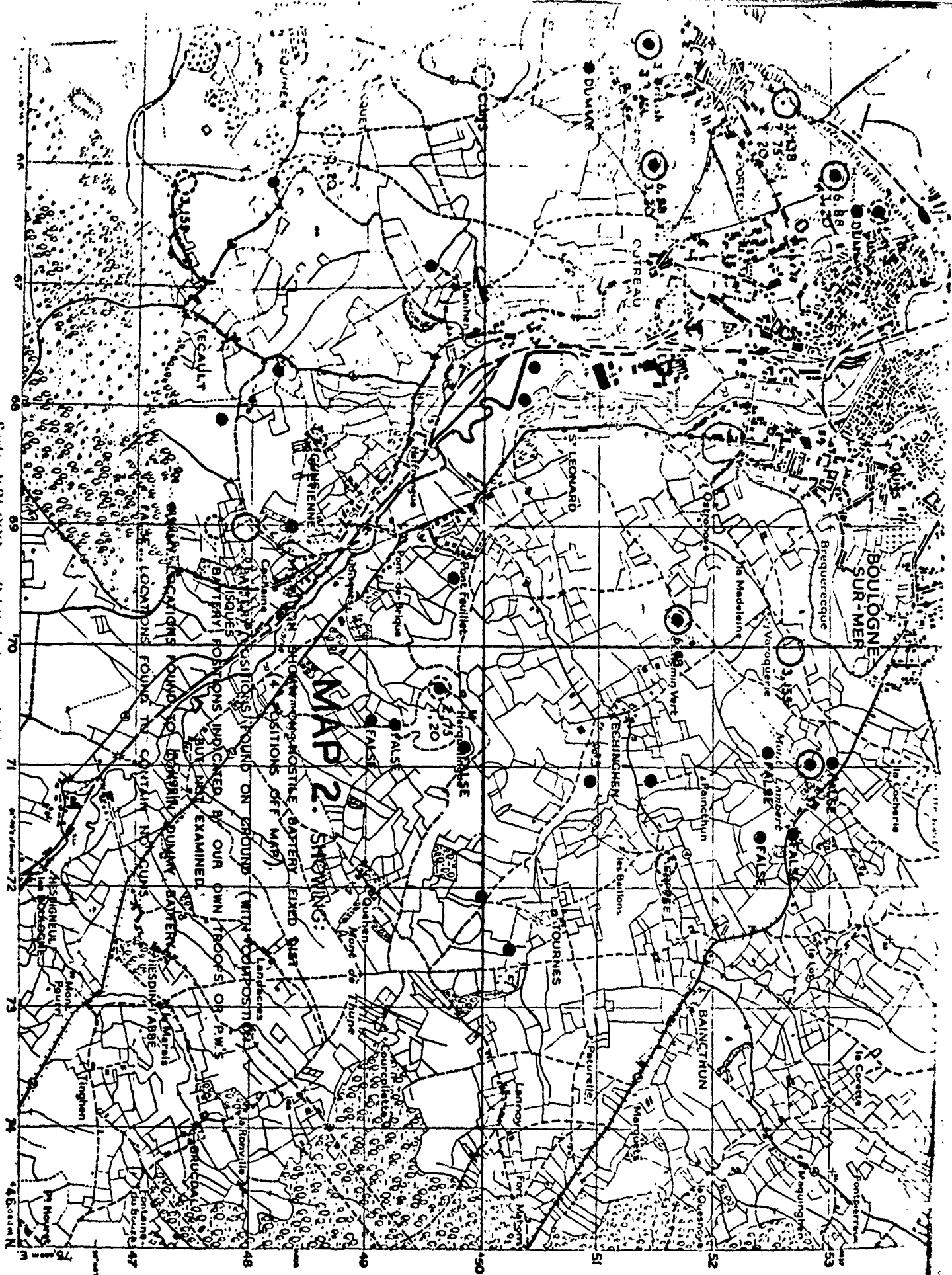
Plane	How Ref.	No. & Type of Gun	No. & Type of Gun Out of Action and Status of destruction	Approx. Total of Gun Firing Battery (Esti- mated from Reports)	No. of Fire put on by Plane in case of downing of enemy plane or downing of enemy plane in case of downing of enemy plane	(Note: The most probable type of shell responsible is referred but cannot be confirmed)
NAVY	66054	5 80 mm. Flak 3 20 mm.	270° 1 80 mm. 270° 1 80 mm.	80 mm. 1200	270° 300 Bombs 16 R.P. 32	80 mm. 1. Out of action by action on rearward from 3 Hedon on port. 2. Veritable until destroyed by crew. 1 Navy in can pit. 3. Can largely demolished well before attack. 4. Can undamaged. 5. Can in pit. 6. Can undamaged. 1 Field in pit. 20 mm. Not credited.
NAVY	67555	2 240 mm. Naval 6 105 mm. Naval 2 75-2 mm. Flak 2 37 mm. Flak 1 20 mm. Flak	270° 1 105 mm. 270° 2 105 mm. 270° 2 105 mm.	105 mm. 20	270° Unknown Bombs 63 R.P. 111	240 mm. 76.2 mm. 37 mm. 20 mm. Undamaged. 105 mm. 1. Out of action by direct hit on barrel. Field. 2. Can and piston turned over. Bombs by her. 3. Distortion of trunnion by her side from her. 4. Can undamaged. 80 mm. 1. Can undamaged. 2. Can undamaged. 1 Field in pit. 20 mm. Not credited.
NAVY	66552	6 80 mm. Flak 3 20 mm. Flak	270° 2 80 mm. 270° 11 20 mm.	80 mm. 2000	270° 5700 Bombs 111 R.P. 111	80 mm. 1. Can undamaged. 2. Can undamaged. 1 Field in pit. 20 mm. Not credited.
NAVY	66554	4 130 mm. Naval R.P. 130 mm.	270° 1 130 mm. R.P. 130 mm.	130 mm. 1500	270° Unknown Bombs 111 R.P. 32	130 mm. 1. In equipment. Can undamaged. 2. Few splinter strikes but can undamaged. 3. Can undamaged. 4. Can out of action by action in pit. Later destroyed by crew. 76.2 mm. Destroyed by crew. 20 mm. Undamaged. Rearfender Destroyed by R.P.
NAVY	67556	3 37 mm. Flak	270° 1 37 mm.	37 mm. 37	270° Unknown Bombs 111 R.P. 32	37 mm. 1. Can destroyed by direct hit from Hedon. 2. Can undamaged until destroyed by crew. 3. Can undamaged until destroyed by crew.
NAVY	66055	6 80 mm. Flak 4 20 mm. Flak	270° 1 80 mm. 270° 1 80 mm. 270° 2 20 mm.	80 mm. 2000	270° Unknown Bombs 111 R.P. 32	80 mm. 1. Can undamaged until destroyed by crew. 2. 11mm. strikes due to heavy m. portage. 3. Can undamaged. 4. Can undamaged. 5. Can undamaged. 6. Can undamaged. Hedon in pit. 20 mm. 1. Direct hit from 1000 lb bomb. 2. First hit from 1000 lb bomb. 3. Can undamaged. Navy on portage. 4. Can undamaged.
NAVY	70056	3 130 mm. Flak	Bombs 1 130 mm.	130 mm. 60	270° 111 Bombs 111 R.P. 32	130 mm. 1. Can undamaged. 2. Can undamaged. 3. 11mm. strikes due to 1000 lb bomb along side.
NAVY	70058	5 80 mm. Flak 3 20 mm. Flak	270° 1 80 mm.	80 mm. 200	270° Unknown Bombs 59 R.P. 64	80 mm. 1. Can damaged by splinter from Hedon in pit later destroyed by crew. 2. Can undamaged. 3. Can undamaged. 4. Can undamaged until destroyed by crew. 5. Can undamaged until destroyed by crew. 20 mm. Not credited.



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BREAKWATER





APPENDIX D.NOTE ON THE COMPOSITION OF THE GARRISON,
P.W. TYPES, MORALE, AND THE EMPLOYMENT OF PSYCHOLOGICAL
WARFARE AT DOULOONE.

SOURCES: Interrogation of 8 Offrs. and 37 O.N.s., representing every unit in the garrison, captured between 17th and 22nd September, 1944, area DOULOONE.

21 A.Gp Report on Psychological Warfare dated 1st October, 1944.

Major F.O. SHEPHERD, CSO 2 Psychological Warfare, P and PW Branch, M.Q. 21 Army Group.

1. Composition of DOULOONE GARRISON.

The garrison was mixed Army, Navy, and Air Force in approximately the proportions 5 : 4 : 1.

Total strength estimated at 8,700 all ranks.

This force was organised into three infantry battalions (each with parts of static fortress battalions under command), four artillery battalions, totalling twenty troops, with guns varying in calibre from 30.5 cms to 3.7 cms, two engineer companies left by a retreating infantry division, and a considerable number of assorted M.Q. units from the M.Q.s formerly located at the port.

2. P.W. Types and Morale.

70% of P.W. interrogated were over 35 years of age.

P.W. appeared soft and, in some cases, actually ill.

Only four made any real attempt to be secure and they were all younger men from the Airforce M. unit, 501 Mixed M. Battalion which, having had good weapons, good positions, and better officers than most of the other units, was of higher morale.

Naval personnel were all old and felt out of place fighting a land battle, but had tried, at least hard enough to "satisfy their honour."

Army personnel, without exception, were of low mental and physical types; morale, even of officers, was poor. Partly on account of their training, which enabled them better to appreciate the danger and hopelessness of their position, partly due to old age, infirmity and general satiety of war, considerable numbers had made a previous decision NOT to resist - which decision our artillery and aerial bombardment did nothing to alter.

The infantry, being unwilling to fight, and the other arms lacking the necessary training in infantry tactics, our own infantry were always able to outwit them, nor did any of them appear to have had any great desire to engage in close fight.

3. Enemy Casualties.

Enemy appeared from P.W. statements to have suffered approximately eight casualties per unit of company strength; total approximately 300 killed and wounded.

Wounds were usually caused by artillery; fatal casualties were more often due to bombs or small arms fire.

4. Reasons for Surrender.

The P.W. interrogated did NOT surrender for one particular reason only, but all appeared to have surrendered for a mixture of reasons. The following percentages are arrived at by adding up the proportion of P.W. who attributed their surrender to the various causes listed.

Planned intention NOT to resist:	7%
Lack of will to resist due to bombing and artillery fire:	30%
Lack of weapons with which to continue the fight:	12%

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Domination by assaulting troops, tanks, or flamethrowers: 40%

Directly owing to allied propaganda: 3%

Surrender because others had surrendered, in the case of Officers, their men: 5%

It should be noted, however, that of the P.W. selected for interrogation: large proportion were officers, or were chosen because they came from units which had resisted more strongly, and from whom we wished to know why our weapons had NOT affected them. Of the garrison as a whole, for instance, it is known that 10% surrendered because of P & PW broadcasts alone, whereas in this sample only 3% attributed their surrender to propaganda.

5. Opinions of Officers.

German Officer P.W. did NOT as a rule commit themselves to an opinion on military matters. The opinions quoted here, coming from two infantry officers and one officer attached to an H.Q. are a good indication of the poor type of officer and the low state of morale, particularly of army troops.

(a) Capt. HUPPELBERG, Commander 3 Arty Bn 164 Arty Regt, captured 18th September on MONT LAMBERT.

".....position was indefensible due to the number of covered approaches - pillboxes, intended for air raid shelters, are difficult to protect."

(b) Lieut. OTTLIEB, Commander Naval-Sigs, captured in the Citadel, 18th September.

".....position appeared hopeless from the start. Poor quality German troops would never be able to stand up against the picked Canadian infantry and the immense allied superiority in artillery and planes."

(c) Capt. HERBERG, Commander 27 Fortress Battalion, captured at ST. ETIENNE, 20th September.

".....poor quality men, and large number of covered approaches, made the defence of ST. ETIENNE appear very difficult."

6. Psychological Warfare.

(a) Leaflets.

A special series of leaflets (see translation below) was produced by this H.Q. for this operation.

14th September, 1944:	16 bombs	=	240,000 leaflets;
15th September, 1944:	12 bombs	=	180,000 leaflets

were dropped, in addition to approximately 40,000 self conductors fired into the perimeter during the attack.

(b) Loudspeaker Activities.

Broadcasting scout cars worked with the normal amplifying unit on opportunity targets. They broadcast on the following days with the following results:

18th September	:	150 P.W.
19th "	:	60 "
20th "	:	200 "
21st "	:	10 "
22nd "	:	500 "

The last broadcast was timed to coincide with the forming up of the Canadians for the final assault on the last centre of resistance. It is reported that not a single German soldier was wounded in this attack.

The figures given for P.W. taken are those which the Brigade carrying out the operation officially credited to the broadcasts.

(c) Comments of Major SHEPHERD.

Success was dependent on the combination of the propaganda with force. With such an assemblage of force, in the shape of bombers, guns and tanks, BULLDOG was very suitable for Psychological Warfare.

(d) Translation of Leaflet.

"THE LEMON OF LE HAVRE FOR THE DEFENDERS OF BOULOGNE.

Le Havre was the strongest fortress in the whole Atlantic Wall.

The Canadian Army attacked this fortress at 1745 hours on 10th September, after three days of very heavy sea and air bombardment.

42 hours later, at 1145 hours 12th September, the last soldier of the garrison had surrendered.

The Garrison of Le Havre numbered some 9,000 Officers, N.C.O.s, and men. Of these 9,000, in 42 hours 7,792 surrendered. They will soon see their families again. The remaining 1,208 perished. They now lie buried under the ruins of a French port 1,000 kms from their homeland.

Every one of you, the defenders of BOULOGNE, must now decide for himself whether he will belong to the 1,208 uselessly sacrificed at LE HAVRE, or whether he will belong to the 7,792 who saved themselves for the future.

THE WESTERN POWERS NOW FIGHT IN THE RHINELAND.

YOUR GARRISON, WRITTEN OFF, CAN DO NOTHING TO STEM THE ADVANCE.

WHY DIE IN BOULOGNE IN THE LAST DAYS OF THE WAR?

APPENDIX E

MORALE AND TYPES OF P.W. AND THE EFFECTS OF SUBMERSION
AT CALAIS (OPERATION UNDERDOG).

Ref. Maps: FRANCE 1:25,000 Sheets 38 NE, 39 NE, 39NW, 28 SW.

1. MORALE AND P.W. TYPES.

Seven officers and twenty eight O.R.s, captured in the area CALAIS town, were interrogated.

Physical types, age groups, and state of morale were similar to those encountered at BOULOGNE.

Army personnel were old, ill, and lacked both the will to fight and to resist interrogation; naval personnel were old and were NOT adjusted to land warfare; only the air-force A.A. gunners showed any sign of good morale - and were also the only youthful element of the whole garrison.

Officers excused their relatively weak resistance by saying that they felt that the garrison had fulfilled its duty and had delayed a considerable number of our troops and artillery for a long time, when these would have been invaluable elsewhere. They appeared to have had little confidence in their men whom they accused of deserting in large numbers.... this lack of confidence was reciprocated, the men maintaining that their officers were drunk and hid in their dugouts for the duration of the battle.

The Allied reverses at ARNHEM had an uplifting effect on the more intelligent types.

First Canadian Intelligence Summary No. 94 says that Lt.-Col. SCHROETER, the commander of the CALAIS garrison, attributed his lack of success almost entirely to the Allied command of the air.

2. R.P. ATTACKS AND RESULTS AT CALAIS.

The total effort employed against CALAIS from 12th September, 1944 to 26th September, 1944 consisted of 153 sorties, in which 1162 R.P.s. were directed at 23 separate targets in 30 separate attacks.

Target	No. of Attacks	No. of R.P.s.	Remarks
CO Camp at 087793	3	95	According to P.W. NO results were obtained, but examination of the area showed that hits were obtained on the base of the control tower and a fire had been caused. The weapons and the fire control mechanism remained undamaged.

Target	No. of Attacks	No. of R.P.s.	RESULTS
6 x 8.8 cms AA guns at 866792	3	79	NO damage seen on examination of the ground. P.W. stated that the L.A.A. gunners did NOT take cover, but engaged the aircraft, causing them to turn off.
6 x 8.8 cms AA guns at 898740	2	96	NO damage attributed to R.P.s. by P.W.
FORT NIEULAY 846771	2	39	NO damage to equipment attributable to R.P.s. but the attack was quickly followed up by the infantry, who were NOT fired at despite the fact that a number of weapons were intact.
Own Position 882789	1	32	NO damage.
Position 889789	1	32	This position was a dummy.
	12	375	

The table shows that NO actual damage to weapons was achieved for the expenditure of 375 R.P.s.

The Ops log of 3 Canadian Division shows that the three batteries listed above were amongst the principal causes of delay and casualties and air support was asked for on successive days.

The high morale value of the weapon is shown by the ease with which FORT NIEULAY was overrun. P.W. complained of the terrifying noise and the uncomfortable sensation experienced by anyone seeing the rockets actually fired.

Conclusions.

These results support the conclusions arrived at in the report on BOULOGNE as to the need for very heavy attacks if any material destruction is to be achieved, but that the high morale value of the weapon might be exploited by a quick follow up of an attack.

3. EFFECT OF SHELLING OF ENEMY BATTERIES.

The following account of effects of shelling of some of the most active enemy batteries are given by P.W.:

FORT LAPIN 8578. Shelling which preceded the assault on the fort on 27th September, 1944, cut the line communications in the area, as they had worked close to the surface in the sandy soil. During the shelling all the garrison took cover, which enabled our infantry to approach unseen.

W. A. B. P. Posn. 897740. Officer P.W. stated that the position was continually under fire, but that only one gun was put out of action - this is confirmed by frequent references to its nuisance value in the operations log.

CO. B. B. POSITION 740, 887792 Commander of the Battery stated that shells were continually falling in or near his position, but in insufficient quantities for him to give the order to take cover; this policy cost him some casualties. If he actually fired, however, he could reckon with receiving a concentration within two to three minutes and could take the necessary precautions in advance.

Heavy A. Posn. 866792. Position was frequently shelled, and some casualties were suffered when the battery continued to engage our aircraft in spite of the shelling. One 2 cm gun was put out of action by a splinter..... this was confirmed on the ground.

As the battery's primary task was to engage hostile aircraft, the men usually took cover from shelling when no aircraft were in the vicinity.

Examination of the position showed that the guns had fired about 100 rounds each.

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C.B. Intelligence Reports state that the above batteries gave continual trouble despite repeated shelling, but claimed that the batteries were largely neutralised by C.B. during some air attacks.

Conclusions.

The results shown above and the enemy reactions to our fire were very similar to those at BOULOGNE.

4. FRAGMENTATION BOMBING.

As an experiment the area bounded by the co-ordinates 538787 - 853767 - 840773 - 848775 was bombed with instantaneous fused bombs on 25th September, 1944 - D-day for the attack on CHLAIS.

Examination of the ground and interrogation of P.W. showed the following results:-

Out of three 21 cm guns in FORT LAPIN, one was put out of action by a direct hit.

Communications of the fort remained intact.

P.W. noticed the heavy blast and splinter effect, but seemed less impressed than by large craters.

7 Canadian Infantry Brigade was held up by fire from the fort on the edge of the area. The ground was NOT deeply cratered but tanks were held up by fire from L.Tk. guns in the fort, which had not been silenced by the bombing.

However 7 Canadian Infantry Brigade's lack of success in this area should NOT be attributed to the lack of effect of fragmentation bombing. Some other areas which were crater bombed were easily overrun, but it is doubtful if it was intended to hold them in any strength, whereas the defence of FORT LAPIN was the first and principal determined resistance that was met.

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Suggested Plan
Falaise.

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CHAPTER 2.

HEAVY BOMBING BEHIND THE LINES FOR INTERDICTION.

CONTENTS

Suggested Plan to block a German Retreat from Argentan and Falaise.	(Report No. 10)
Crater Bombing on River Lines in Normandy.	(Memo No. 1)
Contribution of Air Forces to Stopping Enemy Thrust in the Ardennes, December, 1944.	(Memo No. 6)
Bombing of Communication Centres prior to Operation "Plunder".	(Memo No. 2)
Interdiction of Road Communications by Bombing	(Memo No. 3)

REPORT NO. 10.

SUGGESTED PLAN TO BLOCK A GERMAN RETREAT FROM ARGENTAN AND FALLISE.INTRODUCTION.

The scheme that follows is not put forward as an operational plan worked out in detail, but rather to show that, with the heavy bombing resources now available, an almost complete block can be placed in the path of the retreating German army. The scheme only indicates the lines on which such a block might be arranged; the exact plan for such a block would of course need careful preparation with the help of air photographs and any other information available on the roads, villages, bridges and detailed formation of the countryside.

METHODS OF BLOCKING.

The observations of this Section in Operations "ARMWOOD, GOODWOOD, BLUECOAT and TOTALISE have shown clearly the following points in connection with hampering enemy movement:-

Deep cratering bombs (500 and 1000 lb bombs, .025 sec delay fuzed).

(a) In heavily built up areas quite a low density of bombs, about 5 per acre, will produce a complete block, needing several days to clear. This requires roughly a 50 bomber raid.

(b) In villages and less heavily built-up areas a greater density of bombs is needed, 10 - 15 per acre, but the blocking is heavy and likely to take 1 - 2 days to clear. This requires a 100 - 150 bomber raid.

(c) In very open country a greater density still is necessary, up to 25 - 40 per acre, when the craters are almost overlapping. This requires a 300 - 400 bomber raid. Even so, detours may be possible.

(d) In close country, with banks, trees, orchards, ditches, and streams, about 10 - 15 bombs per acre are necessary to produce a block. This results in at least 15 craters in any road running through the area. These must be filled in or else large detours made, which is seldom easy in close country. This requires a 100 - 150 bomber raid.

It should be noted that the area affected in these raids, more or less irrespective of the size of the raid, is about a 1500 yd diameter circle.

OUTLINE OF THE PLAN.

In this plan it is assumed that the enemy is attempting a retreat through a gap, flanked by the high ground Northeast of FALLISE and by the high ground south-west of EMBE. It is further assumed that these two positions are firmly held so that enemy attempts to break out to a flank can be resisted.

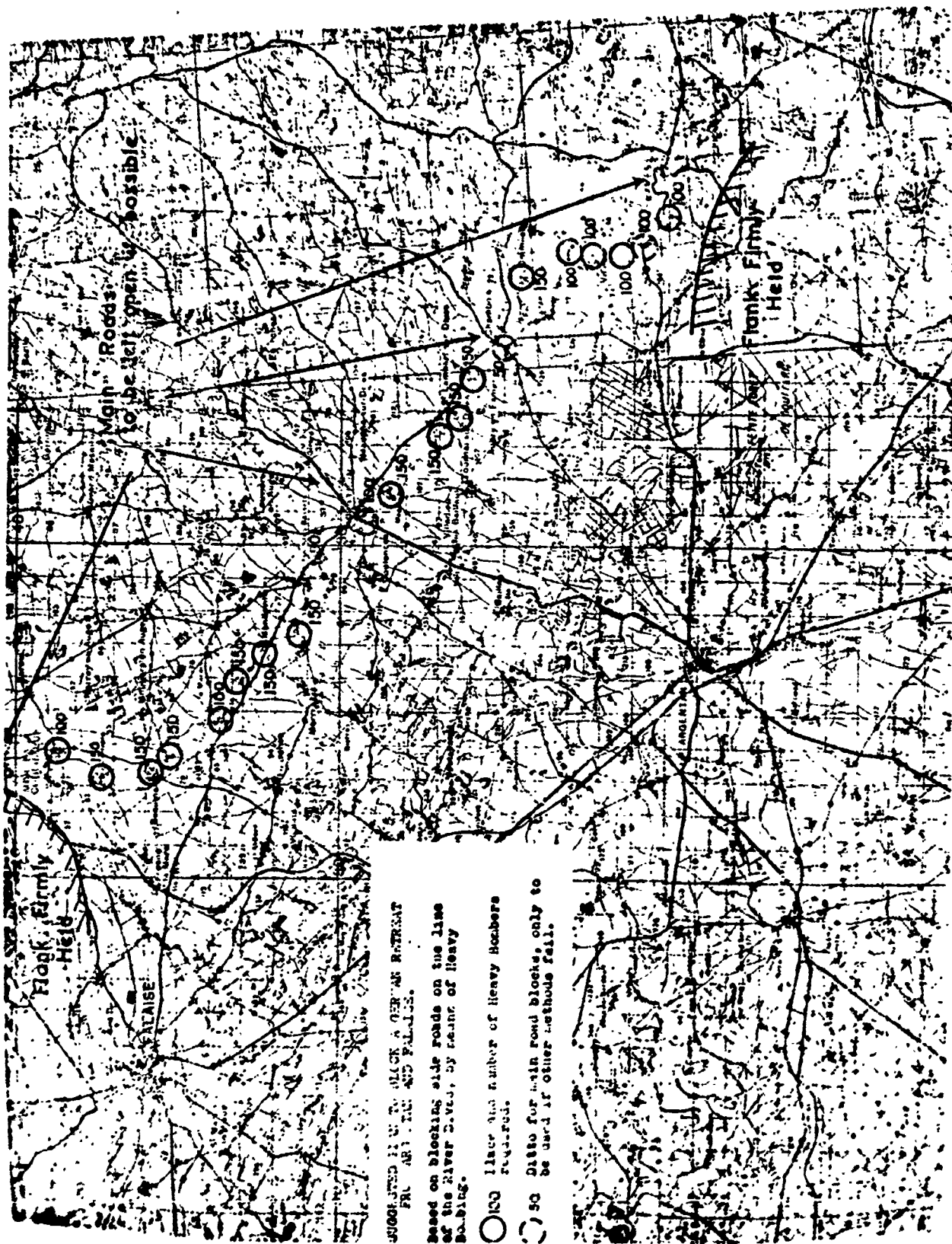
Various methods of hampering the enemy's retreat are possible, the most obvious being heavy bomber attacks on FALLISE, ARGENTAN and perhaps other towns, together with F/A and RF attacks on his road columns. It is suggested however that this would not produce more than a partial block, since the countryside in question has innumerable side roads and much of it is wooded. By night, and even by day, movement would be possible on these side roads.

To block all the possible routes, whether by bombing villages or roads, would involve an impossible number of attacks. An alternative plan is therefore suggested, based on blocking the approaches to bridges (the number of roads decreases considerably at river lines). Since the main roads are likely to be needed by us for subsequent advances, they are to be left open, while all the side roads will be blocked along the lines of the River Dives. This leaves the enemy the alternatives of using the side roads and attempting to clear them, or of using a very few main roads. If he chooses the former alternative an immense strain will be imposed on his organization, he will be very seriously held up, and in all probability completely jammed. If he keeps to the few main roads he can be readily discovered and heavily attacked by day or night with fragmentation bombs or strafed with Fighters and Fighter-bombers. This should destroy and disorganize his columns and ultimately jam them completely. Should however this fail or become impossible for any reason, the main roads can be bombed and the line of obstacles completed.

The plan is shown on the attached map, but the detailed arguments for selecting the particular target areas and weights of attack are not given. In any case, the whole plan would no doubt need considerable modification to suit the exact circumstances that may arise. There would be many necessities; the ends of the line of blocks would be closed by artillery and the whole plan would be co-ordinated with the ground attack. These matters are not discussed at all.

3000

Base
of the
Bomb



SUGGESTED PLAN TO BLOCK A GERMAN RETREAT
FROM THE MOUNTAINS AND PALAISE.

Based on blocking side roads on the line
of the River D. V. by means of heavy
bombing.

○ 100 If air and number of Heavy Bombers
required.

○ 50 Ditto for main road blocks, only to
be used if other methods fail.

It must be emphasised that the object of the bombing outlined in this plan is not to knock down bridges, but primarily to crater roads to such an extent that they are unusable. A River Line is chosen for blocking, simply because the number of roads at such places is reduced to a minimum and the task of blocking therefore simplified. The result of an effective block on the road approaching a bridge, is to make the bridge as impassable, for a time at least, as if it had been knocked down. The enemy has only two courses open to him to fill in all the craters and so re-open the road, or to make a new road and a new bridge somewhere else. Under the conditions of a retreat, he is not likely to be able to do either very easily. If however he should open a new crossing, it too must be bombed in the same way.

The plan as at present set out requires about 2,250 bombers for blocking the side roads, and a further 250 for blocking the main roads should this prove necessary. The total weight of attack is large, and the plan is complex. It does however aim at cutting off a very large number of enemy troops.

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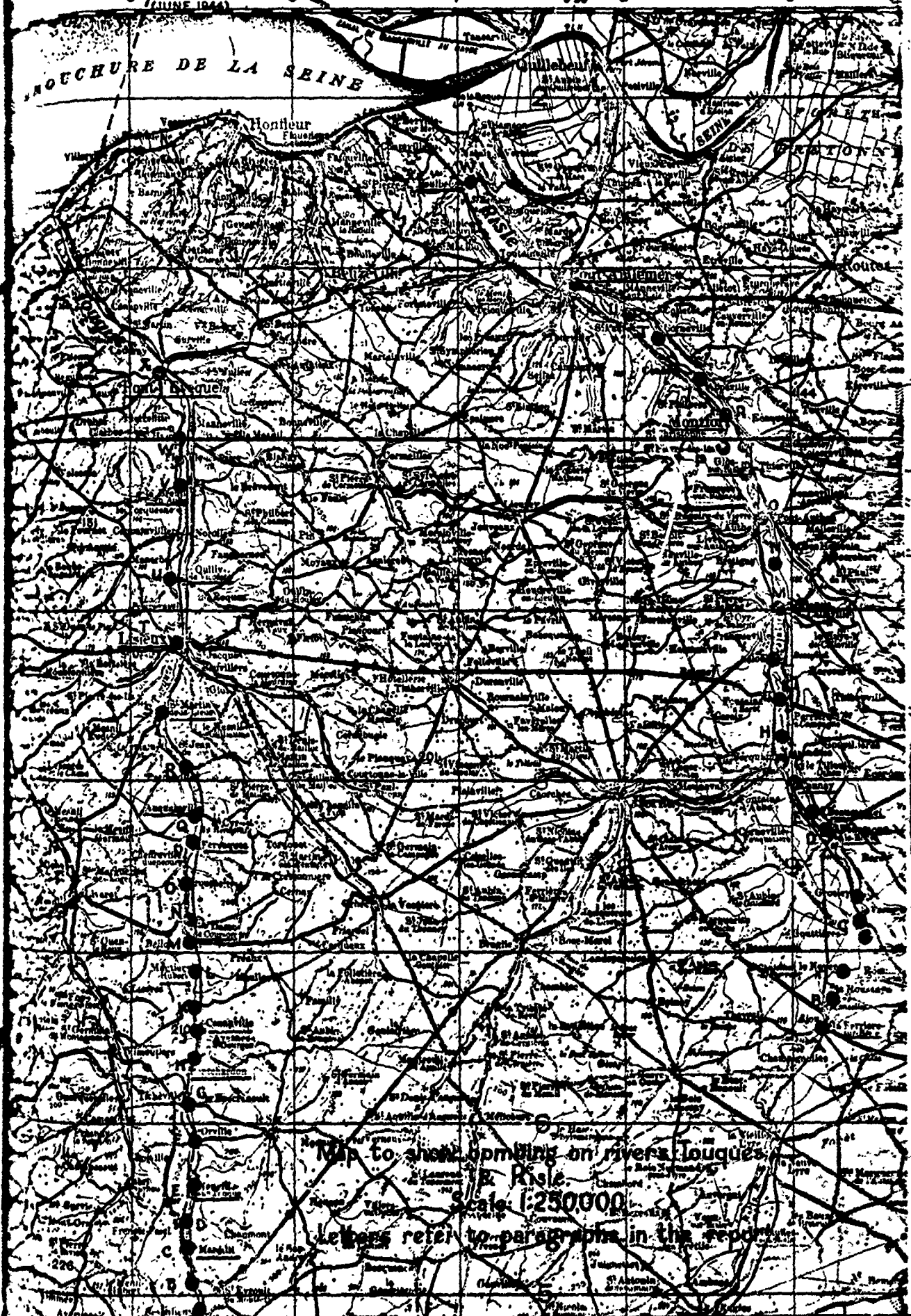
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BOUCHURE DE LA SEINE



Map to show bombing on rivers Louques

Risle

Scale 1:250,000

Letters refer to paragraphs in the report

46.

MEMORANDUM NO. 1.

CRATER BOMBING ON RIVER LINES IN NORMANDY.

1. In the course of another investigation, the information that follows was collected on the effects of crater bombing on river lines as a means of blocking and delaying the enemy.
2. The rivers in question were the TOUQUES and the RISLE. It is understood that, although some bombing was carried out on the TOUQUES, it was not intended to make a complete interdiction line. In the case of the RISLE, however, this was attempted.
3. The bombing was carried out mainly by B Bomber Command, who are recorded as having made 5 attacks on the TOUQUES and 10 on the RISLE. In fact, there was evidence of many more attacks on both river lines. The reasons for this are not clear.
4. The bombing was not intended purely to destroy bridges, but to crater and block the approaches. In this it was sometimes successful, although only in the heavy bombing of LISIEUX were any bridges actually destroyed.
5. The four appendices give photographs, details of the various crossings of the TOUQUES and RISLE and a map. The important points are summarized below.
6.

Total number of crossings of the TOUQUES and RISLE	47
Number of crossings with bomb craters near	29
Number of crossings officially stated to have been attacked	15
7. Of the 29 crossings that actually had been attacked

Number where complete blockage was effected	3
Number where a partial blockage, or slowing down of traffic was effected	8
Number where no blockage or slowing down was effected	18
8. The numbers of bombs that had fallen around the approaches to the bridges were as follows:-

For complete blockage - 500, 100, 100	<u>Average</u> 230
For partial blockage, 30, 140, 100, 100, 100, 200, uncertain, uncertain	110
For no blockage 1, 4, 12, 20, 30, 8, 15, 5, 80, 40, 100, 60, 16, 6, 100, 50, uncertain, uncertain	36
9. The general impression is that the bombing was not heavy enough to produce full scale blockage of crossings, and that an attack of about 230 bombs is the lightest that will produce this effect with any degree of certainty.

APPENDIX A.

THE CROSSINGS OF THE RIVER TOUQUES.

Note: Category 1 - Complete blockage
 2 - Partial blockage or slowing down of traffic.
 3 - No blockage.

A. GACE (544493 and 544498).

Category

Both bridges were intact. A single 500 lb bomb crater was found 150 yds away from one of them.

3

B. 540507.

A small bridge suitable for light traffic, found to be undamaged. No bombs dropped.

C. MARDRELL (537528).

This bridge was still intact but there were four places where the Germans had made holes for demolition charges which they had never placed. Four bomb craters were found astride the approach road about 150 yds to the west of the bridge.

3



CategoryD. 536545 and 540556.

Two small bridges still intact. No bombs dropped.

E. NEUVILLE-SUR-TOURNE (540572).

Quite a large bridge which had been blown by the Germans. No bombs had been dropped.

F. ORVILLE (542589).

About a dozen bombs were dropped to the S.E. of this bridge, the nearest being 75 yds away, but no damage was caused. The enemy destroyed it later. This target is recorded as having been attacked by mediums, but the number of planes is not known.

3

H. PONTCHARDON (542637).

Blown by the Germans only 40 minutes before the first of our troops arrived. No bombs.

J. CANAPVILLE (543656).

A small bridge blown by the enemy. 20 bombs fell close to the bridge (nearest was 70 yds away) but they may have been aimed at traffic on the N-S road which follows the west bank of the river; at one point a crater had blocked this road.

3

K. LE BOURG (542668).

The bridge was still intact, although the parapet had gone as a result of one bomb within 10 yards. In all about 30 bombs fell around this crossing and several out the road which leads to the bridge on the west bank; a number of German vehicles left the road and became bogged in the water meadows. However, the bombing did not cause a complete stoppage of traffic on this important route. This target was twice attacked by mediums. The number of planes is not known.

2

L. MOUTIERS HUBERT (542688).

This bridge was rather inefficiently blown by the Germans on 22nd August. About a week before, some 30 bombs had been dropped to the east of the bridge and some craters had been made in the N-S road which follows the east bank of the river.

3

M. NOTRE DAME DE COURSON (543705).

Some 100 bombs were dropped around this crossing; one landed only 20 yards from the bridge and several made big craters in the embankment along which the main LIVAROT - ORSEC road approaches the bridge. This bombing was so effective that the Germans made a detour through the forest and used the MOUTIERS HUBERT bridge instead. Finally they destroyed the bridge at NOTRE DAME DE COURSON as well. 24 B.26s are said to have attacked this target, although it is doubtful if in fact they all did so.

1

N. LE VIGNERIE (540720).

This bridge was blown by the Germans. No bombs fell in the neighbourhood.

O. 539731.

The bridge here was also destroyed by the enemy. No bombing took place.

P. PERVAUSE (542765).

The bridge here, though capable of carrying heavy traffic, was still intact. There had been no attempt at bombing or demolitions.

Q. ARQUAINVILLE (544779).

The notice board says "6 tonnes" maximum load but the bridge is an old wooden construction hardly capable of carrying a Jeep. Neither side paid it any attention.

48.

R. 57606.

CATEGORY

This bridge was cut by the enemy. 8 bombs fell in the valley between here and AUMAINVILLE and one near the LISIEN road.

S. ST. MARTIN DE LA LIEUE (526843).

Although there was a large pile of explosive at the roadside the bridge was not destroyed as the guards deserted. Over a hundred bombs fell around the crossing in very close pattern. The parapet was destroyed by one and several more made such craters in the approach road and brought down so much debris from the houses near by that this route was effectively denied to the retreating enemy. This target is recorded as having been attacked by 34 B.26s.

T. LISIEN (529877).

There were 8 bridges in the town which had been heavily bombed. The result was that 2 bridges were cut by our bombing. One of these was replaced by a temporary structure by the Germans but the other was left. Demolished buildings caused some obstruction to traffic but the enemy were not prevented from passing through. Before they left they destroyed the six remaining bridges and their temporary one. LISIEN was attacked on more than one occasion by Heavy Bombers.

U. CHILLY LE VICINTE (531917 and 526937).

Both bridges blown by the enemy but no bombs had been used.

V. LE BREUIL EN ADOE (534972).

15 bombs were dropped near this bridge without effect as they all landed in the water or soft meadowland. The Germans destroyed both this bridge and a private one nearby which might have served as a diversion.

W. 534999.

Steel girder bridge on a minor road had 5 craters in the fields within a hundred yards of it. The Germans blew it up.

X. PONT L'ETREQUE (520038).

About 80 bombs fell on the outskirts of the town without affecting either the bridges or the main roads. The Germans blew both bridges and set fire to the centre of the town.

APPENDIX B-

THE CROSSINGS OF THE RIVER RISLE.

NOTE:-

Above LA FERRIERE-SUR-RISLE (MR.921655) the river is no real barrier as it can easily be forded at a number of points; in any case the roads which cross the river south of LA FERRIERE were not used by the enemy in his retreat. A detailed examination of the bridges and their approaches from LA FERRIERE to the sea is set out below.

1. LA FERRIERE-SUR-RISLE (921655)

CATEGORY

A total of 140 bombs were dropped at night around this crossing point. One bomb fell on the road to the west of the town at a point where it is carried on an embankment: the next day the inhabitants filled in the crater at the point of a byway. (See Photograph 1). This task was completed some time in the afternoon but the Germans then made a detour across a ford to the south of the village because, although the bridge was still intact, debris from houses and another crater in the road made the approach impassable. The majority of the bombs aimed at this crossing fell on the east side of the river where both craters and fallen masonry caused effective blockage. It appears that for 12 hours after the bombs were dropped no traffic passed, and that in the next 24 hours only a reduced stream managed to cross. Subsequently the route returned almost to its normal traffic carrying capacity. Finally, the Germans blew up the bridge and placed mines in the ford. This target is recorded as having been attacked by mediums but the number of planes is not known.

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Photograph I - Partially filled in crater on embanked road.



Photograph II - Bomb craters around bridge at Beaumontel. Bridge was blown up by Germans.

B. 928674.

Category

A steel girder type bridge spans the river at this point; it is approached by a secondary road through dense woods. Down this road over 600 horse-drawn vehicles are said to have passed and, during the last day, about a hundred lorries also. The bridge was quite unamaged, no bombs having been aimed at it nor had the enemy attempted to blow it. When questioned on this point local inhabitants stated that the Germans did not trouble to blow the bridge because the ford alongside it was so good that it would not have held up the pursuing British troops at all.

C. 926687, 936688, 943695, 947708, 944712, 945720, 942730, 937745.

All these crossings are where minor roads cross the river which is still very easily forded because it has a good firm pebble-bed and is only about 9" deep. The Germans do not appear to have used these crossings, and they were not bombed.

D. BEAUMONT-LE-ROGER (928768).

There were three bridges in this town. The most southerly of these was well signposted by some enemy unit, and they appear to have suffered no obstruction whatsoever. When they had finished with the bridge they blew it up as they did with the two further north in the town.

Bombs had fallen in the town, two of them very near the middle bridge which suffered very slight damage, though its traffic-carrying capacity was not affected. Of the 40 or so bombs which were dropped on the town, one fell harmlessly very close to the northern bridge, but none fell in the roadways.

The net result of the attack was nil as far as slowing down or disorganising the German retreat through BEAUMONT-LE-ROGER.

This target is said to have been attacked by 36 B-26s, although it seems unlikely that they can all have dropped their bombs here.

E. BEAUMONT (917780).

Bombs had been dropped around this crossing on several occasions. On 23rd March the bridge was hit and damaged, but the Germans soon repaired it. Bombs fell again in May and June but the significant attack occurred on 16th August; on this latter occasion, though the bridge sustained no damage, several bombs fell on the roads leading to and from the bridge. The Germans made detours fairly easily but they only used this crossing for a small quantity of light transport (mostly impressed saloon cars). They blew the bridge before leaving.

A photograph taken from the top of the church tower shows the pattern of the bombing (about 100 in the most recent attack) with relation to the bridge.

It is said that 67 tons of bombs were dropped on this target, but this would appear unlikely. (See Photograph 2).

F. 913789.

The road which appears on the map is in reality only an overgrown track which crosses the river by a ford with a footbridge for pedestrians. At least 100 bombs were dropped around this crossing, but the track was untouched and the footbridge still stands. No Germans appear to have used this crossing.

Similar fords occur at 910796 and 905604.

G. POINT COUPIERE AND PETITE LAUNY (901113 & 905110).

There are two main branches of the river at this point. The eastern stream crossed by the reinforced concrete bridge at POINT COUPIERE was not attacked with bombs and was very inefficiently blown by the enemy as it was still possible for tracked and short wheel-based vehicles.

At least 500 bombs were dropped in and around the village of PETITE LAUNY and, though the bridge was undamaged until blown by the enemy, a most effective road blockage was caused. At least 7 craters made the road impassable and the debris from bomb-broken cottages added to the difficulty. (See Photograph 3). The enemy had made no attempt to clear a way through this village and thus the bombers effectively denied him the use of this crossing on the main BEAUMONT - LOUVIERS road. The bomb density in the village was between 10 and 15 per acre and there was naturally a very large spill over into the surrounding fields.

Category

This target was said only to have had 46 tons of bombs, but must in fact have received at least double this quantity.

N. MASSANDRES (900822).

Many bombs had been dropped in this area, probably over a hundred, but all except for 2 or 3 fell harmlessly in fields about 250 yards south of the road. However, these few successful bombs cratered the road and caused the enemy to make a diversion through gardens and fields, which no doubt slowed down the speed of the traffic. The local population stated that for three days and nights (days of poor visibility) the enemy poured through in a ceaseless stream consisting of thousands of lorries and an unspecified number of tanks. Eventually the Germans blew the bridge.

2

33 B-26s were said to have been used for this target.

K. 900847.

The main LISIEUX - EVREUX road crosses the Risle at this point by two bridges. Apparently about 60 bombs were dropped around the crossing but no effect was produced on the main road or bridges although a large bomb had cratered the M-8 lateral road just short of its junction with the main road on the east side of the river. One of the two bridges was blown by the enemy before they finally left the area.

3

L. 891867.

A secondary road crosses the valley by means of one large and two small bridges; the latter were left and the Germans blew the former in a very amateur fashion and it could still be used. 16 Bombs were dropped across the valley without effect.

3

M. PRIONNE (897901).

There were two bridges in this town (both blown by the enemy). Some 6 bombs fell on the BERNAY road where it approaches the southern bridge and tended to slow up the traffic to a certain extent. The northern bridges and its approaches were unaffected.

3

N. 894922.

This bridge, eventually destroyed by the enemy, had no bombs aimed at it. The road was used by a continuous stream of cars and trucks for 3 days and nights.

O. PONT LUTOU (883943).

In all about a hundred bombs were dropped here and three of them fell on the main road, whilst others caused masonry and general debris to litter the streets. The Germans made no attempt to fill the craters and only a small stream of traffic filtered through between them. When the bridge was blown by the retreating enemy it was done in such a manner that the pursuing British troops had less difficulty in crossing than in clearing the debris and filling in the craters.

2

24 B-26s were used for this target.

P. LE ROMAINCON (880970).

There are two bridges here and the road passes a cotton mill (water-powered) as it leaves the eastern bridge. The mill was gutted as a result of incendiary bombs on 14th August according to the evidence of local inhabitants. No bombs had damaged the bridges nor had the Germans blown them; the explanation of this is that the guards, charged with the responsibility of these demolitions, were rendered incapable by residents who purposely plied them with excessive quantities of liquor. The enemy had apparently used this route for tanks and lorries for two days and nights without success.

3

Though there were no bombs (except the incendiaries on the factory) near the bridges, well over a hundred bombs had fallen some 300 yards further north and a few of these had partially blocked the M-8 lateral road. A few more had fallen on GLOS-SUR-RISLE where more slight blockage of the same road occurred.



Q. LA BARONNIE (862993).

Category

The bridge on this road is limited to loads of up to 2 tons and was not much used by the Germans. They did not attempt to destroy it but allied aircraft attacked it with what a local inhabitant called "small bombs"; the craters are compatible with the use of rocket projectiles, one of which penetrated the concrete of the bridge.

3

R. MONTFORT-SUR-RISLE (867015).

About 50 bombs were dropped around this crossing; some small ones landed between the rail and road bridges which were both blown by the Germans. No blockage of the road occurred and the enemy appear to have retreated by this route for 4 or 5 days.

3

This target was stated to have been attacked by 34 A.20s, although this number seems unlikely.

S. Unnamed place between MONTFORT and CORNEVILLE.

There were 2 bridges here over the divided river. This road was much used by horse-drawn traffic and the bridges were both blown by the Germans. No attempt seems to have been made to bomb the crossings.

T. CORNEVILLE (8206).

At least 200 bombs were dropped in several distinct patches of high density in the area of this crossing. The road leading to the bridge was badly cratered but detours through the fields at the side of the road were successfully made. (See Photograph 4). The bridge was very effectively destroyed by the retreating enemy.

2

U. HAIRVILLE-SUR-RISLE (8007).

The bridge here was blown by the Germans but no bombs had been aimed at it. It had been used quite considerably by the enemy in his retreat.

V. PONT LAJERIER (7709).

Many bombs had been dropped on this town and considerable damage done, but the two bridges were not damaged, nor did craters or debris block the main roads. Both bridges were effectively destroyed by the Germans.

3

This target was twice attacked, but the number of planes is not known.

W. POULEEC (7015).

This swing bridge over the tidal reaches of the RISLE was the last possible crossing of the river. Bomb craters around the bridge and on the approach road had the appearance of being somewhat old, but the ferrymen contended that they had been dropped in August, and it is possible that the damp soil accounted for the vegetation which was beginning to grow in some of them. The route had only been used by horse-drawn vehicles which made detours round the craters. The bridge was blown with fellerwines, some of which were still in place and had not exploded.

2

This target is said to have been attacked by 28 B.26s, but this number seems unlikely.

MEMORANDUM NO. 6-

THE CONTRIBUTION OF THE AIR FORCES TO THE STOPPING OF
THE ENEMY THRUST IN THE ARDENNES, DECEMBER, 1944.

INTRODUCTION-

1. During a very limited investigation involving the examination of enemy armour claimed to have been destroyed by pilots of 2nd T.A.F. in the Ardennes Salient (see Joint Report No. 1) it became clear that valuable lessons could be learned by widening the scope of the study to include the air effort as a whole in its relation to the enemy thrust.

SOURCES.

2. Check points at LAROCHE, NOUFFALIZE, VIELSALM, RECHT and ST VITH were visited twice, once when the inhabitants were still sorting out their dead and the second time after an interval of two or three weeks. Responsible persons were interrogated until the investigators were satisfied that they had obtained unbiased estimates of the duration of delay imposed on the enemy by the bombing.

3. For the purposes of this memorandum the Air Ministry War Room Air Staff Operational Summaries have been relied upon for details of heavy and medium bombing. The relevant area has been taken to be that bounded by a line drawn through COLOGNE - COBLENZ - TRIER - CLERVAUX - ROCHEFORT - COLOGNE. Fighter-bomber statistics were taken from IX and XIX U.S.A.A.F. Ops Flashes and from 2nd T.A.F. Daily Log.

4. Information obtained from prisoners of war has been taken from S.H.A.E.F. Enemy Communication Summary No. 23 and from P.W. Intelligence Bulletin No. 1/29.

AIR EFFORT AND THE GERMAN ADVANCE.

5. In addition to the attacks on targets in the battle zone a very large air effort was directed against the enemy's supply lines. The attacks by the heavy bombers were chiefly on the railway system and those of the mediums on both roads and railways.

6. On 18th, 19th and 21st December small weights of bombs were dropped on COLOGNE, COBLENZ, TRIER and SCHLIDEN but the weather did not allow a really large scale effort until the 23rd when (as is shown on the graph at Appendix A) the weight of bombs rose sharply to over 1500 tons a day and remained at that level. The bombing of the more distant marshalling yards is shown by a separate line on the diagram; it also has a peak on the 23rd.

7. The rate of the German advance, expressed in kilometres per day, is plotted on the graph at Appendix A. It continued at about 20 km per day until the 23rd; on the 24th it had slowed down considerably and on Christmas Day it ceased altogether. There was no sudden change in resistance on the ground to account for this abrupt stop, whereas the timing of the air effort fits the events perfectly.

8. Although some effect of the bombing on the L of C could be expected to be felt at the front on the following day, a two day time lag would represent a more reasonable allowance for the full effect on supplies travelling from the bombed area to the forward troops. The coincidence of the graphs, with a two days phase difference, is evidence that the heavy and medium bombing on the L of C played a significant part in stopping the thrust. It is known from intelligence reports that there was a shortage of fuel and ammunition at the front.

9. In the same way it was found that the fighter-bomber effort was also significant. The daily number of sorties flown by fighter-bombers in attacks on vehicles in the Salient has been plotted on the same graphs. These operations were nearer the front and a time lag of one day would fit the theory that the effect of the fighter-bombers was to reduce the supplies reaching the front rather than to stop the advance by direct attacks on armour.

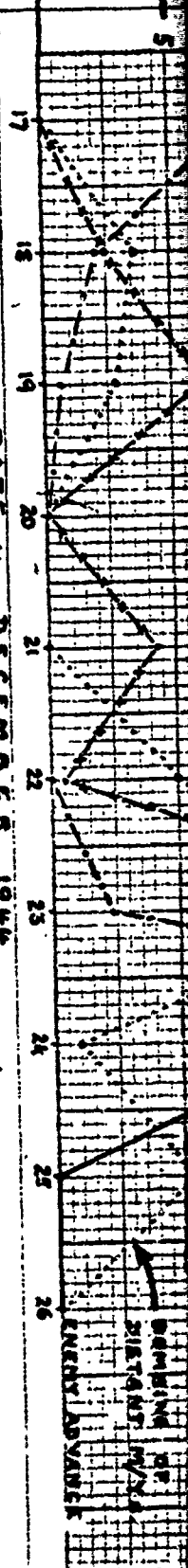
10. The evidence does not suggest that any one part of the indirect air effort was more important than another. It is probable that the bombing of the distant marshalling yards and the attacks on the L of C, both behind the Salient and in it, were complementary. What the evidence does show is that the indirect support was decisive whereas the direct support was of much less significance. To sum up:-

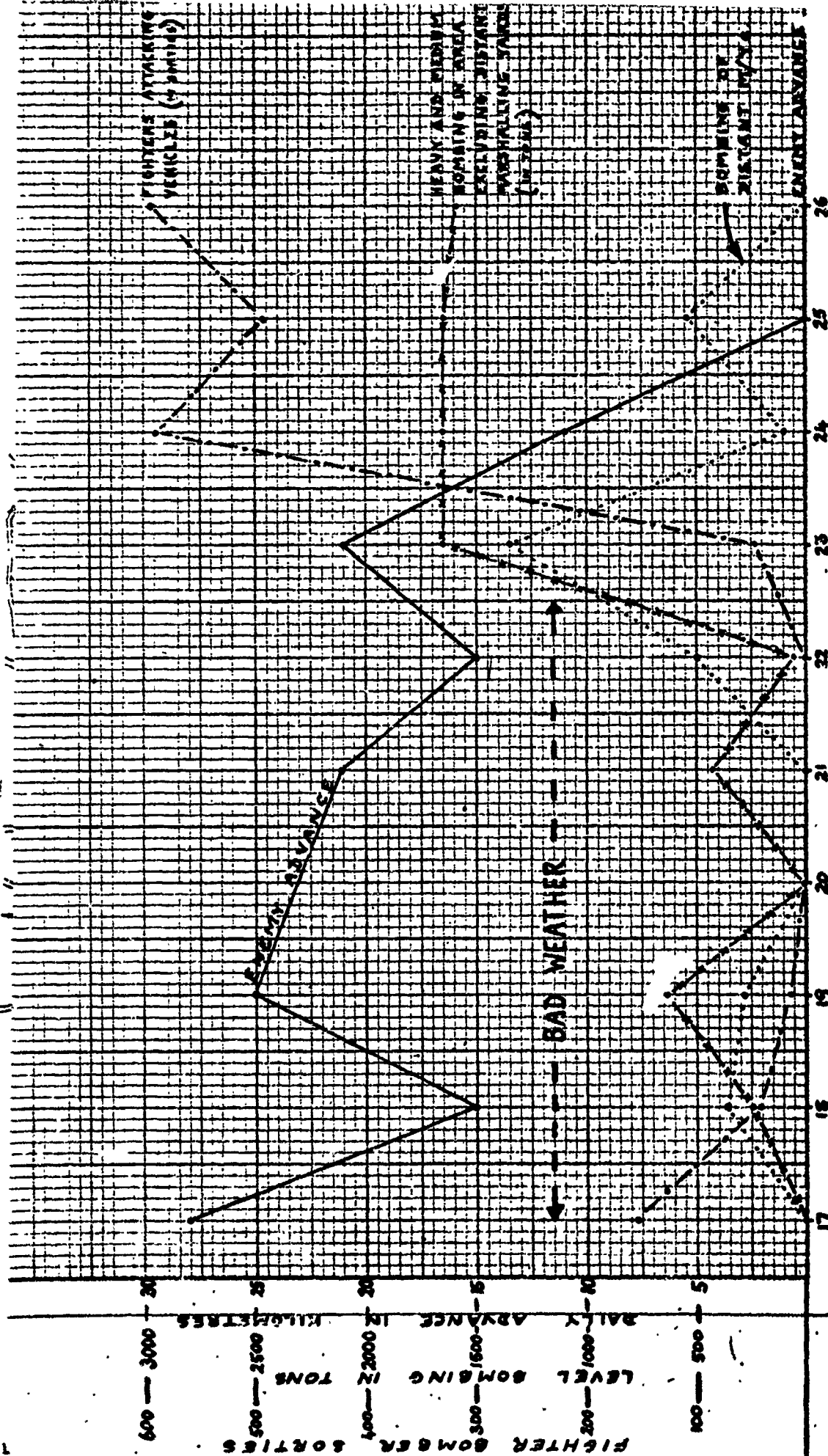
(a) During the period of bad weather before Christmas, when little or no flying was possible, the rapid advance continued.

(b) The first really heavy bombing in the rear areas coincided with a considerable advance by the Germans.

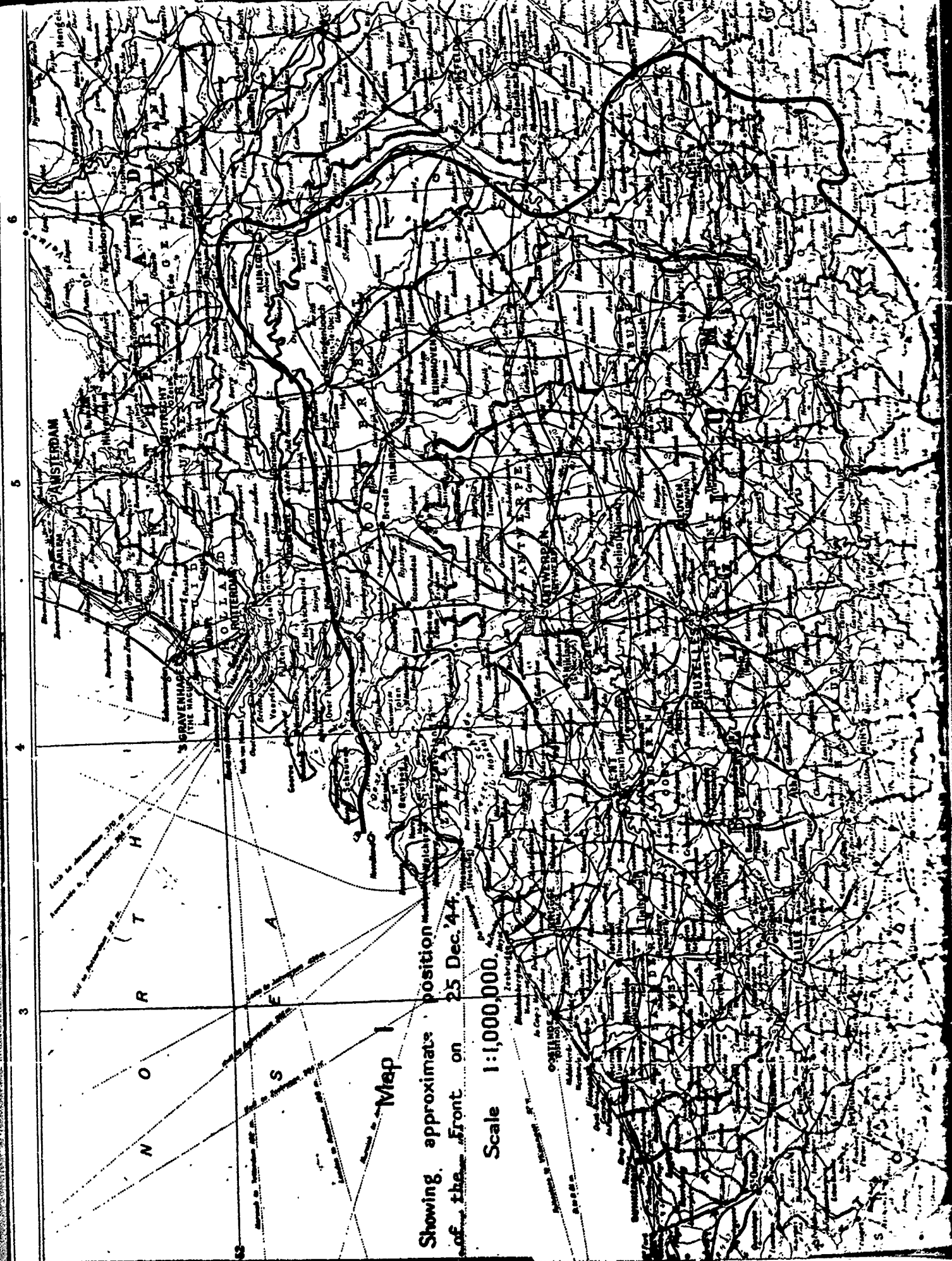
(c) The following day, when the fighter-bombers resumed their activity and when the effect of the previous day's heavy bombing was beginning to be felt on the L of C, the advance was slowed down.

DATE : DECEMBER 1944





DATE : DECEMBER 1944



Showing approximate position
of the Front on 25 Dec '44.

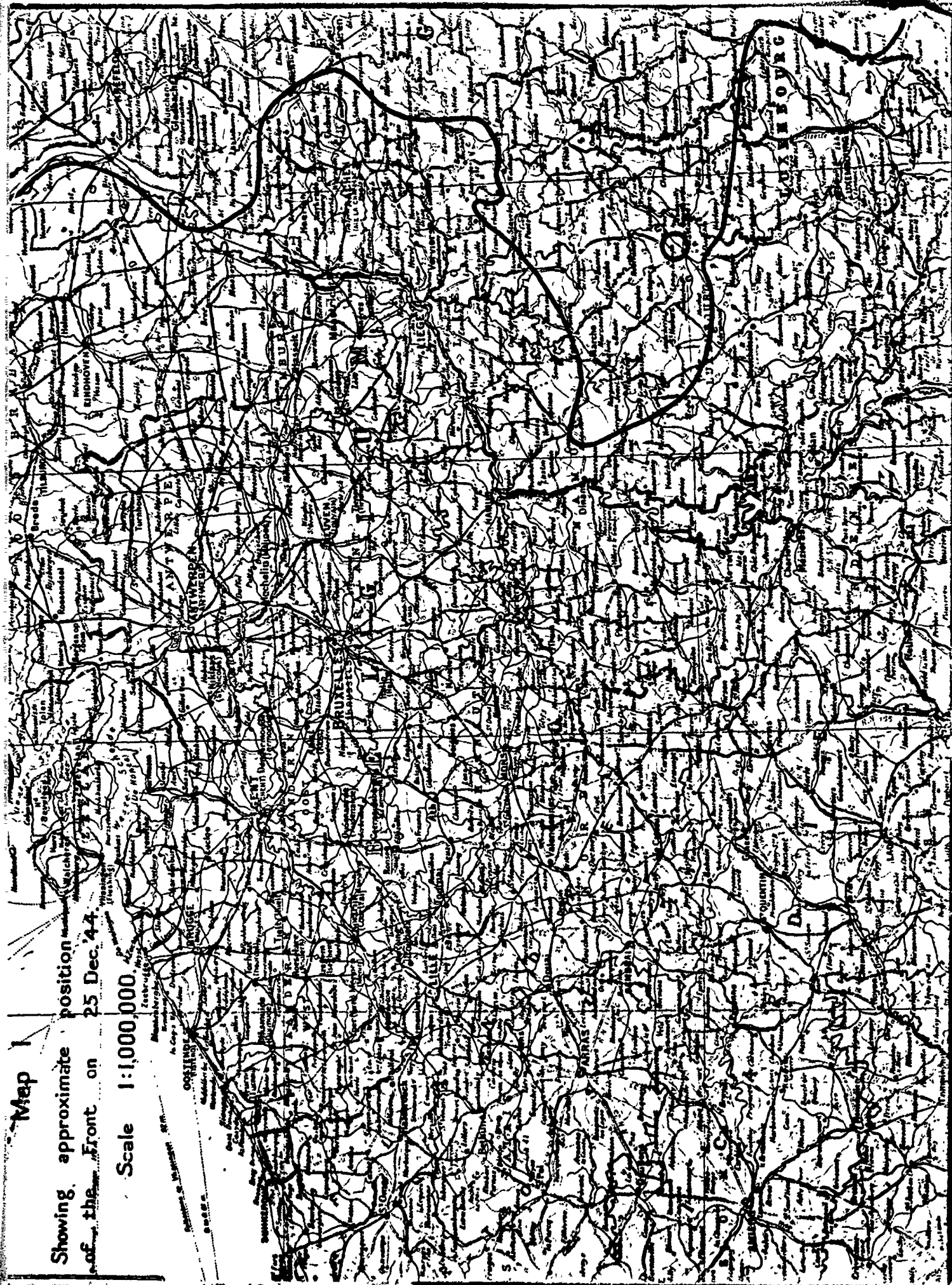
Scale 1:1,000,000.

Map 1

Map 1

Showing approximate position
of the Front on 25 Dec '44.

Scale 1:1,000,000.



Magnetic Variation at centre of sheet
Annual change 10' East

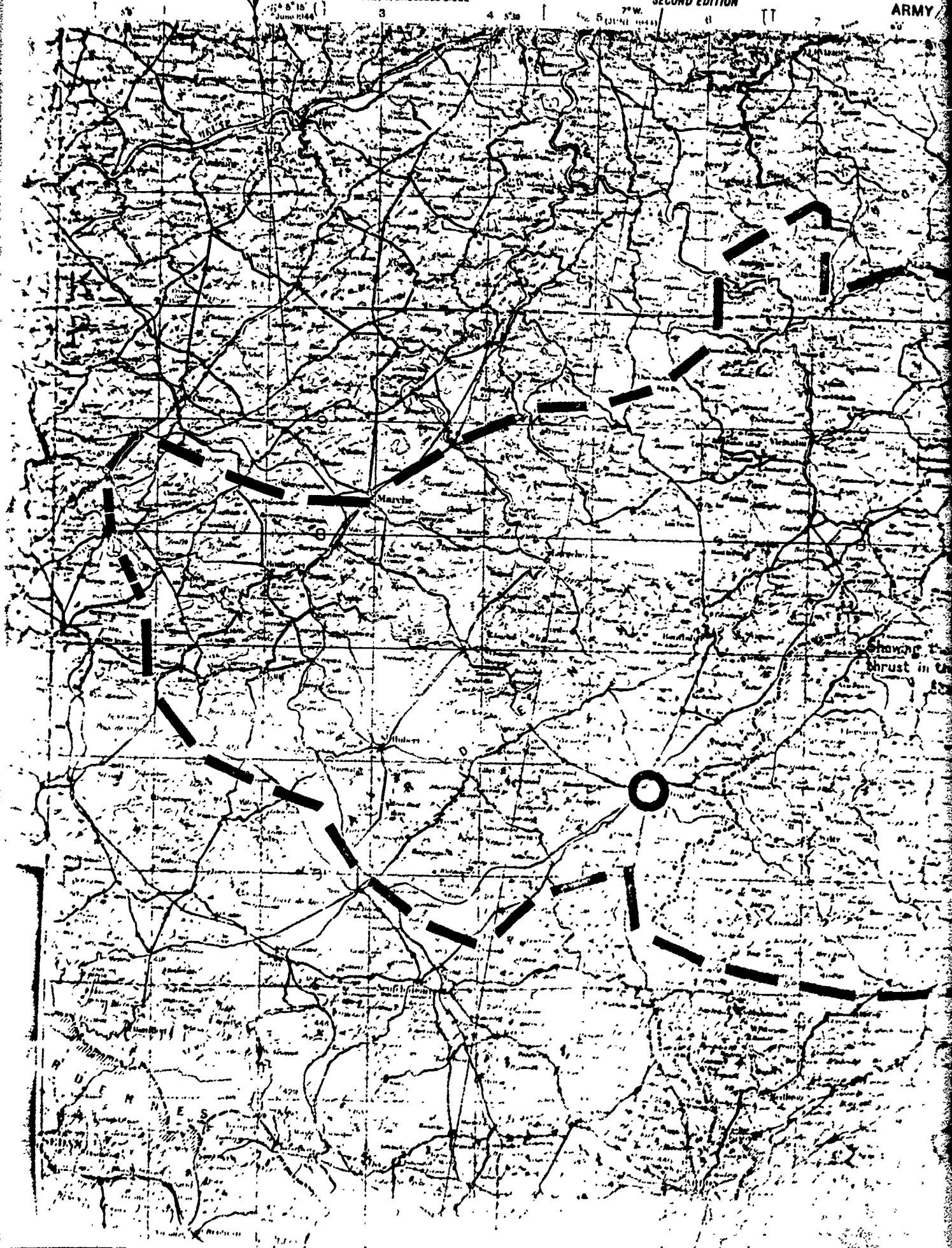
NAMUR-LUXEMBOURG

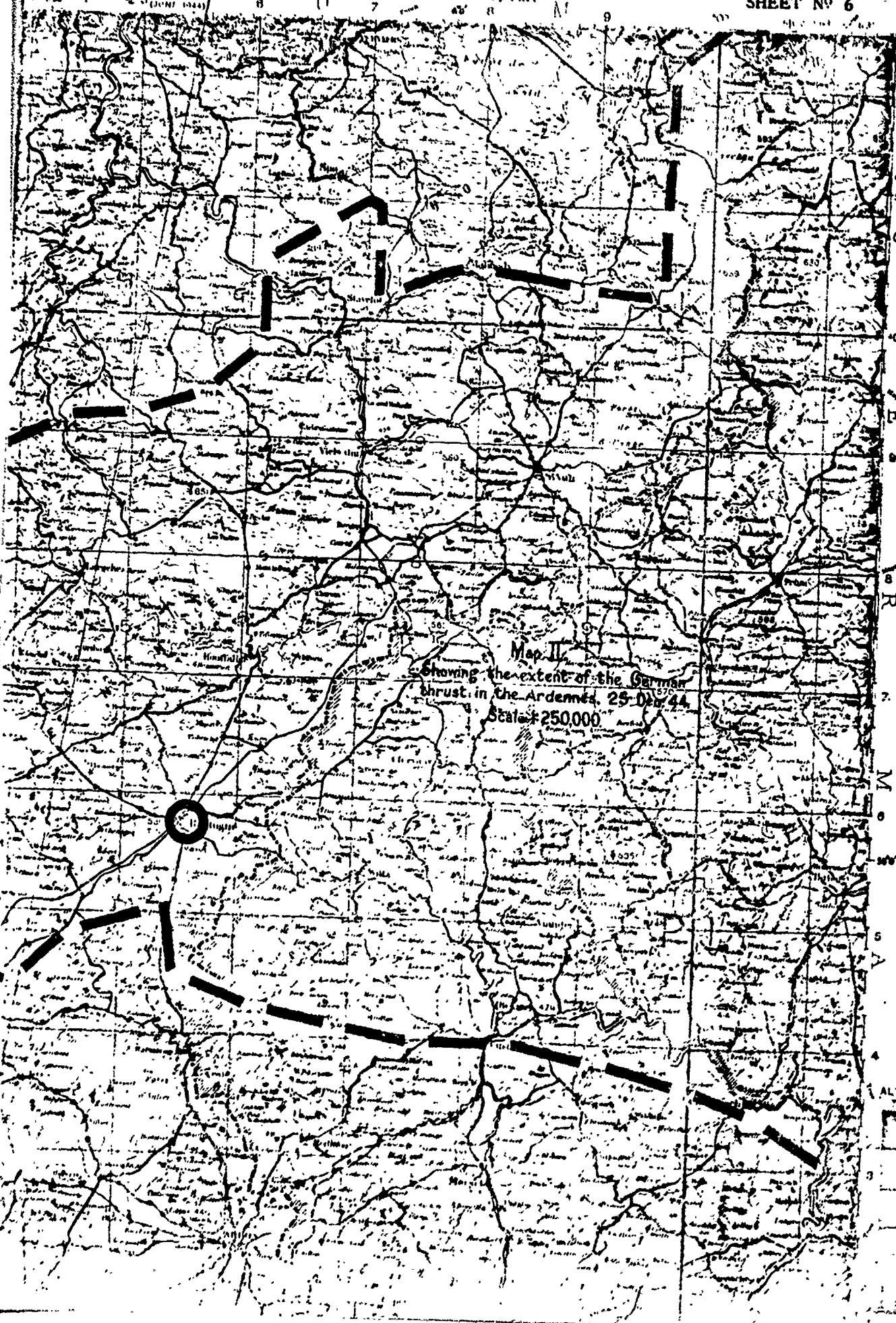
25 Km OVERLAP ON SHEET 3, BRUSSELS-LIEGE

June 1944

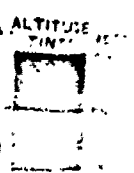
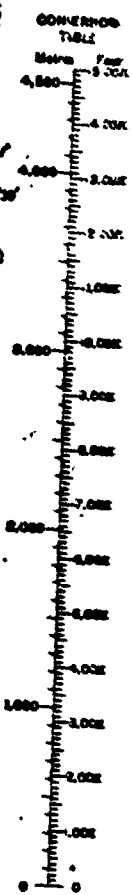
SECOND EDITION

ARMY





Map II
Showing the extent of the German
thrust in the Ardennes, 25 Dec 44
Scale: 250,000



(d) The next day, when the effect of the fighter-bombers on transport in the Salient and that of the heavies in the rear areas had both made themselves felt at the front, the offensive came to a standstill.

(e) Thereafter no further advance was made and the Germans began to withdraw under continuous attack by all types of aircraft both in and behind the Salient.

BOMBING OF ROAD AND RAIL CENTRES.

11. Evidence of the effect of attacks on more than 20 road and rail centres behind the Salient is available in S.H.A.E.F. Intelligence documents which show that considerable dislocation took place in the movement of troops and supplies. Interrogation of civilians in the road centres of NOUFFALIZE, LAROCHE, VIELSALM, ST VITH and RECHT shows that bombing attacks caused up to a day's delay. If this is a fair sample of what took place behind the Salient also, it would be reasonable to assume that supplies were one day late in reaching the front, especially when one takes into consideration the additional effect of the ubiquitous fighter-bombers.

12. There is no doubt that the heavy and medium bombing of the choke towns achieved a considerable measure of success in delaying supply traffic. Nevertheless, looking at the operations after the event, one is tempted to suggest that some of the bombing was wasted and that, with the same resources available, substantially greater delays could have been imposed on the enemy.

13. At LAROCHE the retreating Americans failed to blow the only bridge but this was rendered impossible by the first bombing raid on 26th December. In addition to stopping traffic through the town, this raid denied the accommodation to the enemy. The second and third raids (on 27th December and 1st January) were unnecessary, although in the conditions of P.R. at the time it is unlikely that the Staff could have known that. The bridge connects six roads on the south and west with two to the north and east and, although its destruction was of great value, this did not prevent the use of the southern roads.

14. To isolate LAROCHE completely would require the cutting of these eight roads and of two possible by-passes. On these ten routes it is possible to select, at some little distance from the town, points where the road is engineered into the steep hillside or where there is a series of hair-pin bends. Road-cutting attacks at such points would have two advantages; firstly the flak risk is less, away from the towns and secondly, as the enemy used only manual labour to repair the roads, transportation of men and tools would impose extra delay.

15. At NOUFFALIZE the bridge was never hit and, if it had been, it could have been repaired very quickly as it was only a small one. The first raid caused damage and casualties and delays of many hours; it also denied to the enemy the use of the town for billeting and storage. The six subsequent raids (including the unsuccessful blind bombing attack on 3rd January) did not cause more than 3 - 4 hours delay each. Although it cannot be doubted that these occasions of delay helped the Allied ground forces, it is felt that much greater delays could have been caused had the roads been cut at vulnerable points away from the town. One road was, in fact, very effectively cut at P 607717, rather closer to the town than would generally be considered healthy.

16. At ST VITH, where the roads do not all meet at a point as they do at LAROCHE and NOUFFALIZE, the 1131 ton raid by Bomber Command on 26th December produced excellent results. This attack caused the town to be evacuated by the German troops and induced much delay immediately and substantial permanent delay by enforcing the use of lengthy by-passes. The eight roads leading into ST VITH are not all vulnerable to cutting by fighter-bomber attacks but at least four of them are and, had such attacks been carried out, the value of the heavy bombing would have been considerably enhanced.

17. At RECHT the bombing did damage to stores in transport and to troops but its interdiction effect was very small. Three well chosen road cuts would have isolated this centre.

18. The small raids on VIELSALM caused little or no delay as none of the bombs fell away from the town and, in any case, as the road network is very open, small raids could not be expected to cause serious blocking. Further away from the town, however, the roads are very vulnerable and cuts could have caused much delay.

19. As fighter-bombers achieve one rail cut in every six sorties on the average, it is probable that, if flak conditions allowed, 12 sorties would be sufficient to ensure a successful road cut. If this is so, the road-cutting programme suggested in the preceding paragraphs would not have been beyond the resources of the tactical air forces concerned.

MEMORANDUM NO. 2.

BOMBING OF COMMUNICATION CENTRES PRIOR TO
OPERATION "PLUNDER".1. OBJECT OF THE INVESTIGATION.

Between 21st - 23rd March, 1945 certain German towns were bombed and an investigation was carried out to obtain answers to the following questions:-

- (a) Did the repeated attacks prevent the enemy resting and sleeping and reduce his will to fight?
- (b) How many Germans were killed?
- (c) What damage was done to communications?
- (d) Were the Germans prevented from continuing to fortify the bombed towns?

A list of targets and attacks is at Appendix B.

2. METHOD OF INVESTIGATION.

- (a) Some prisoners of War from units known to have been in or near the towns were interrogated.
- (b) Civilians, usually mayors and stationmasters, who had been in the towns at the time, were also interrogated.
- (c) The towns were examined approximately one month after the bombing.
- (d) Some reconnaissance reports by REs and Military Government representatives were made available, showing the state of the towns within 48 hours of occupation by our own troops.

3. RELIABILITY OF EVIDENCE.

The principal evidence is that given by local civilians. Those chosen for interrogation were usually officials appointed by Military Government on account of their anti-Nazi opinions.

Their statements were frequently checked by ground observation or by comparison with air recon reports at the time of the bombing and were found to be accurate within the limits of human memory.

The figures for casualties are those given by the mayors of the towns. They are probably within 10% of the true figures.

4. SUMMARY OF PRINCIPAL FINDINGS.

(a) The morale effect of the bombing on regular troops was minimised because there were few stationed in the bombed towns. The morale of civilians and "incipient" Volksturm was greatly lowered.

(b) Approximately 2,500 Germans were killed, of whom perhaps 100 may have been military personnel.

(c) The railway system was so damaged that a single line on the main trunk route was all that the Germans repaired in the whole area, this could only be used at night and NOT beyond DORTMUND.

(d) The road network in the area was so dense that, although all roads in the centres of target towns were blocked, a reasonable by-pass or alternative route was available. The most delay caused was that required to go further over worse roads. The Germans were able to clear those villages which had been bombed to prevent the use of alternative routes.

Both civilians and military knew that the necessity of restricting movement to nights on account of fighter bombers a more serious cause of delay.

It should be noted that 116 Pz Div, which on 23rd March, 1945, was stationed NORTH of the area, was able to cross it and be in action against 9 US Army SOUTH of the LIPPE on 24th March, 1945.

(e) Telephones, and all other public services were put out of action.

(f)
show in how far

5. RESULTS.

It
except in a few

(c)

few troops were
possibility of
the country.

billboard in the

(b)

plus a figure
Possibly 500?

civilians.

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bombed towns
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railway system

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Sheds due to

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these lines

DORTMUND
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1945, and was

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to them, day

(f) None of the towns were defended for long, but there is insufficient evidence to show in how far this was due to the bombing and how far to the general situation.

5. RESULTS.

It was NOT possible to separate the effects of one day's bombing from that of another except in a few instances. The results are therefore considered as a whole.

(a) Morale effects.

No definite evidence of morale effects was obtainable.

However, it is clear from the statements of prisoners and civilians that very few troops were stationed in the bombed towns. Apparently the German Command had foreseen the possibility of a bombing programme and had distributed its reserve units in various farms about the country.

15 Prison Grenadiers and 116 Panzer Division, the principal reserve formations billeted in the area, offered fairly stubborn resistance to 30 Corps and 9 US Army respectively.

(b) German Casualties due to Bombings.

1925 civilians dead.

49 soldiers dead.

plus a figure for DOCHOLT which had not been determined by the time the mayor was interrogated. Possibly 500?

Other types of casualties were NOT known accurately.

All civilians were emphatic that NO military medical services were used to help civilians.

(c) Destruction of communications (For Map, see Appendix A.)

(i) Telephone.

By 24th March, 1945 there was NO telephone communication in any of the bombed towns. This was due to the destruction of the wiring system. In some cases exchanges had received direct hits.

(ii) Railways.

For some time prior to opening of operation PLUNDER no movement on the railway system could be made in daylight.

By 24th March, 1945, the railway system had been rendered practically useless.

The line from LAMUS to DORFEN and DOCHOLT was blocked in all three towns, and at several places in between.

COESFELD yards were completely destroyed on 22nd March, 1945, 500 trucks and 10 engines were put out of action. A further 30 engines were immobilised in the Engine Sheds due to line cuts. The map at Appendix A shows that this at once blocked five lines.

The line COESFELD - DORFEN was also blocked in the station yards of the latter town.

According to local civilians the Germans were not able to bring any of these lines into use again after the bombing.

The trunk line from MÜNSTER to WESSEL was blocked at DUMEN, HALTEN and DORFEN HOLSTENHAUSEN, but the Germans succeeded in a short time in clearing at least one through line inside 24 hours, and the line was being used up till the time of capture of the towns, but at only a small fraction of previous capacity. The line could not be used on 24th March, 1945, and was not used beyond DORFEN.

(iii) Roads.

The Germans had only very limited numbers of motor vehicles and, according both to P.O.s and civilians, were largely dependent on horse-drawn transport, frequently provided by requisitions from local farmers. Thus the road network was relatively unimportant to them, despite the destruction of the railways.

Two main trunk routes cross the area from N.E. to S.W. N 67 from COESFELD and DORKEN to DOCKOLT. N 51 and N 58 from MÜNSTER via DULMEN and DORSTEN to WESSEL.

According to civilians, up to 21st March, 1945, these roads were the main German road supply routes for that part of the RHINE front selected for the assault in BLANDER.

Also of importance was the NORTH - SOUTH route N 70 from RAINE via AHAUS, DORKEN, RAESFELD and GRUNEN to WESSEL.

Of these, N 67 remained usable by by-passing DORKEN and DOCKOLT, the centres of which were completely blocked, but COESFELD was more difficult to by-pass, and the route N 67 appears to have been abandoned in favour of a route by-passing DORKEN to the SOUTH, and passing through HEIDEN and GROSS REKKEN to LETTE, where the Germans established the equivalent to a Forward Maintenance Centre. The bombing of GROSSREKKEN was not effective in blocking this route, imposing however a delay of half a day on the Germans.

N 51 remained open except at DULMEN, which was however by-passed to the NORTH.

The Germans found a useful alternative route via HERFELD - LUDEN - KL. REKKEN - LENDACK - ERLE - RAESFELD. The bombing of RAESFELD did not block this route.

N 70 was so blocked at all the main towns on the route, particularly STADTLOHN, that an alternative route via VREDEN, WINTERSWIJK, HALTEN and ISSELBURG was used exclusively.

The alternative route was blocked by the bombing of VREDEN on 22nd March, but a way was cleared for single line traffic in about 4 hours. This road was extensively used by the Germans during their retreat.

SOUTH of the LIPPE the road F 57 from MÜNKE was completely blocked at DORSTEN and all traffic by-passed DORSTEN on an alternative route via KIRCHHELLEN & 4334.

24th Mar

Bocholt

Dulmen

Dorsten

Dorsten

Coesfeld

Dorken (R)

" (C)

" (C)

" (C)

Haltern (C)

" (C)

" (C)

Ahaus (C)

" (C)

" (C)

Vreden (C)

Stadtlorn (C)

" (C)

" (C)

" (C)

" (C)

Raesfeld (C)

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APPENDIX B
ATTACKS ON "PLUNDER" TARGETS.

Following is a list of attacks on "Plunder" targets from 21st March, through 24th March, as reported by A-3 in "Daily OPS/INT. Summaries."

This does not include attacks on flak positions near the targets listed.

Target	Date (Mar)	Air Force	A/C	Tons
Bocholt (Rly/C)	21	2nd TAF	29	57.5
" (Town)	22	RAF-BC	100/98	(176.8 HE (305.6 IB
" "	22	IX-BD	0/6	12.78
" "	22	2nd TAF	0/6	"
" "	23	2nd TAF	6	10.7
" "	24	IX-BD	39/29	38.8
Dulmen Morning	21	IX-BD	154/123	236.5
" Afternoon	21	IX-BD	0/4	8
" "	22	RAF-BC	130/122	(272.6 HE (119.4 IB
Dorsten Holstarhausen				
Dorsten (Town)	21	2nd TAF	28	55
" "	22	RAF-BC	124/110	(376.6 HE (6.1 IB.
" (Hqs/Camp)	22	VIII AF.	74/74	109.1 GP
" (Town)	22	IX-BD	0/6	10.3
" "	23	IX-BD	0/17	34
" (Com-Can.)	24	IX-BD	27/30	32.4
Coesfeld Morning	21	IX-BD	185/163	286.5
" Afternoon	21	IX-BD	0/15	30
" (Com-Can.)	22	IX-BD	174/132	243.98
" (H/Y.)	23	VIII AF	147/145	(409.5 HE 38.5 IB
" (Town)	24	IX-BD	0/5	10.40
Dorken (Rly/C.)	21	2nd TAF	34	46
" (C.C.)	22	IX-BD	89/122	187.64
" (C.C.)	23	IX-BD	110/85	128
" (C.C.)	24	IX-BD	40/40	59.75
Haltern (C.C.)	21	IX BD	65/43	86
" (C.C.)	22	IX BD	105/49	85.99
" (C.C.)	23	IX BD	46/37	39.5
Lhous (C.C.)	21	IX BD	42/26	52
" (C.C.)	22	IX BD	67/63	80.55
" (C.C.)	23	IX BD	30/22	30.8
Vreden (C.C.)	21	IX BD	86/67	129.5
Stadtlohn (Town)				
Morning	21	IX BD	0/3	6
" (C.C.)				
Afternoon	21	IX BD	95/92	184
" (C.C.)	22	IX BD	69/37	84.21
" (C.C.)	22	IX BD	0/11	26.62
Roesfeld (Town)	22	2nd TAF	21/11	24
" "	23	2nd TAF	20	28.3
" "	24	2nd TAF	48	9.1 (Frog)
Arholt (town)	21	2nd TAF	18	21.75
" (Town)	22	2nd TAF	21/11	24
" "	23	2nd TAF	19/16	14.4
Isselburg (Town)	21	2nd TAF	18	24
" (Town)	22	2nd TAF	12/6	12
" (Town)	23	2nd TAF	36/35	61

58.

Target	Date (Mar)	Air Force	M/G	Tons
Sudichan (C.C.)	22	IX BD	72/46	66.75
" (C.C.)	23	IX BD	42/41	60.5
Gross Raken (C.C.)	22	IX BD	82/39	39.6
" " (C.C.)	23	IX BD	37/34	66.0
Mulfan (C.C.)	22	IX BD	79/77	89.75
Rhecs (Town)	22	IX BD	0/6	12.78
" (Town)	23	2nd TLP	18	32

Appx. A



Area affected by softening up
bombing prior to operation Plunder.

Legend

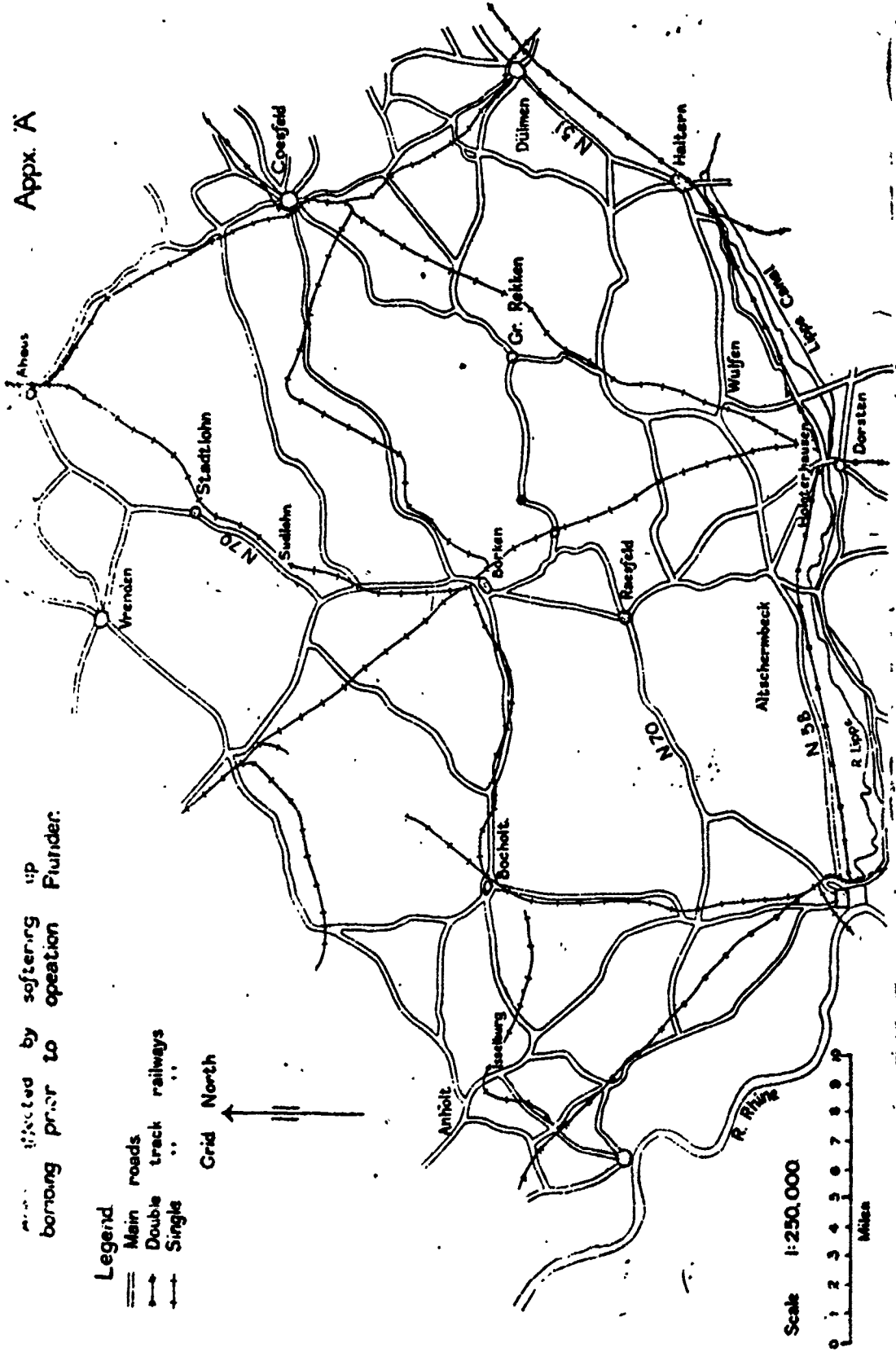
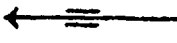
== Main roads
+ + Double track railways
+ Single track railways

affected by softening up
bombing prior to operation Flunder.

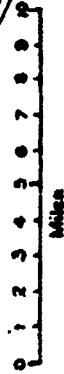
Legend

- == Main roads
- == Double track railways
- Single track railways

Grid North



Scale 1:250,000



MEMORANDUM NO. 3.

INTERDICTION OF ROAD COMMUNICATIONS BY BOMBING.

1. At the commencement of the German retreat from the FALAISE Pocket some calculations were made on the bombing effort required to deny the use of roads to the enemy. The calculations were based upon the results on roads of a number of bomb-falls in earlier operations in NORMANDY, and the validity of the principles on which they were based was confirmed by studying the effectiveness of some attempts at interdiction that were made along the rivers TOUQUES and RISLE.

2. It was found that to establish a line of interdiction with the least effort, the line should be chosen along a river. This was not because interdiction could easily be produced by breaking the bridges, but because numbers of roads converged and joined near to river crossings, so that the total number of roads that had to be stopped was a minimum.

3. Unless a very large effort is made, a bridge cannot be destroyed with any certainty on a particular date whereas provided an adequate effort is made a road can be interdicted for a limited period with reasonable certainty.

4. The following table of the crater densities required to block roads in different types of country has been prepared by combining results actually seen in NORMANDY with what might be expected on theoretical grounds. Times to clear are based on times actually taken and on estimates.

Type of Country	Crater Density (bombs per acre)	Minimum time to clear	Remarks
Heavily Built-up town	5	48 hrs	The classic example is the town of CAEN which was very heavily built-up.
Village or suburban area	15 - 20	24 hrs	There are numerous examples of this type.
Close or very wet country (where not possible to move off roads)	10	12 hrs	This density should provide 10 - 15 craters in the length of road attacked.
Open country (where it is possible to move off roads)	(25)	Even with this density it is very likely that a way round will be found.	

5. The time to clear depends very much upon circumstances. It has been assumed above that either mechanical equipment such as a bulldozer is available or a considerable labour force. In or near villages labour may be readily available and it is known that the Germans have impressed civilian labour to clear roads.

6. It appears that in general interdictions can best be effected in close country at points remote from towns and villages. Apart from heavily built up towns, interdictions in close country are the most economical in bombs, and remoteness should delay the start of work to clear the obstruction.

7. From available details of the accuracy of tactical bombing, it appears that the numbers of aircraft to produce a given crater density about the aiming point are as follows:

Heavy night bombers	-	20 times the crater density.
Medium bombers	-	10 times the crater density.

The smaller bomb load of the mediums is more than offset by their greater accuracy. The advantage of the mediums is however lost when a number of roads or the streets of a town, can be covered by heavy bombers using one aiming point only, where the mediums would need to use several.

CHAPTER 3

FIGHTER AND FIGHTER-BOMBERS AGAINST H.T. AND TANKS

CONTENTS

Investigation of an Air Attack on a German Column near La Balue. (Report No. 3)

Air Attacks on Enemy Tanks and Motor Transport in the Mortain area, August, 1944. (Report No. 4)

Enemy Casualties in Vehicles and Equipment during the Retreat from Normandy to the Seine. (Report No. 15)

Air Attack on Enemy Armour in the Ardennes Salient. (Joint Report No. 1)

REPORT NO. 3.

INVESTIGATION OF AN ATTACK ON A GERMAN COLUMN NEAR LA BALEINE.

I. GENERAL SITUATION.

As a result of the American break-through (Operation CODRA), a retreating German column was attacked during the afternoon of 29th July, by Rocket-firing Typhoons of 121 Wing, 83 Group and American Thunderbolts carrying 500 lb bombs. 99 sorties were made by 121 Wing.

It is not possible to state how long this particular German unit had been fighting as its name is not known but, on the evidence of its abandoned equipment, it was a mixed column containing Panther tanks, S.P. guns, armoured troop carriers, lorry-drawn 4 tk guns and howitzers, Pupachen rocket guns, armoured and staff cars.

According to local inhabitants the column was passing throughout the day and was joined by troops from the vicinity who looted as they left.

II. TERRAIN.

The path of the German retreat in the area under consideration is shown in the appended map. It lay through country well dissected by deep narrow twisting valleys, much of the area being heavily wooded.

The side road which was used leaves the main road about 1 kilometre south of ST DENIS-LE-GAST (MR 315443) and descends rapidly to LA BALEINE where the River SIENNE is crossed. This road has a steep wooded cliff on one side and a sheer drop to the river on the other so that it was impossible for vehicles to draw off the road.

At LA BALEINE (MR 323427) the road crosses the river by a bridge which had been sufficiently damaged by 500 lb bombs dropped by Thunderbolts to prevent heavy traffic from crossing.

After crossing the bridge the road turns south closely following the course of the river and a few feet above water level. On the east a densely wooded hill rises abruptly from the roadside making manoeuvre impossible. Half a mile down this stretch of the road (at point 'A' on the attached map) the road twists sharply away from the river up a side valley. At this corner the road is well exposed to air observation and attack.

For the next quarter of a mile along the road as it climbs up towards the north-east there is fairly thick screening from the air, but just before the cross-roads (C) there is a short stretch that is much more open. At C the route followed by some, and perhaps all, the Germans turns south and continues to climb between high banks through farmland and orchards. At several points along this stretch there are gaps in the road banks giving access to the fields.

To the east of C abandoned and destroyed vehicles were found along a fairly level road through fields with trees lining all the hedges and along a similar one turning south from it. As these roads are well outside the area attacked by the Typhoons the route was not examined further.

III. DETAILS OF DAMAGE.

Note: Letters and numbers refer to points marked on the attached map.

Point 1. Two camouflaged Panthers were placed in an orchard and facing the main road from ST. DENIS-LE-GAST. They were probably in this position for several hours as there were signs that meals had been cooked. Craters caused by 500 lb bombs were seen within 50 yards of the tanks; these are thought to have been dropped by American Thunderbolts which are known to have been operating in the area. The tanks had not been hit but the crews apparently failed out, set fire to their tanks, and destroyed one of the guns by leaving an H.E. round in the chamber.

Point 2. A 75 mm S.P. with thick concrete reinforcement of the turret was found pushed off the road by a bulldozer. This S.P. was undamaged but 5 strikes from the air (cannon or machine gun) had made "cups" in the concrete. There was a 500 lb bomb crater 35 yards away. If the S.P. had been left to block the road it would have been set on fire by its crew; as it was not, the presumption is that it was abandoned in haste.

Points 3 and 4. Round about points 3 and 4 a number of 500 lb bomb craters were observed. At point 3 a Panther had been left on the road in perfect condition with full complement of petrol and ammunition. At point 4 another Panther was found undamaged in every respect. If the commanders of these tanks had wished they could have travelled down the right hand bank of the stream and attempted a crossing as Shomons later succeeded in doing.

62.

All along the river bank between point 3 and the bridge at LA MEINE an assortment of SD vehicles, all burnt out and beyond recognition, had been pushed off the road by bulldozers. A fair estimate would be eight vehicles (lorries and cars).

On the east side of the bridge a wrecked German saloon car was found at the foot of a 10 foot bank.

Point 5. A Panther was found to have been hit in the engine by a rocket projectile. It had brewed up.

Between the bridge and point 5 were a lorry towing a Howitzer and a saloon car; all three were completely wrecked and burnt out. R.P. strikes on the ground were numerous in this area.

One hundred yards south of Point 5 was another lorry towing a Howitzer; the lorry was a charred wreck but the Howitzer seemed to be undamaged.

4. Just north of corner A, by the edge of the wood, was a burnt out lorry which had been towing a 50 mm A tk gun. A Pupschen rocket gun was also found at this point; both guns were undamaged.

At corner A, where many R.P. strikes were observed, was a Panther which had not been hit by anything and appeared to have been abandoned intact. Also at this corner were 5 armoured troop carriers (half-tracks) which were all completely destroyed. R.P. was definitely responsible in one case and probably in all, but the damage was too great to allow accurate estimation.

Point 6. A troop-carrying lorry was found burnt out; R.P. strikes were numerous in this area and the lorry was probably destroyed by this means.

Point 7. A Mark IV Special was found completely wrecked and pushed off the road; the great number of strikes in the immediate vicinity would suggest that it had been hit by R.P.

A little further up the road were a saloon car and a lorry, both completely destroyed and burnt.

Point 8. A Panther was found wedged between a barn and a high bank; it also had stones in the tracks. A broken towing hook and tracks on the ground showed that another tank had tried to tow it out and failed. This Panther had received no damage of any sort but was set on fire by the crew in the presence of the farmer.

In an orchard opposite point 8 was a Volkswagen which had been hit in the engine by cannon or machine gun fire from the air.

A few yards up the road from Point 8 an armoured car (captured from the Americans and painted with German markings) had brewed up as a result of a hit in the engine. Although this looked rather like R.P. damage there were no strikes or debris anywhere near the point where the fire took place.

Point 9. A lorry was found burnt out; again there were no signs of rocket strikes.

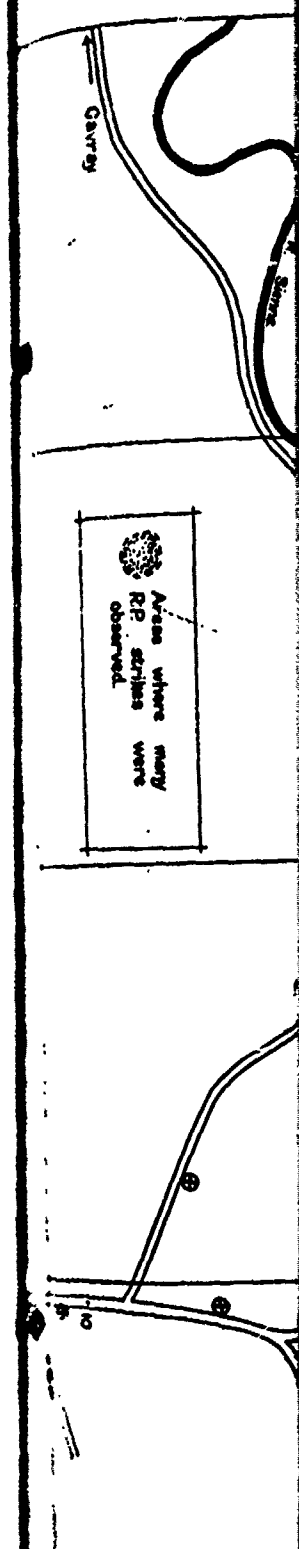
In fields just off the road, at points marked s on the map, there were cars abandoned in various states of destruction. None of these had been hit by R.P.

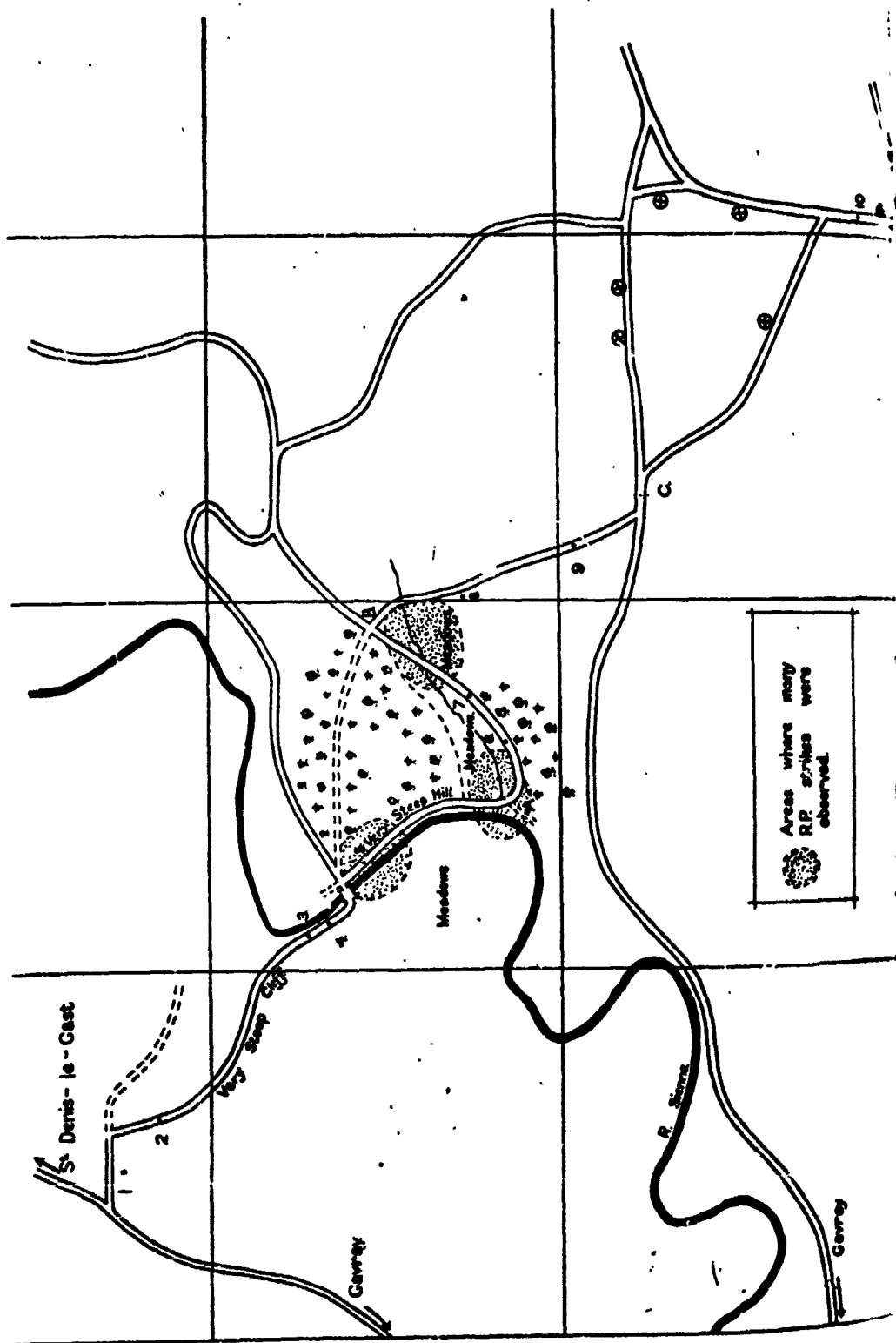
Point 10. A 75 mm S.P. gun was found burnt out but with no visible sign of the cause of the fire. A few yards away was a 50 mm A tk gun, the breech of which had been deliberately destroyed.

Point 11. A Panther had an AP hit in the engine and another on the left driving sprocket; the left track was off. The gun had its barrel completely destroyed in a manner that suggested deliberate destruction on the part of the crew. This Panther had brewed up but the tyres were intact. It was a long way from the nearest area where rocket strikes were observed.

Throughout the area no German graves were found and only one German corpse, said by local inhabitants to have been that of a sniper shot subsequent to the passing of the column. It is possible that American forces had taken the dead to a distance to bury them but no proof or disproof of this could be found.

Many French civilians were examined in the area and their evidence confirmed the statements made in this report.





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IV. SUMMARY OF DAMAGE.

The details of damage are summarised in the following table:-

	Destroyed by					Aban- doned	Totals		
	R.P.	possibly R.P.	unknown shells	unknown causes	crew				
Panther	1	-	1	-	3	3	8	1) Armour
Pz Kw Mk IV Special	1	-	-	-	-	-	1	1	
Armoured Cars	-	1	-	-	-	-	1	17	
Armoured Troop Carriers	5	-	-	-	-	-	5	5	
75 mm S.P.	-	-	-	1	-	1	2	2)
90 mm A tk guns	-	-	-	-	1	1	2	2) Guns
Howitzers	-	1	-	-	-	1	2	3	
Pupachens	-	-	-	-	-	1	1	1	
Lorries	-	-	-	8	-	-	8	18)
Cars	-	-	-	10	-	-	10	10	
Totals:	7	2	1	19	4	7	40		
	33								

Destroyed

Aban-
donedNote to Summary.

The high proportion of abandoned Panther tanks to the total number of such tanks should be noted.

The M.T. was so mangled that identification of the causes of destruction was impossible; in consequence, the "unknown causes" total has been unduly loaded. It would probably give a truer picture of events if the M.T. losses were spread over all the table in the same proportion as the other losses.

V. CONCLUSIONS.

There can be no doubt of the success of the attack, the detailed results as stated above being compatible with a high degree of demoralisation resulting in an abandonment of vehicles. It should also be noted, as further confirmation of demoralisation, that in spite of material destruction no German graves were found in the vicinity.

REPORT NO. 4.

"AIR ATTACKS ON ENEMY TANKS AND MOTOR TRANSPORT IN THE MORTAIN AREA, AUGUST 1944"TACTICAL SITUATION.

1. At the beginning of August, 1944 the Allied armies had begun their break-out from the Normandy beach-head; the British and Canadians were pushing southwards from CAUMONT and CAEN, and the Americans, having driven down the west coast of Normandy, were rapidly moving eastwards and northwards thereby threatening to surround the German armies in Normandy.

2. The following diary of events in the MORTAIN area illustrates the circumstances in which the air attacks took place:-

- 6 Aug. During the day the enemy counter-attacked strongly against 30 Inf. Div in the MORTAIN area and they re-occupied the town.
- 7 Aug. In the early morning the enemy launched a strong armoured attack in the MORTAIN area. Although small numbers of tanks penetrated U.S. positions at a few points, the situation was soon under control. During the day large enemy concentrations of tanks and M.T. were attacked from the air with excellent results.
- 8 Aug. Little change reported. Enemy still exerted pressure in the MORTAIN area.
- 9 Aug. The enemy continued his efforts to break through to AVRANCHES with the greater part of his armoured formations. Although the enemy held MORTAIN, 4, 9 and 30 Inf. Divs. with 2 and 3 Arm. Divs. resisted strongly on the high ground to the north, west and south of the town. 35 Inf. Div. made some progress with an attack SW of MORTAIN.
- 10 Aug. SE of MORTAIN 2 Arm. Div. made progress, reaching a point 6 miles east of the town. Heavy concentrations of enemy armour (5 divisions) remained in the MORTAIN - DOMFONT area but no large scale counter-attacks developed. 4, 5 and 30 Inf. Divs. continued to meet heavy opposition.
- 11 Aug. The enemy withdrew from the MORTAIN salient and the town was re-occupied by troops of VII Corps. North and south of the town all divisions advanced against little or no opposition.

AIR EFFORT.

3. Bad weather prevented flying in the morning of 7th August but arrangements were made for the Second Tactical Air Force to come to the assistance of the IX U.S. Air Force as soon as conditions permitted. The weather cleared quite suddenly about mid-day, between which time and dusk 294 sorties were flown by Typhoons of 2 T.A.F. in support of the American ground forces in the MORTAIN area. Although, owing to their many other commitments in France, the IX U.S.A.A.F. only flew some 200 sorties to MORTAIN that afternoon, they continued their attacks over the next three days and flew 441 sorties in all.

4. Conditions on the afternoon of 7th August were ideal from the pilot's point of view as no opposition was encountered from enemy aircraft nor, till late in the day, was there any appreciable flak reaction. Under cover of mist and low cloud the Germans seemed to have neglected all normal precautions and, when the weather cleared, they were sighted in large numbers head to tail in narrow roads and lanes. The pilots reported that they were able to go in very close to attack, rockets being fired at 1000 yards range and cannon and machine guns from even closer. Claims made by the pilots during the MORTAIN Battle (7th - 10th August) are shown in Table I below.

TABLE I.

PILOTS' CLAIMS

Armour	Destroyed	Probably Destroyed	Damaged	Total
2 T.A.F.	84	35	21	140
IX U.S.A.A.F.	69	8	35	112
Totals	153	43	56	252
M.T.				
2 T.A.F.	54	19	39	112
IX U.S.A.A.F.	94	1	21	116
Totals	148	20	60	228
GRAND TOTAL (ARMOUR & M.T.)	301	63	116	480

GROUND INVESTIGATION

5. Between 21 Army Group and battle area around compared and collated

6. It was because, although the latter, American pilots dropped some were not considered the air have been

TABLE II.

Type of Vehicle
Panther tank
Mark IV tank
SSP. Gun
Arm. Tp Carrier
Arm. Car
Arm. Recovery
Total of all armour
Car
Lorry
Ambulance
Motor cycle
Total of all M.T.
GRAND TOTAL (ARMOUR & M.T.)

7. Tanks in Table II above can hardly be considered such claims are

8. Similar indirect victims comparing pilots

9. It is particularly as such attack and all the "Unknown" 36 and M.T., 12 the air forces.

10. The or several days it confirmed by the plotting the post this means.

11. The of the large dis numbers found. burnt out and many prisoners established that

GROUND INVESTIGATION.

5. Between 12th August and 20th August members of the Operational Research Sections from 21 Army Group and Second Tactical Air Force conducted separate ground investigations of the battle area around MORTAIN (see map at Appendix A). The results of the two investigations were compared and collated to produce the figures shown in Table II.

6. It was not possible to discriminate between the victims of IX U.S.A.F. and of 2 T.A.F. because, although the 500 lb bomb was the favourite weapon of the former and the rocket that of the latter, American pilots fired some 600 rockets in the course of these attacks and British pilots dropped some bombs. The respective merits of the 50 calibre M.G. and the 20 mm cannon were not considered and all vehicles that had been destroyed by small projectiles fired from the air have been classed as "Cannon or M.G."

TABLE II. RESULTS OF GROUND INVESTIGATION.

Type of Vehicle	Destroyed By			Air Total	Abandoned (Intact)	Destroyed by crew	Destroyed by U.S. Army	Unknown Causes	Total Vehicles found
	R.P.	Cannon or M.G.	Bomb						
Panther tank	5	-	1	6	6	4	14	3	33
Mark IV tank	2	-	1	3	1	-	5	1	10
S.P. Gun	-	-	-	-	-	-	1	2	3
Arm'd Tp Carrier	7	4	-	11	1	-	3	2	23
Arm'd Car	1	-	-	1	-	-	3	1	5
Arm'd Recovery Veh	-	-	-	-	-	-	1	-	1
Total of all Armour	15	4	2	21	8	4	29	13	75
Car	2	2	-	4	-	-	4	3	11
Lorry	-	6	-	6	1	1	2	20	30
Ambulance	-	2	-	2	2	-	-	1	5
Motor cycle	-	-	-	-	1	-	1	2	4
Total of all H.Q.	2	10	-	12	4	1	7	25	50
GROUND TOTAL ARMOUR & HT	17	14	2	33	13	5	36	41	125

7. Tanks and other vehicles classed as "Abandoned" have not been included in the Air Total in Table II above because, although they were probably abandoned as a result of air attack, they can hardly be considered to have been among those which the pilots claimed to have destroyed as such claims are generally supported by mentions of fire or explosion.

8. Similarly those enemy vehicles listed as "destroyed by crew" may be regarded as indirect victims of air attack but cannot justifiably be taken into consideration when comparing pilots' claims with what was found on the battlefield.

9. It is most unlikely that all of the unknown causes were due to air attack, particularly as many of them were found at considerable distances from the nearest signs of such attack and as ground forces were also fighting fierce battles in this area. However, if all the "Unknown causes" are added to the air totals, the resultant figures (Armour, 21 + 13 = 36 and H.Q., 12 + 25 = 38) are still only about a quarter of the numbers claimed as destroyed by the air forces.

10. The area was not very extensive and as two teams were searching it over a period of several days it is not considered that any appreciable number of vehicles was missed. This is confirmed by the fact that one of the investigators flew low over the area in an Auster, plotting the positions of vehicles seen from the air; no fresh vehicles were discovered by this means.

11. The efficiency of the German recovery system has been put forward as an explanation of the large discrepancy between the number of vehicles claimed to be destroyed and the actual numbers found. Tanks and lorries that are destroyed as a result of air attack are almost always burnt out and would not be worth salvaging unless time and labour were both very plentiful. Many prisoners have been questioned on the subject of the recovery of tanks and it has been established that burnt-out tanks are never salvaged. In addition it has been ascertained that,

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contrary to certain statements made about the MORTAIN battle, very little recovery was done in this part of Normandy at the time, in fact the repair and recovery teams were already pulling out of Normandy when the battle of MORTAIN was at its height. In any case before considering the recovery of the "destroyed" tanks and M.T., the "probably destroyed" (43 tanks and 20 M.T.) and the "damaged" (56 tanks and 60 M.T.) must have presented the recovery organization with a large task without counting any that may have been damaged by the ground forces.

12. At Appendix B is a list of the vehicles found by members of No. 2 Operational Research Section together with the causes of destruction where it was possible to assess them. No similar record is available for the vehicles which were examined only by members of O.R.S/2 T.A.P.

CONCLUSIONS.

(a) The attacks by the Allied Air Forces had a considerable effect on the enemy's unsuccessful counter-attack at MORTAIN.

(b) The number of vehicles claimed by the pilots as "destroyed" was about four times the actual number discovered.

(c) A number of vehicles, though not claimed by the pilots, were lost to the enemy by "indirect" air action (i.e. abandoned or destroyed by the crew).

APPENDIX B.

1. Road JUVIGNY LE THEATRE to ST. BARTHELEMY.

At pt 565145.

2 PANTHERS.

(a) A.P. shot above track on LHS of hull penetrated and killed some of crew. Gun, tracks, engine and petrol all O.K. No fire. Abandoned after A.P. hit but probably driven off road first.

(b) 105 mm HE 7 strike 2 ft up from hull on LH rear corner of turret. Fragments damaged cupola and periscopes; also top hull plate torn (L shape 10" x 6") just below strike; engine air louvers damaged.

Also 75 AP hit through bogies on LH side. Engine O.K. petrol O.K., gun O.K. Deep scoop by 75 AP on rear. Abandoned by crew unharmed: no bodies, no gore. There were 4 R.P. strikes in field on other side of road and one on this side hit tree at roadside.

Next field, same side of road.

2 PANTHERS.

(a) No visible sign of damage. Petrol, engine, tracks and gun all O.K. Even sights left on gun. Abandoned undamaged.

(b) Hit by 75 A.P. on LHS just below turret in ammunition storage. Brewed up. Also hit on RH track and sprocket. None of these hits could have been from air.

Field north side of road, same place.

3 PANTHERS. 1 ARMED CAR. 1 ARMED TP CARRIER.

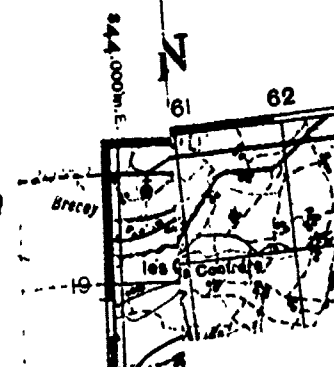
(a) Panther received slanting blow into track and bogies on RHS. Definite A.P. hit as proved by debris but poor explosion as shown by small damage. Everything else in the tank quite O.K.

(b) Panther received 4 hits from 75 AP (3 scooped and 1 penetrated) on underside of front, almost belly. This can only be exposed when climbing bank. Terrific brew up yet tyres on LHS untouched.

(c) Panther had 4 75 A.P. scoops on front glacis plate. Gun, engine, petrol and tracks all O.K. Deserted intact.

(d) Armed Car. R.P. crater and debris below RH front wheel; explosive forced upwards and inwards. Brewed up.

(e) Armed Tp Carrier had 105 mm AP hit on LHS and was completely brewed up.

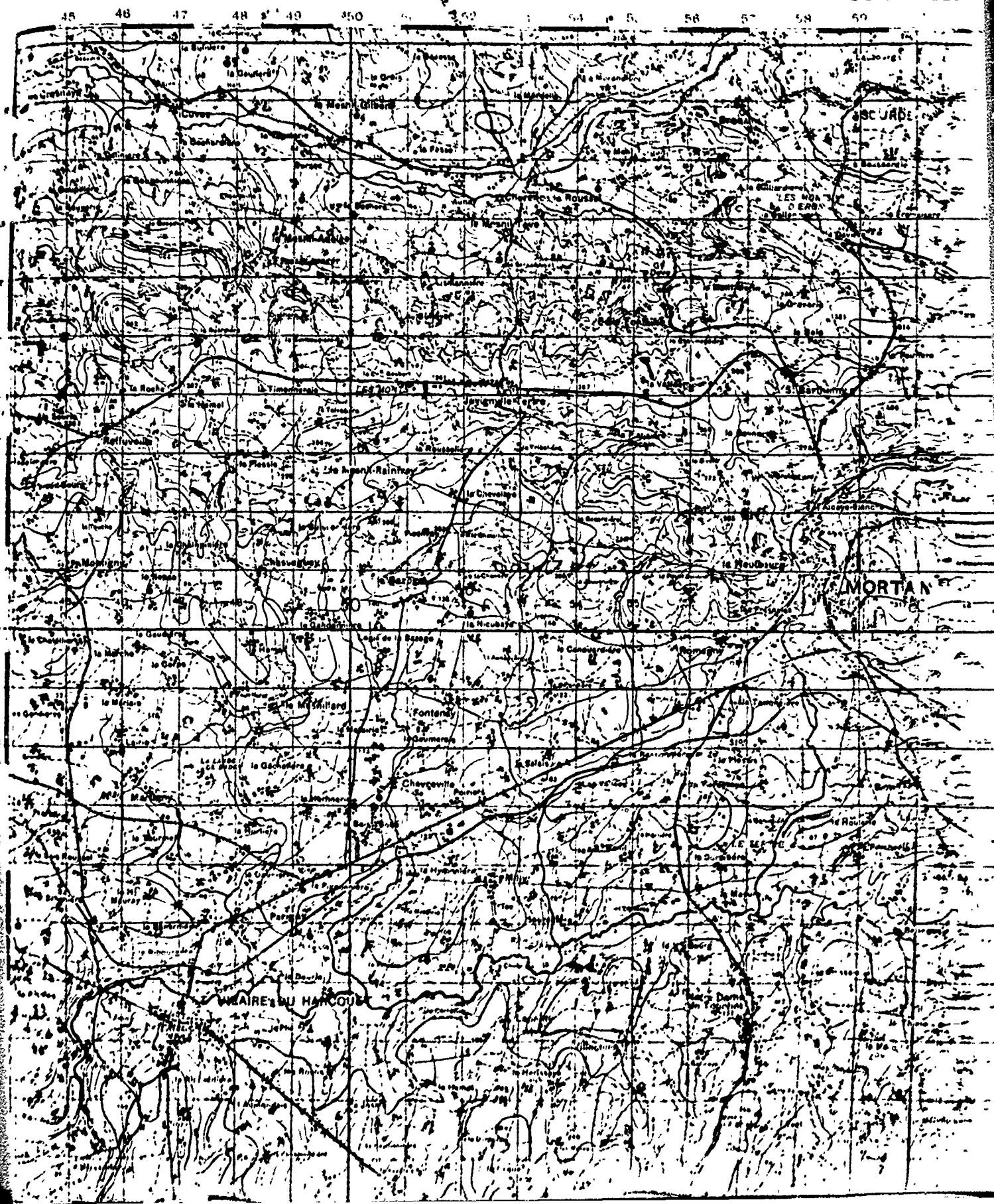


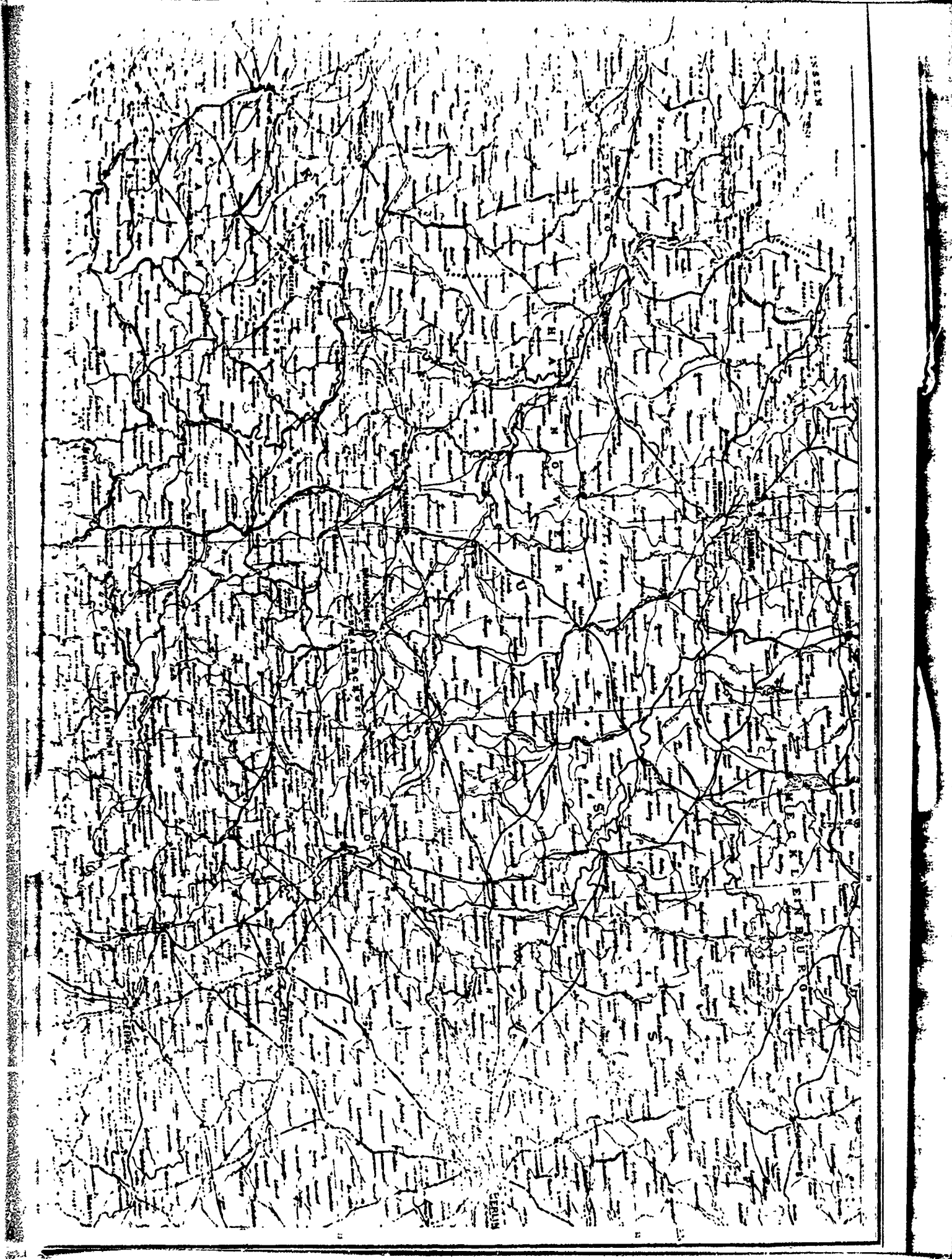
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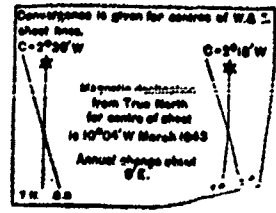
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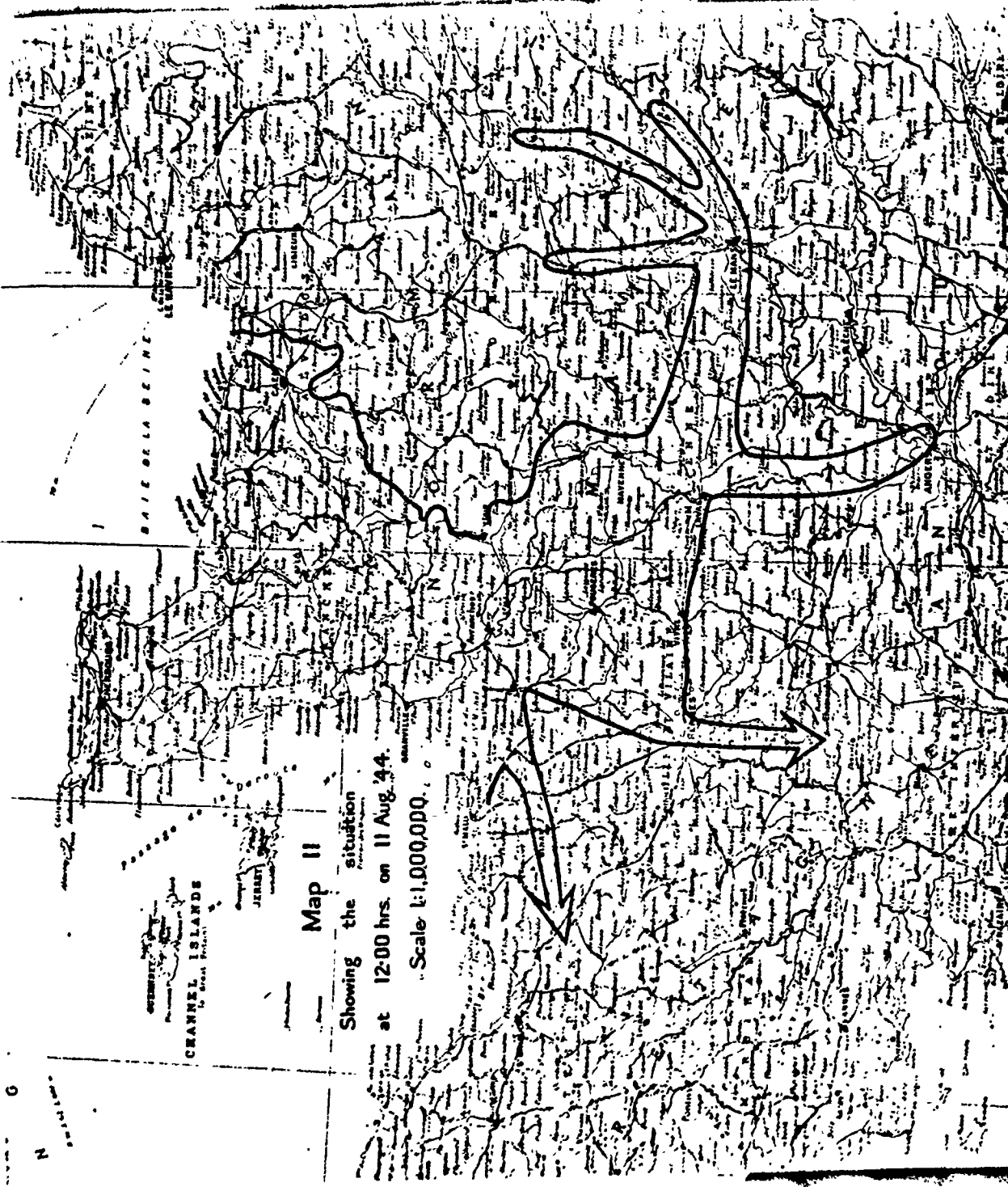
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GRANTVILLE 7/26/75	WIRE 8/7/5	FLIES 10/7/5
BRANCHES 8/1/5	MORTAIN 8/2/5	DESPICHT 7/8/1
ANTHAIN 8/2/5	LANDIVT 8/2/4	AMCO-100 7/8/5

GRANTVILLE 7/26/75	WIRE 8/7/5	FLIES 10/7/5
BRANCHES 8/1/5	MORTAIN 8/2/5	DESPICHT 7/8/1
ANTHAIN 8/2/5	LANDIVT 8/2/4	AMON-100 7/8/5

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Map II

Showing the situation

at 12:00 hrs. on 11 Aug. '44.

Scale 1:1,000,000.

CHANNEL ISLANDS
to West Point

BAIE DE LA BEINE

JERSEY

On N side of road, few yards further east.

PANTHER. R.P. strike under rear had blown petrol tank and caused brew up.

At point 568147 in lane.

PANTHER with two huge holes in turret from above. Also hit on leading edge of front glacis plate (probably RP). 2 75 AP accepts one on glacis and other on mantlet. Major damage (holes in turret) might have been RP but several bomb craters (500 lb 025 sec delay) within 15 yds suggest possible direct hit by bomb. Complete write-off.

Few yards east along road.

ARMED TP CARRIER complete wreck as gun exploded and blew side off. Brew up from unknown causes.

Other side of road, same ref.

PANTHER. RP strikes all along road but bazooka hit on LHS into gun storage space caused brew up. Angle of attack suggests infantrymen fired from high bank on roadside at almost point blank range - could have been after desertion.

30 yds further east.

2 ARMED TP CARRIERS, 1 PEOPLES CAR (AMPHIBIOUS).

(a) Armed Tp Carrier with R.P. craters all round it. Complete wreck; looks like it hit on RH rear corner.

(b) Armed Tp Carrier with downward strike through side armour and then floor. Almost definitely R.P.

(c) Peoples Car brewed up from unknown causes.

At point 570148.

2 ARMED TP CARRIERS.

(a) Direct hit RP. LH near burned out.

(b) RP hit from RH corner. Brew up.

South side of road.

PANTHER with AP strike on turret. Brewed up.

Orchard W of cross roads.

AMBULANCE and ARMED TP CARRIER.

(a) Ambulance peppered with fragments and abandoned.

(b) Armed Tp Carrier unknown causes brewed up.

At cross roads 575144.

PANTHER; holes in floor over track which suggested downward attack but no possible entry for hit, therefore caused by explosion of min. Unknown causes for brew up (possibly by crew).

2. Road from CHERENCE LE ROUSSEL via ST. BARTHELEMY to MORTAIN.

At point 556157.

ARMED TP CARRIER AND LORRY.

(a) Armed Tp Carrier: 3 R.P. strikes very near; complete blow up and brew up; possibly R.P.

(b) Lorry completely wrecked by causes unknown.

Slightly east of 556157.

Peoples Car (Amphibious) completely destroyed by unknown causes. No R.P. strikes near.

SS.

In BELLEFONTAINE.

Open Command Car with Rangefinder. 2 R.P. cretars 2 yds from rear and many more in garden nearby. Browed up probably R.P.

East of BELLEFONTAINE.

ARMED TP CARRIER AND LORRY.

(a) Armad TP Carrier completely destroyed by unknown causes but RP strikes in neighbouring field.

(2) As above.

Slightly further south.

2 PANTHERS.

(a) 75 L.P. hit in rear of hull caused brow up. Tracks O.K.

(2) Hit on RH sprocket. Abandoned and set on fire by crew.

ARMED TP CARRIER: direct hit by unknown shell centre of LHS. Brow up.

At point 580138.

PANTHER: no visible cause of damage though bazooka and bits all around. Burnt out in entrance to lane; possibly set on fire by crew.

At same spot.

Behind PANTHER in lane was a lorry quite burnt out and partly exploded. Destroyed by crew.

3. Road MORTAIN to BARENTON.

Note: No signs of RP strikes along this road. Some HE, but in general this main road was avoided by the Germans.

PANTHER wrecked from unknown causes at 619076.

At 625371.

An 88 mm gun riddled with HE fragments and end of barrel blown off.

Between there and BARENTON.

4 lorries destroyed by unknown causes; probably HE or cannon fire from air.

At point 620073.

Panther on its side. Unknown shell hit (HE ?).

4. Road BARENTON to GER. No R.P. strikes seen along this road.

88 mm L/T gun at 678066 abandoned.

4 lorries burnt out between BARENTON and LE CUE ROCHOUX.

At point 693095.

2 75 mm S.P.

(a) L.P. shot on LHS of gun shield. Brow up.

(b) Unknown hit on RHS. Brow up. Blow up and harrier gun away from chassis. Possibly self-destroyed as result of bogging.

On other side of road.

50 mm L/T gun with trail damaged but otherwise intact.

ARMED TP CARRIER (to tow 50 mm L/T). Hole through bottom on RHS. LH wall blown off. Probably HE.

At point 69510

German

Half mile further

ARMED

At 700105.

Petr

And

This

5. GER - MON

At 695137.

German

1 km further

And

Cross-roads at

Dur

1 1/2 km further

And

Lor

At 653124.

Pan

Petrol O.K.

Few yds further

75

Pan

Lor

At pt. 620119

2

1

At 597118.

ARM

One

At 586123.

Hike

On other side

Inc

Arm

6. Road MO

At 587140.

On

1/2 mile further

Lor

At point 695100.

German saloon car riddled with HE fragments.

Half mile further on.

AMRD TP CARRIER gun exploded and blew back off. Front and engine O.K.

At 700105.

Petrol-carrying lorry burnt out and chassis warped by heat.

Another lorry wrecked just near.

This area bombed by 500 lb, one of which made crater across road near second lorry.

5. GER - MONTAIN Road. No R.P. strikes seen near this road.At 695137.

German lorry burnt out. Causes unknown.

1 km further on.

Another burnt out lorry - possibly H.E.

Cross-roads at DIRE FEUGERAY.

Burnt-out lorry.

1 1/2 km further west.

Ambulance) Both destroyed by unknown causes.
Lorry)

At 653124.

Panther in line. RH track very loose. Crew were about to repair when surprised.
Petrol O.K. Gun O.K. Abandoned.

Few yds further west.

75 S.P. (Mk. III chassis) complete blow up with gun separate from body.

Peoples Car abandoned.

Lorry burnt out.

At pt. 620119.

2 lorries burnt out (unknown causes.
1 car wrecked)

At 597118.

AMRD TP CARRIER abandoned with front wheels removed (since).
One dead German on stretcher in back.

At 586123.

Mk. III with 75 mm hit by AP above track on RHS of hull. Jrew up.

On other side of rly.

Another Mk. III (Both completely wrecked
Arm'd Tp Carrier (and burnt out.

6. Road MONTAIN to SOURCEVAL.At 587140.

German lorry burnt out with 500 lb bomb craters very near.

3 mile further N.

Lorry and trailer burnt out.

At LA TOURNERIE.

PANTHER without turret, fitted up as recovery vehicle. Hole on front glass plate exactly like that caused by magnetic bomb. Charred body inside. Burnt out lorry at same spot.

Between LA TOURNERIE and SOURDEVAL.

4 burnt out lorries {
2 H/C and Staff Cars burnt out { all possibly N.E.
Peoples' Car abandoned {

7. Road LA TOURNERIE to ST. CLEMENT.

Pt. 596145.

Mk. III. RH track gone. Hit on rear at RH by unknown shell. Inside O.K.

Pt. 610140.

PANTHER. One bogey damaged. Both tracks off, being towed. Petrol O.K.; abandoned.

R.P. strikes in field each side of road and one on a tree at roadside near PANTHER.

Pt. 620142.

PANTHER 1 barrel gone. Minus tracks; was being recovered. Possibly self-destructed.

Tracked recovery car, full of spare parts, used for recovery purposes. Burnt out on road and towed into field. Causes unknown.

PANTHER brewed up. Gun mantlet thrown forward suggesting demolition.

8. Road LE OUE ROCHOUX - LA CONERIE - BARENTON.

4 burnt out lorries. Causes unknown.

INTRODUCTION.

The prime losses due directly to air weapons.

AREAS COVERED.

The areas the Shambles and

I. The Pools

This is CONDE-SUR-NOIREAU. This area the retreat heavily but increase

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PART I. THE POOLS1. Collective

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REPORT NO. 15.

ENEMY CASUALTIES IN VEHICLES AND EQUIPMENT
DURING THE RETREAT FROM NORMANDY TO THE SEINE.

INTRODUCTION AND PART I.

INTRODUCTION.

The primary object of this investigation was to ascertain the extent of the enemy's losses due directly or indirectly to air attack and to assess the effectiveness of different air weapons.

AREAS COVERED.

The area involved can be divided into three portions, which we have named the Pocket, the Shambles and the Chase.

I. The Pocket.

This is the area bounded by a line passing through the following places:- FALLISE, COMDE-SUR-NOIREAU, VASSY, TINCHEBRAY, CER, BARENTON, COMFORT, LA FERTE-MACE, ARGENTAN. In this area the retreat appears to have been reasonably orderly, casualties were not particularly heavy but increased steadily towards the eastern end.

The area immediately east of MONTAIN is not included as it was a battle rather than a retreat area. It has been dealt with in a separate report.

II. The Shambles.

This area is at the mouth of the Pocket and is bounded approximately by a line passing through PIERREFITTE (on the FALLISE - ARGENTAN Road) - ARGENTAN - CHIMBOIS - VINCOTTES - TRUN - PIERREFITTE. Here the retreat appears to have become very disorderly, the density of the casualties is high and the area is well described by the name given.

III. The Chase.

The area leading to the SEINE crossings, showing signs of a reasonably orderly retreat and with casualties lightly spread over a large area.

PART I. THE POCKET.

1. Collection of data.

The method of investigation in the Pocket has been to patrol the most likely routes and to record the following data:-

- (a) Type of vehicle or equipment.
- (b) Cause of casualty.
- (c) Date of casualty.
- (d) Direction in which proceeding.
- (e) Whether burnt or unburnt.
- (f) Ease of visibility from the air.
- (g) Degree of dismantling of the vehicle.

Local inhabitants were interrogated whenever possible.

In addition to the main roads a number of side roads were also examined in particular areas where it appeared likely that vehicles might be found.

Statements by inhabitants as to where vehicles were or were not to be found proved to be mainly correct when checked and have therefore been used to avoid searching every road in the area. Even so, we have no doubt that vehicles have been missed and that our totals are at the best only approximate. However, from the wooded nature of the country and the conditions in which the vehicles in side roads were found, we are confident that few of these have suffered directly from air attack.

There was difficulty in estimating the time at which a casualty had occurred. Local inhabitants informed us of many which dated from about D day. In many cases it was obvious from the appearance of the wreckage, and from the state of development of plants growing in burnt verges that the casualty was an old one. Further evidence of date was provided by the direction in which the vehicle was pointing and the degree of dismantling. It is assumed that during the retreat only a small number of vehicles could have been pointing west and that although wheels or tyres and possibly items of ignition systems might have been quickly removed as spares, it would hardly have been feasible to remove such items as engines and back axles. There was no evidence that any major dismantling was being carried out by the French or our own troops; plenty of opportunities were still outstanding and were not being used to any appreciable extent while we were in the area.

2. Results.

(a) At Appendix A is a table giving details of the total numbers of vehicles and equipments that were found and examined. By comparing the numbers on side roads with those on main roads in a few areas, it is estimated that had all side roads been examined, the total would have been increased by not more than 50% in the case of guns and L.P.V's and 30% for other vehicles.

The table is of general interest only; it contains all vehicles and equipments found, regardless of the date on which they became casualties. However it may serve as a comparison with other counts that have been or will be made.

(b) The table at Appendix B includes only those casualties which occurred or might have occurred since the encirclement of the enemy. It is impossible to assess exactly what proportion of abandoned vehicles and equipments can be attributed to air action. Abandonment must often have come as a result of the extreme congestion and disorganisation which prevailed during the retreat; traffic was often totally blocked and petrol became scarce. Inasmuch as the congestion and disorganisation can be attributed very largely to the air, abandonment must in the majority of cases be attributed to air action. All abandoned vehicles and guns are therefore included in Appendix B.

A number of casualties attributed to air attack must first have been abandoned. Unless a vehicle had been set on fire or was in a traffic stream, there can have been no means of telling from the air whether it was already a casualty. Several cases have been quoted by local inhabitants of vehicles that had been shot up from the air repeatedly. One particular example was just outside PUTNICES where an armoured troop carrier abandoned in a somewhat conspicuous place with no petrol was said to have been machine-gunned twelve times. Its appearance and that of the roads and buildings nearby supported these statements.

(c) At Appendix C is a trace showing the roads that were patrolled and illustrating the results given in Appendix B. It shows how the density of casualties increased progressively from the western to the eastern end of the Pocket, as would be expected. The assembly of guns around the point A (M.R. 846175) had all been abandoned at about that point, though they were actually found in a R.E.M.E. workshop. The concentrations around the points B and C, (M.R.'s. 9224 and 0626) were in for repair or had been stripped to provide spares for other vehicles.

(d) Wherever possible the wheels of vehicles had been removed. Inhabitants invariably informed us that the Germans had taken them, and it has been subsequently confirmed through I channels that this was their normal practice.

(e) The great majority of soft vehicles that had been hit by cannon and machine gun attack were burnt. In a sample of 153 lorries and cars near the mouth of the Pocket 77 had been hit and burnt, 7 hit and not burnt, 4 burnt-but not hit, 65 neither burnt nor hit. It was found to be almost a rule that where the pock marks of strikes appeared in the roads, there a burnt vehicle was to be found.

FIGURES for other vehicles may be increased by about 30% for the same reason.

ATTACHMENT A.

TOTAL DAMAGE TO BURNT VEHICLES AND EQUIPMENT IN THE POCKET.

(From D. day onwards)

TYPE	R.P.	MOVES	CUSTOM AND R.P.	A.P.	R.E.	MINES	DESTROYED BY CROW	ABANDONED	LOCATED	UNBURNED CLIPS	TOTAL	%
TANKS	4	2	0	8	2	0	32	33	0	9	90	7.1
S.P. GUNS	5	0	0	2	2	0	12	4	2	4	31	2.4
2ND. VEH.	2	2	21	1	5	1	8	12	0	4	56	4.4
LOANERS	5	36	283	0	40	8	11	192	9	75	699	52
CLAS	0	9	86	0	14	3	9	165	24	42	352	27.7
MOTOR/CLAS.	0	0	2	0	3	1	0	10	3	3	22	1.7
GUNS	0	0	1	0	5	0	9	41	0	4	60	4.7
TOTALS	16	49	393	11	71	13	81	457	38	141	1270	
PERCENTAGES	1.2	3.8	31	1	5.6	1	6.4	36	3	11		

NOTE:- Figures for guns and A.P.'s may be increased by not more than 50% when raised side-roads and lanes are taken into account.

Figures for other vehicles may be increased by about 30% for the same reason.

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Figures for cars and L.P.V.'s may be increased by not more than 50% when mixed side-roads and lanes are taken into account. Figures for other vehicles may be increased by about 30% for the same reason. A further addition of 10% might be made to all figures to allow for those excursions which have been attributed to unknown causes but which were in fact due to air action.

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TYPE	S.P.	BONES	CLONES AND H.C.	*11% 2012	ALLOWED ON DIS- TRIBUTED BY THE COM	GRAND 2012
TOTALS S.P. CLONES APPROVED VEHICLE	31	4	10	33	101	133
TOTALS CLONES NOTION CIRCLES	4	43	276	305	306	701
CLONES	0	0	1	1	90	91
TOTALS	15	47	297	309	506	805
PERCENTAGE	1.7	5.3	33.5	-	59.5	-

dition it is not certain whether damage occurred in this phase of the battle or earlier, it is included in the table).

Due directly or indirectly to Air (AP, ME, Minor, Accidents and Unknown Causes excluded).

ANALYSIS OF DELAYS IN AIR ATTACK TO ENEMY EQUIPMENT DURING THE POKISTAN PERIOD.

APPENDIX B:

ΣΥΛΛΟΓΗ:

Approx 1 : 200,000

1 inch = 25.4 millimeters

WASY

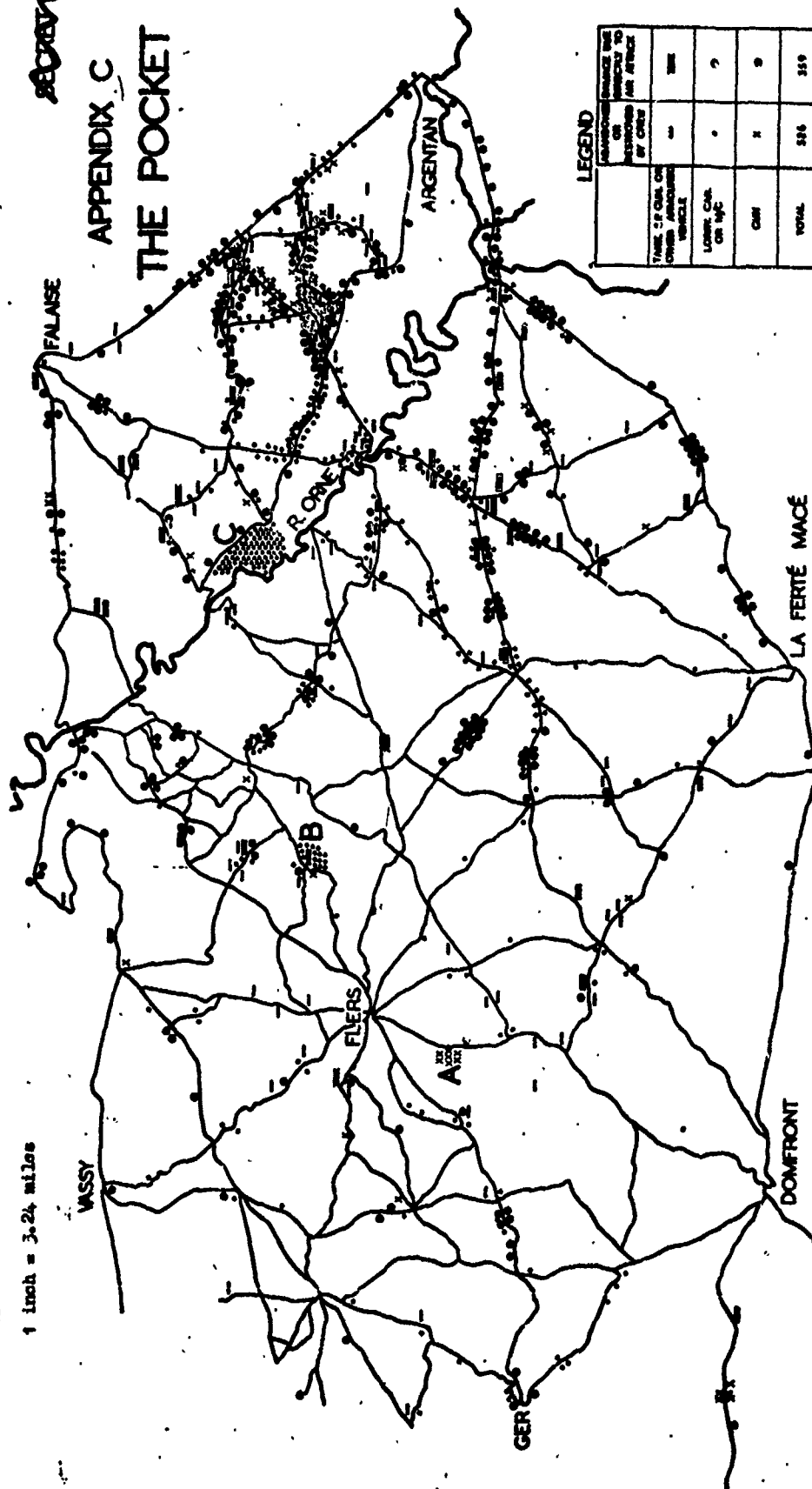
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APPENDIX C

SECRET

APPENDIX C
THE POCKET

Scale:
Approx 1 : 200,000
1 inch = 3.24 miles

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ANALYSIS OF DAMAGE BY AIR ATTACK TO BOMB EVIDENCE DURING THE POCKET PERIOD

APPENDIX B

PART II.THE SHAMBLES.1. Area Covered.

The area covered is bounded approximately by a line passing through PIERREFITTE (on the FALAISE - ARGENTAN road) - ARGENTAN - CHAMBOIS - VINCOUTIERS - TRUN - PIERREFITTE.

2. Collection of Data.

The method of investigation used in this area was to patrol all the main roads and any side roads which, from the evidence of German signposts, had been used in the retreat.

A preliminary examination showed that there were so many vehicles that a detailed examination of each was impossible; accordingly a simplified investigation involving a general count and a detailed study of samples only was made. Vehicles were classified as follows:

- (a) Heavily armoured vehicles - Tanks and S.P. guns.
- (b) Lightly armoured vehicles - A.T.C's and Armoured Cars.
- (c) Soft vehicles - lorries.
- (d) Soft vehicles - cars.
- (e) Guns.

Classes (a) to (d) were further sub-divided into burnt and unburnt. In the case of cars and lorries classification into burnt and unburnt had proved a good indication of whether the vehicle had been hit or abandoned (see Part I para. 3(e)), hence the reason for adopting this classification.

In view of the high density of vehicles in this area as compared with The Pocket no attempt was made to discriminate between old and recent casualties. The number of old ones is considered to be insignificant.

Random samples were taken from time to time and examined in detail; one in seven of all vehicles were so examined and one in three of tanks and S.P. guns.

Local inhabitants were questioned but provided little information. Few had been in the area during the relevant period, but such information as they did provide confirmed our own inferences.

Horse-drawn transport was excluded from this survey for several reasons. Firstly it is so easy to destroy that it is difficult to tell afterwards what weapon was responsible; secondly the stench of dead horses was so overpowering that where there was any number of horse-drawn vehicles that area had to be passed with all speed. It is estimated that about a thousand carts and wagons, some belonging to the German Army and some farm carts impressed for the occasion, were seen in the area.

3. Results.

(a) Although it is possible that a few tracked vehicles may have been missed in the wooded area to the north-east of ARGENTAN, the total count of 3043 vehicles, tanks, and guns is probably a very good estimate of the losses which the enemy suffered in this area. This total was made up as follows:-

	TANKS AND S.P. GUNS	LIGHTLY ARMoured VEHICLES	LORRIES	CARS	GUNS
BURNT	112	64	1011	224	-
UNBURNT	75	93	767	445	-
TOTALS	187	157	1778	669	232

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76.

(b) At Appendix F is a map showing the roads which were patrolled and the approximate distribution of vehicles and equipment found on them or in their vicinity. Four categories are represented, lorries and cars being lumped together as they appeared to us to have been equally vulnerable.

The exact positions of the vehicles are not shown on the map as they were only recorded according to the stretch of road near which they were found. The map therefore only represents storage densities of vehicles along stretches of road.

(c) In the area enclosed by the dotted line the great majority of casualties are presumed to have been due to land action or abandonment. It is in this area that the jaws finally closed, artillery fire was brought to bear on massed enemy transport and the Polish armour came down from the north. There are many shell craters and abundant examples of fragment strikes on vehicles, but whether before or after abandonment is not known. The majority of the vehicles are to be found down up-lying hedges, in narrow lanes, and in orchards. A German officer captured at St. LOUIS-SUR-LOIRE gave a most lucid illustration of the chaotic state of affairs that existed on the main LEZ-CHAMBOIS road at the time. His statement is quoted at Appendix E.

(d) The table at Appendix D gives an analysis of 82 tanks and S.P. guns which were examined in detail. The 35 destroyed by the crew were all set on fire, while the 33 abandoned had suffered only minor, if any, damage. The numbers shot from the ground or the air are too small to make it possible to estimate from them the total number so destroyed, but it is reasonable to presume that much the greatest number of burnt vehicles were destroyed by the crew and the unburnt abandoned. Had any considerable proportion of the unexamined armour been destroyed by R.P., our attention would undoubtedly have been drawn to that by the presence of the typical craters.

For fuel tanks were inspected for four of booby-traps. In those that were, the quantity of fuel varied from nothing to practically full, but with a bias towards the former.

(e) 31 lightly armoured vehicles (mostly armoured troop carriers) were examined in detail with the following results:

	Cannon or M.G. from Air	Arty Fire	Destroyed by crew	Abandoned by crew	Unknown causes
BURNT	5	2	3	0	5
UNBURNT	0	0	0	13	2

The ratio of unburnt to burnt in the sample is approximately 1 : 1 and in the remainder 16 : 1. It is clear that the sample was not truly representative and, in the case of the burnt vehicles, the numbers in each category are too small for generalisation. It is probably safe to assume that the great majority of unburnt vehicles were abandoned and that a large proportion of those burnt were destroyed from the air.

(f) The 2447 lorries and cars, almost equally divided between burnt and unburnt, constituted the majority of the vehicles found in the area. The 330 which were examined in the samples included 158 burnt and 172 unburnt; analysis of the samples yields the following:

Cannon or M.G. from the air	99
Bombs (mostly fragmentation type)	9
Rocket Projectiles	2
Total "Air" casualties	110
Shellfire	15
Mines and accidents	11
Destroyed by crew	7
Unknown causes	32
Abandoned unburnt	135
	330

Of the 110 "Air" casualties, 91 were burnt and 19 unburnt and of the 135 abandoned vehicles 12 were unburnt and 123 were burnt. The samples did not include any vehicles from the area (see para. 3 (e) above) where land forces are known to have caused the casualties. The figures quoted above show that, outside this one area, it is probably safe to assume that the number of burnt soft vehicles is a good measure of the number of casualties directly due to air attack (see para. 3 (e)).

The air ground forces, along roads in almost 200 cars set fire to most observed here and transport and fire

It appears considered as the roads which were

(g) The 250 fragments from been put out of

TYPE	No. (shot)
TIGER	0
PANTHER	3
MARK IV	2
MARK III	2
S.P. GUNS	1
TOTALS	8

In addition examined in detail

The following on 21st August, 1944

"At 2 a.m. to move and drove roads which were set into each other, we stuck in it. Then arrived forward of them. They were soon surrounded and were put in the vanguard. Suddenly there was tank guns and mortar and ran over some of the rear to hold up me and brought them down however the tank

The area enclosed by the dotted line contained some 350 cars and lorries destroyed by ground forces, to which one should probably add a further 150 for vehicles similarly destroyed along roads in the vicinity. The very congested area slightly south-west of this contained almost 200 cars and lorries which had been left in a great hurry; the Germans had attempted to set fire to most of these but were only partially successful. Few signs of air attack were observed here and the local farmers told us that the Germans had deliberately destroyed their transport and fled without having been attacked by aircraft.

It appears that, in the Shambles area, about eight hundred vehicles may reasonably be considered as directly destroyed by air attack and a somewhat larger number as abandoned along roads which were attacked by aircraft.

(g) The 232 guns were all classed as abandoned because, although a few showed strikes by fragments from bombs or shells, none were really destroyed by these means. They had almost all been put out of action by their crews.

APPENDIX D

ANALYSIS OF TANKS AND S.P. GUNS.

("Shambles" Area)

TYPE	L.P. (shot)	R.P. (air)	DESTROYED BY CREW	ABANDONED	OTHER OR UNKNOWN CAUSES	TOTAL
TIGER	0	0	9 incl 3 Tiger IIs	3	0	12
PANTHER	3	0	8	11	0	22
MARK IV	2	2	12	6	0	22
MARK III	2	0	1	1	1	5
S.P. GUNS	1	0	8	12	0	21
TOTALS	8	2	38	33	1	82

In addition, the following tanks and S.P. guns were observed but not examined in detail: 69 which were burnt and 36 unburnt. This adds a further - 105

GRAND TOTAL: 187

APPENDIX E

The following information was obtained from Interrogation of an Officer P.W. captured on 21st August, 1944 at ST. LAURENT-EN-ANJOU:-

"At 2 o'clock we received a report that the gap had been forced. We were accordingly to move and drove off with three cars. We drove two or three kilometres and then came onto roads which were completely blocked. There were four or five columns of traffic which had run into each other, with dead and wounded in between. We put our vehicles into one column and got stuck in it. Then we went on foot from 3 o'clock in the morning until six. Eventually we arrived forward at the place where the gap was supposed to be, and met about two to three hundred men. They were composed of a paratroop 'Bataillon', to which SS and Army and G.I. and Navy personnel had attached themselves. Two tanks joined us - a Mark IV and a Panther; they were put in the vanguard with scouts ahead and one platoon behind them, and then the troops. Suddenly there was heavy firing into the sunken road. At first it sounded like fire from anti-tank guns and mortars and HMGs, interspersed with rifle fire. The tank immediately reversed and ran over some of our men, whereupon all the infantry screamed back. I took up a position at the rear to hold up the retreat and I shot the first one who came along. An R.C.M. stood beside me and brought them to a halt. Then the tank drove up and I ordered it to drive ahead again. Soon however the tank was hit and set on fire. We lay down flat and then came heavy firing

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along the sunken road from ahead. We had a great many dead and wounded. We lay for 10 minutes and then the fire eased off a bit. I heard the sound of tanks, so I made two men come forward with "Faustpatronen" which we still had with us. It slowly became light and then we saw Americans in the opposite hedge. We fired at them with M.G. and tommy-gun fire. Then the enemy started firing again. There was suddenly heavy fire out of the whole hedge with cannon and M.G.s. Then someone at the front started to wave a white flag on a stick. We shot him at a distance of 100 m. After a second attempt with a white flag had also proved unsuccessful, we heard the noise of an enemy tank ahead again. In the meantime we had brought up our second tank, the "Panther". This was given orders to take up a position behind the shot-up Mark IV tank and to shoot up the advancing tank with its guns. The "Panther" made a mistake in not taking up a position directly behind the Mark IV but driving past it. It was hit and burst into flames. Later, another white flag appeared, and again we fired at the troops surrendering. We were occupied with trying to get up to the enemy tank with the "Faustpatronen" when American troops captured us.

VIMOUTIERS

TO FALAISE

RECEIVED

TO VIMOUTIERS

APPENDIX 'F'

"THE SHAMBLES"

Scale 1/100,000

187 TANKS & S.P. GUNS.
187 LIGHTLY ARMoured VEHICLES.
3417 LORRIES, CARS, MOTOR CYCLES.
252 GUNS.

TOTAL 3048

THE "POCKET" AREA
SEE APPENDIX 'C'

FALAISE
VIMOUTIERS
PIERREFITTE
ARGENTAN
CHAMBOIS
LAUNAY
TRUN

Scale 1-100,000

187	TANKS & S. P. CUNGS.
187	LIGHTLY ARMOURD VEHICLES.
9447	LOMMES CARS, MOTOR CYCLES.
212	CUNGS.

8408 2048

THE "POCKET" AREA
SEE APPENDIX 'C'

PART III.THE CHASE.1. Area Covered.

The area is bounded approximately by a line passing through VIMOUTIERS - LIVAROT - LISIEUX - PONT L'EVÊQUE - PONT AUDEMER - QUILLÉBEUF - along the left bank of the R. SEINE to LES ANDELYS - EVREUX - GACE - VIMOUTIERS.

2. Collection of Data.

(a) The roads examined were the principal ones leading from the Shambles area to the crossings of the SEINE and especially those which were known from sortie reports to have carried a great deal of traffic or to have been attacked from the air.

(b) Casualties to vehicles and equipment were counted and recorded under the following headings:-

- (1) Heavily armoured vehicles - Tanks and S.P. guns.
- (2) Lightly armoured vehicles - A.T.Cs. and Arm. Cars.
- (3) Soft skinned vehicles - lorries, cars, and M/Cs.
- (4) Guns.

No samples were examined in detail but, in order to investigate the destruction of armour from the air, two thirds of the heavily armoured vehicles were examined individually with great care.

Horse-drawn vehicles were not counted but were not very numerous except near the banks of the SEINE.

(c) Local inhabitants provided useful information especially concerning the causes of casualties to heavily armoured vehicles.

3. Results.

(a) At Appendix H is a map showing the roads that were patrolled and the vehicles and equipment that were counted on them. The marks on the map do not represent the exact locations but rather that the vehicle or equipment was found on the adjacent stretch of road. They therefore provide a measure of the densities of casualties along the various stretches.

The total numbers of vehicles and equipment counted are set out in their categories in the following table:-

	TANKS AND S.P. GUNS	LIGHTLY ARMoured VEHICLES	LORRIES, CARS, M/Cs.	GUNS
BURNT:	114	115	2475	-
UNBURNT:	36	39	903	-
TOTALS:	150	154	3178	166

GRAND TOTAL: 3648

(b) As it was not possible to cover every road in such a large area, the total number of casualties is not known and cannot easily be inferred but some indications can be given. The main axis along which the densities of casualties are high is clearly indicated on the map and the limits to north and south at which they become low are fairly well defined. In an area south-east of BERNAY all likely roads were covered and found to contain much smaller densities than the main roads running north-east through the town. As will appear later, there is reason to suppose that air attack was in a large measure responsible, directly or indirectly, for the casualties and the roads which we were told had been so attacked were all covered.

Taking these factors into account we have estimated that the total number of casualties was less than twice that recorded.

(c) On the left bank of the river to the west of the wrecked bridge in NOUEN was found a mass of burnt vehicles and equipment consisting of 20 A.P.V's, 48 guns, and 660 other vehicles. It appears that a traffic jam was formed owing to a misapprehension that there was a serviceable bridge. The R.A.P. and IX U.S.A.A.F. attacked the jam and started fires which destroyed the lot.

A total of 150 tanks and S.P. guns were examined in detail and the results of the examination are set out in Appendix G. The hardest cases to assess were those which were blown-up and burnt open as a result of explosions of ammunition or demolition charges. In almost all such cases the cause was assessed as destruction by the crew and this was frequently confirmed by the presence of empty German demolition charge containers and by local inhabitants who told us that the tank had broken down or run out of petrol and been set on fire by the crew. On only one occasion did an inhabitant tell us otherwise, when he persisted that the tank had been "mitraille par les avions" and one of the crew killed; in this case there was a bullet mark on an engine louvre but it did not appear to have penetrated and it was not likely that the tank had been surprised with a hatch open. Other possibilities are that the tank was set on fire by our own troops either as a policy or through *joie de combat*. In such case was confirmed and the point is a minor one as it could only lead to a difference of tanks from the category of "destroyed by crew" to that of "abandoned". None of the tanks examined had been destroyed by A.P., nor were any of the typical craters found in the area. Fuel tanks as were examined in unburnt vehicles contained little or no fuel.

The condition that numbers of burnt and unburnt soft vehicles are approximately equal in the numbers shot and abandoned does not apply in this area in the way that it was shown to do in the areas covered by Parts I and II of this report. It may have held good in the early part of the area where, as in the Pocket, the burnt lorries were commonly marked by the tell-tale pock marks of cannon and machine gun fire on the roads, but in the western part of the SEINE it was clear and was confirmed by inhabitants that the Germans were setting fire to their vehicles when there was little hope of getting them across the river.

The ratio of burnt to unburnt soft vehicles is noticeably higher in this area than in that covered by Parts I and II.

A trace overlying the map at Appendix H shows the total numbers of vehicles reported from the sources in various roads and in certain areas on all days during the relevant operations. Although the figures are undoubtedly very rough, the trace does show that the densities of casualties do not conform to the traffic densities on the roads, and that heavier casualties than might have been caused had a greater concentration of air attack been devoted to the roads with most traffic. A striking example of this is provided by a comparison between the main road west of LISIEUX and the smaller THIBERVILLE - BERNAY roads. A civilian inhabitant of THIBERVILLE who appeared to be particularly intelligent confirmed that the density of traffic on the latter road was very much higher than that on the main road but that, whereas the main road was constantly attacked from the air, the other never was, though he had constantly prayed that it would be.

There were few indications of land action in the area and the enemy casualties were attributed mainly to air action, either directly or indirectly. The example of the two main roads in the previous paragraph indicates that where there was no air action there were few casualties. The attention received by the SEINE crossings may be presumed to have caused the large amount of abandonment and destruction of vehicles by the Germans. The mass of burnt vehicles due directly to air action has already been referred to.

Most of the 166 guns were found left by the roadside in the western part of the zone and almost always been put out of action by their crews. They have been omitted from the map at Appendix H to avoid further congestion.

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SECRET

LEGEND

FIGURES INDICATE NUMBERS
OF VEHICLES REPORTED TO BE
MOVING ALONG ROADS.

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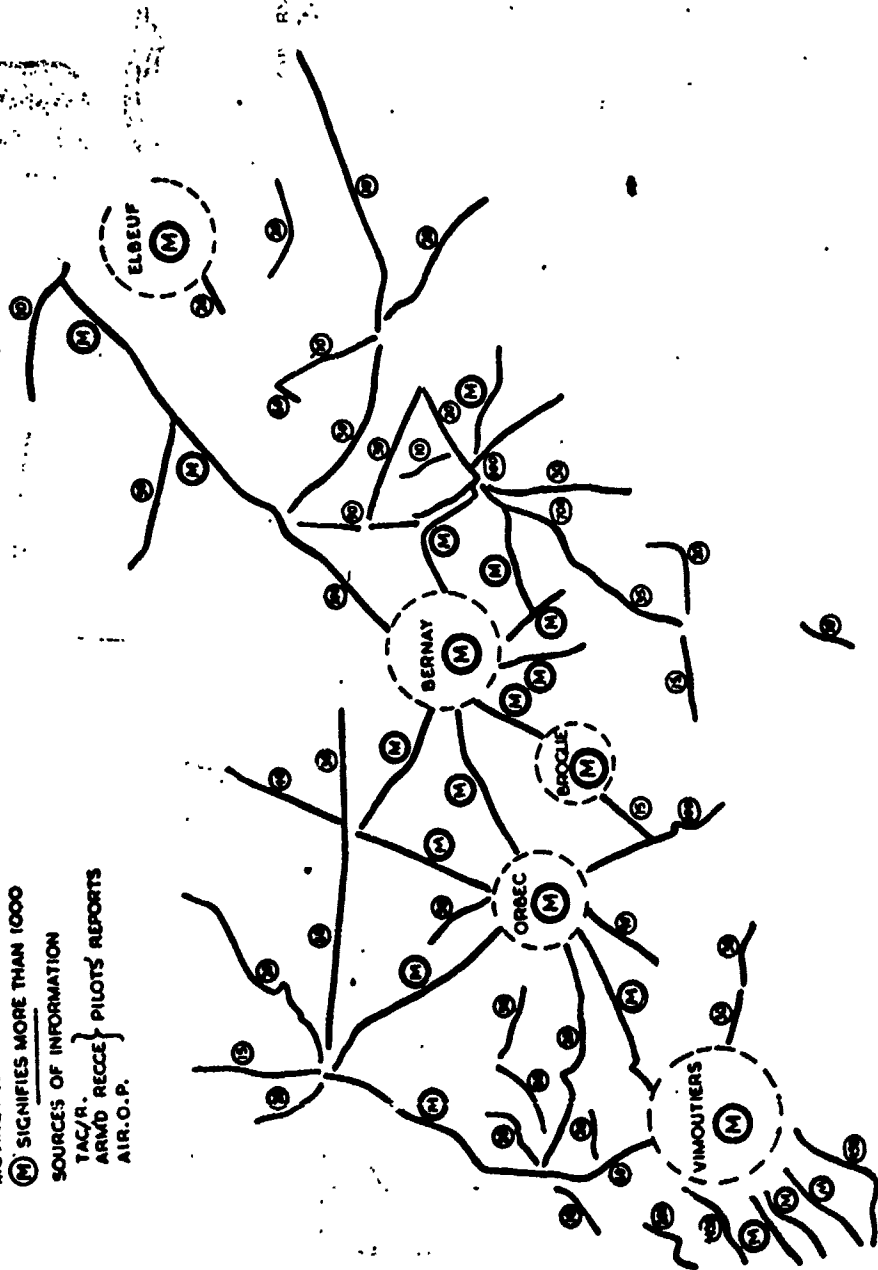
LEGEND

FIGURES INDICATE NUMBERS
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(M) SIGNIFIES MORE THAN 1000

SOURCES OF INFORMATION

TAC/R.
ARMED RECCE } PILOTS' REPORTS
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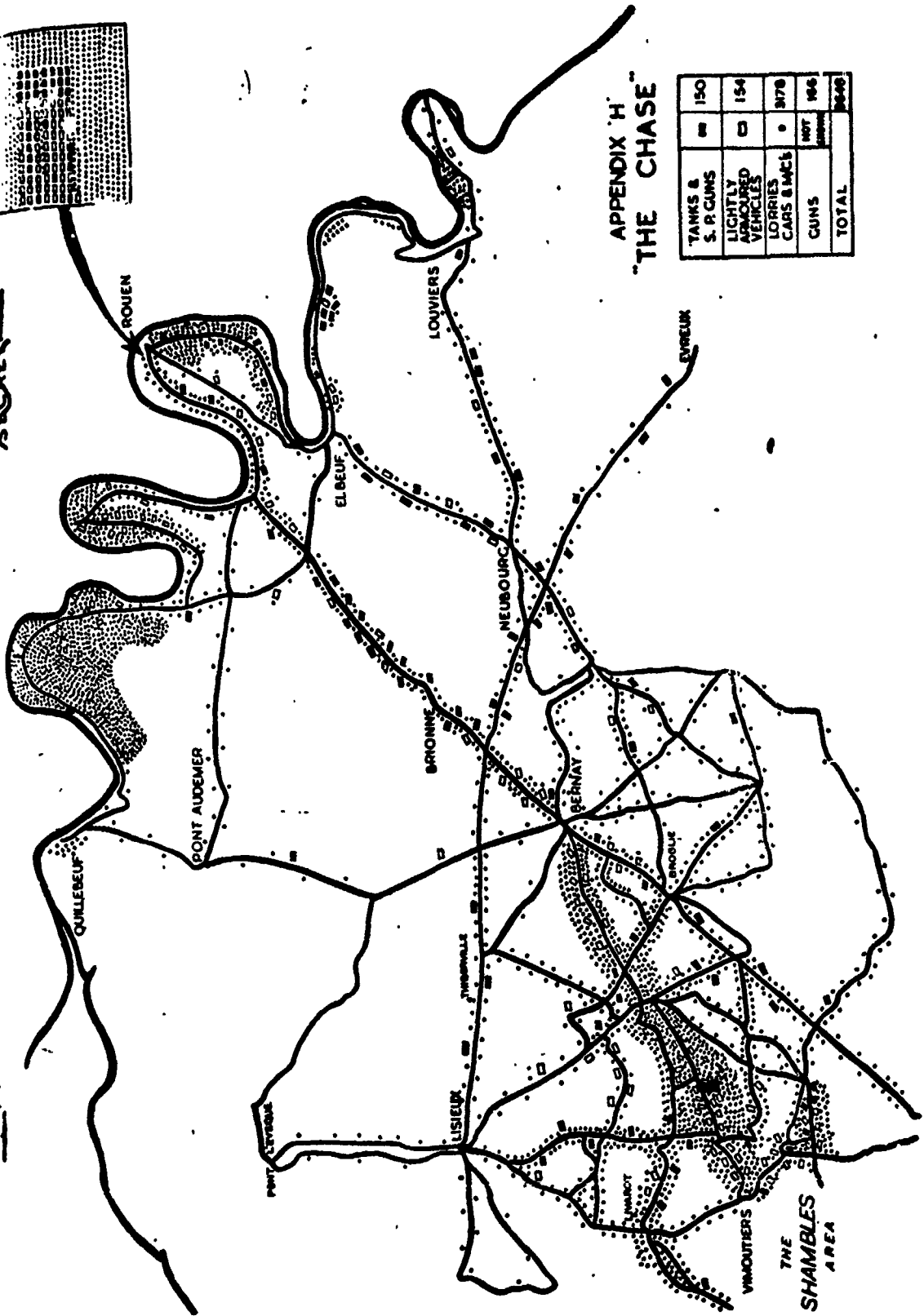


APPENDIX 'H' "THE CHASE"

TANKS & S. P. GUNS	■	150
LIGHTLY ARMoured VEHICLES	□	154
LOBBIES	•	3178
CARS & BUSES	●	106
CUNS	NOT	106
TOTAL		3440



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APPENDIX G

ANALYSIS OF TANKS: AIR, A.P., CRST.

("Close" Area)

T Y P E	A.P. (shots)	DESTROYED BY CRST	ABANDONED	OTHER OR UNKNOWN CUSES	T O T A L
TIGER	0	7	4	0	11
PANTHER	2	23	1	2	28
MARK IV	3	16	7	2	28
OTHER TANKS	0	0	2	1	3
S.P. GUNS	3	9	12	4	28
TOTALS	8	55	26	9	98

In addition, the following tanks and S.P. guns were observed but not examined in detail: 39 which were burnt and 13 unburnt. This adds a further

52

190

GRAND TOTAL:

PART IV

THE SEINE CROSSINGS.

1. Area Covered.

Having followed the path of the German retreat as far as the SEINE and tried to estimate his losses, it seemed that it would be of value to try to find out how much equipment had got across. Accordingly the left bank of the SEINE was covered from LES ANDELYS (3991) to QUILLEBEUF (7932).

2. Method of Investigation.

Most of the information set out in this part of the report was obtained from local inhabitants including officials of the Gendarmerie, the F.F.I., and the Fire Brigade. The roads leading to the crossings were examined for abandoned and destroyed vehicles and those which were found have already been included in Part III of this report.

3. Results.

(a) The points marked on the map at Appendix J are numbered to correspond with the following paragraphs which contain notes on the twenty-four crossings which were discovered.

(i) PETIT ANDELYS (3991). The Germans had a ferry which only worked at night. During daylight vehicles were hidden in woods around TOSNY. All kinds of vehicles were ferried across to PETIT ANDELYS including tanks, but during the last few days only impressed civilian horse-drawn traffic was carried.

(ii) BERNIERES - LA ROQUETTE (3592). There was a small ferry which carried horse-drawn vehicles and some pieces of artillery. This ferry was sunk as a result of air action and the service was discontinued.

(iii) BETWEEN LA ROQUETTE and HUIDS (3491). The Germans tried to build a pontoon bridge but Allied aircraft gave it constant attention (there was a regular daily raid at 1900 hrs) and, although on one occasion a tank managed to cross, the enemy gave up the unequal struggle.

(iv) VEUMBLER - HUIDS (3189). Two ferries, each capable of carrying six lorries, made about 4 trips per hour for six nights and three days. No tanks were ferried across. During the three days, though the weather was bad, much abuse was made of the Red Cross. Over 20 burnt and abandoned vehicles were found on the west bank of the SEINE at this crossing point.

(v) ANDE (2791). The Germans had intended to build a bridge here and the two ends remain, but all that passed over was infantry in small boats.

(vi) PORTE JOIE - HENQUEVILLE (2992). Much traffic passed this way. At first there was one ferry in daylight and two at night, but latterly they used as many as five ferries, all capable of carrying 60 tonnes. A smaller ferry (35 tonnes) operated from a farm a few hundred yards upstream. An old lady there said that the Germans had a pontoon bridge which they used at night and tied up under the trees on the east bank during the day, but other and more reliable sources of information explained that the ferries were moored under the trees in a line and might look like a floating bridge. About 40 tanks were seen to cross on the 60 tonne ferries and these included some broken-down tanks being towed by good ones. These crossings were in use for a fortnight and, though planes were frequently seen and heard attacking transport on roads, the ferries were never attacked. The troops were said to be very disorganised and all were taking the way to MIENS. Only a few abandoned vehicles were found near this crossing.

(vii) BETWEEN PORTE JOIE and POSES (2995). A single ferry was operating for the carriage of heavy transport. No further details were obtained.

(viii) POSES (2999). A pontoon bridge was in use here for 5 nights and 3 days. A local inhabitant kept a record of the traffic as it passed his house; this was said to amount to 16,000 vehicles, mostly lorries but including also some light armour and two large tanks. Although this great total was well substantiated, we are loath to accept it as it means that traffic was passing at the rate of 3 vehicles per minute for the whole of the relevant period, which would have been a masterpiece of organisation.

This is the only point at which the use of a bridge was confirmed and the figure given above, even though it is thought to be too large, indicates the great difference that the use of a bridge made.

There was very little air activity and, when the bridge was once damaged, it was rapidly repaired. The Germans had appreciably lowered the level of the river here by blowing the weir 2 kilometres downstream.

Vehicles are said to have approached the POSES crossing from both north and south, but very few were found burnt or abandoned on the roads leading to the bridge.

(ix) LES DIMPS (2499). A chain ferry was operating between two moored barges for 5 nights and 3 days, making about 4 trips per hour; it carried four lorries at a time. This might account for some 1500 vehicles, but a local inhabitant insisted that about 20,000 had crossed there.

The railway bridge at LES DIMPS was wrecked by our bombers.

(x) PONT DE L'ARCHE (2299). The bridge here was destroyed in 1940. The Germans had built a wooden one on the same site and it was stated locally that the R.A.F. had wrecked it some time this year. Three Panthers, a Mk. IV, and a 75 mm S.P. gun were found on the west bank near the bridge.

(xi) CRIQUEBEUF (1800). Only a small number of Germans crossed the SEINE here and they were mostly infantry. They had intended to build a bridge but never really started.

(xii) CAUDEBEC-LES-ELBEUF (1399). A chain ferry working only at night and making about 15 trips per night was capable of carrying 6 lorries at a time. It is said to have taken some tanks. Two Mk. IVs and an S.P. gun were found abandoned near the ferry as were also upwards of 200 carts and a few lorries.

(xiii) ELBEUF (1199). The F.F.I. informed us that there were two ferries operating here and one at ORIVIL. These were working continuously for five days and nights, making approximately three crossings in the hour. Each ferry could carry either 1 tank or 3 lorries.

(xiv) AMFREVILLE (2110). A ferry was improvised from two large metal pontoons and this was in use for two days and nights. Local inhabitants say that not more than 60 vehicles crossed here but the true figure is probably somewhat greater. No tanks crossed at this point.

(xv) ROUEN (2015). Members of the local Fire Brigade informed us that the railway bridge was not in use during the relevant period. A great many small improvised ferries were working continuously carrying men and children. Two regular ferries were in use but, as far as they knew, had carried only soft or lightly armoured vehicles. They did not know of any tanks crossing at ROUEN but had heard that tanks had been ferried across at LA PETITE COURONNE.

They gave us the reason for the traffic jam that drivers had been directed to ROUEN expecting to find a bridge and far more vehicles arrived than could possibly be taken across. They said that when the jam became serious many vehicles were driven off into the woods and abandoned, but they could not tell us where and we did not see any signs of them as we came through the woods.

(xvi) LA-FONTAINE (0721). There was no ferry but a raft was used to carry several hundred men and 20 vehicles during the course of the retreat.

(xvii) BERVILLE - DUCLAIR (0421). The ferry was sunk three weeks before the German retreat. Improvised rafts carried hundreds of men across but no vehicles passed this way.

(xviii) LE MESNIL SOUS JUNIEGES (0213). The Germans were crossing here for three days in small boats and improvised rafts or by swimming. No vehicles were ferried here.

(xix) MERTIAUVILLE (9918). The ferry which previously worked here was sunk by air action shortly before the retreat and there is no evidence of how much they managed to get across at this point except that two rafts were left there.

(xx) LE TRAIT (9919). There were at least three points here where boats and rafts were used for ferrying men, several thousands of them, but very little equipment was seen to cross.

(xxi) MAILLERYE (9722). There was one ferry which operated chiefly at night. It was said to have had a capacity of nearly 10 vehicles and yet only ferried some 50 vehicles per night for five nights. These figures include no tanks.

(xxii) CAUDEBEC-EN-CAUX (9326). One ferry was sunk by air action some three weeks before the retreat; another was sunk by the Germans when they left but in the meantime it had carried some 40 to 50 tanks and between 1500 and 2000 other vehicles. Also many anti-tank guns were carried across. This traffic passed on two foggy days and five nights.

(xxiii) VIEUX PONT (8317). There was no ferry here but local inhabitants estimated that about 200 men and 40 horses crossed in small boats.

(xxiv) QUILLEBEUF (7922). The ferry that originally operated here has been taken upstream before the retreat began but some three hundred Germans crossed on improvised rafts. No vehicles were ferried.

(b) From the information provided we have estimated roughly that about 40,000 items of motor transport and 250 tanks and S.P. guns could have crossed the river. The figure of 40,000 is probably more than the Germans possessed when the retreat started but it is reasonable to suppose that the ferries were observed to be carrying the loads stated at the frequencies stated when things were working smoothly. The 16070 vehicles alleged to have crossed at POSEY (20000) were included, although we questioned its accuracy. The figure therefore only gives an indication of what might have been taken care of with perfect organization and no interference. The figure of 250 for tanks and S.P. guns is compatible with an estimate of 100 as the number of tanks left to the Germans out of the total that they had in NORMANDY.

(c) The ferrying capacity above ROUEN was far greater than below and this may be compared with the situation shown in Part III, that few enemy vehicles were to be found near the banks of the SEINE above ROUEN but a great many below.

(d) All the crossings examined the inhabitants stressed the point that the Germans had to work chiefly at night but that, in the vitally important work, there were three days when the weather was very poor and during which they were able to ferry much traffic across without any interference from the A.L.F.

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SCALE 1:250,000
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Numbers refer to paragraph in Section III

Appendix J Map to show German crossing over the R. Seine

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25 Km. OVERLAP ON SHEET 4, HAVRE-AMIENS

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Appendix J Map to show German crossing over the R. Seine

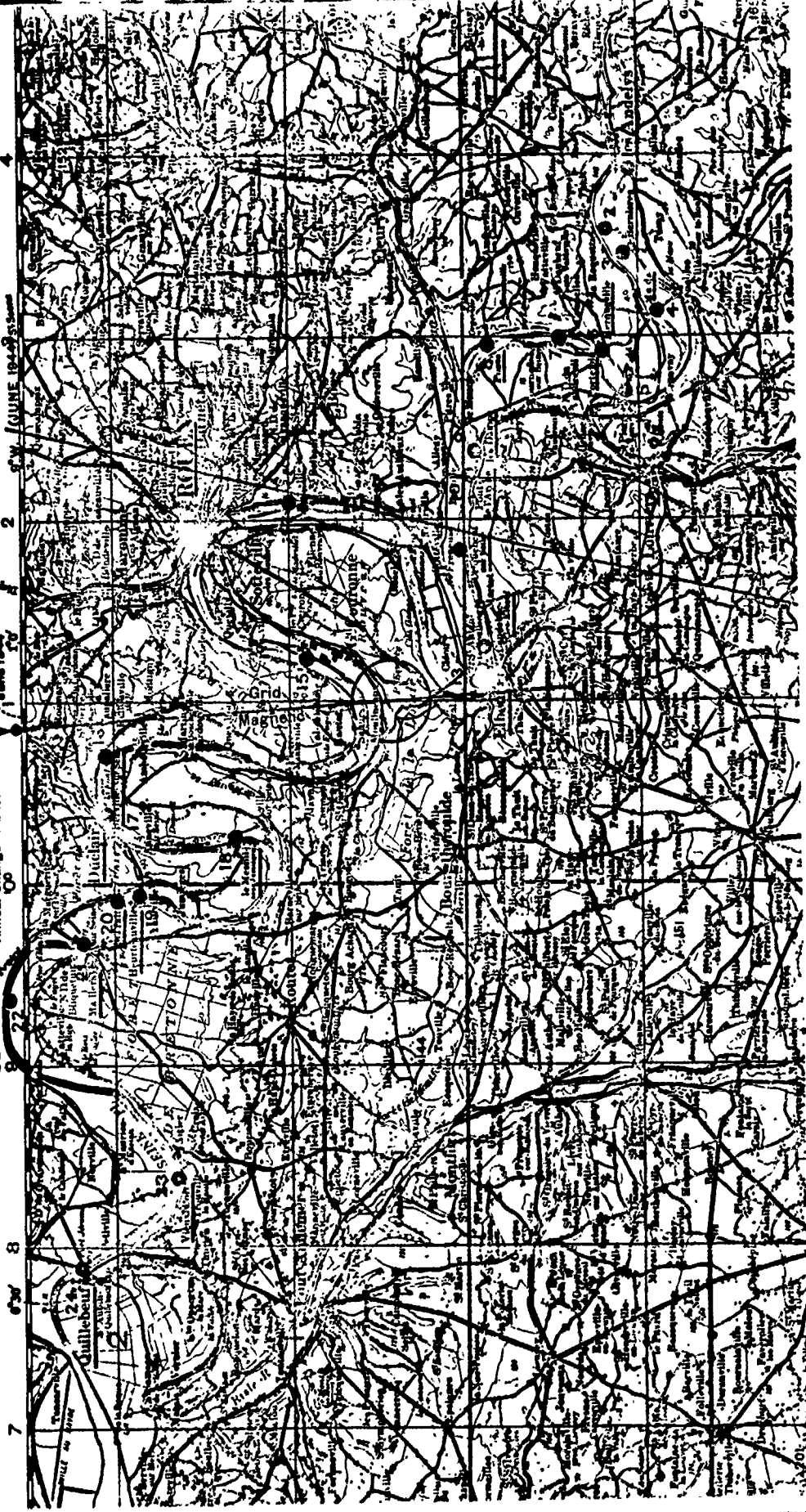
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PART V

DISCUSSION OF RESULTS AND CONCLUSIONS.INTRODUCTION.

The German retreat from Normandy to the SEINE and beyond is by no means the first occasion on which a large scale withdrawal, enforced by land action, has been laid open to air attack. The Turkish retreat through the pass at NUREN, that of the Germans from ALZHEIM, and the British retreats to DUNKIRK and in GREECE are all examples, but in none of those cases, as far as is known, has a detailed study of the resultant casualties been made.

The results of such air attacks are primarily of importance to the advancing army who may have to fight once more against the survivors; it therefore appears relevant to discuss from the military point of view the results of the survey that has been made and, notwithstanding the very great success achieved by the air forces, to consider how even greater success might have been achieved with the resources available.

1. TOTAL CASUALTIES.

(a) At Appendix K are two tables; the first shows the totals found during the ground survey and the second gives figures amended to allow for vehicles which were missed. The percentages added in the case of the Pocket were arrived at by examining two small areas in very great detail to compare side roads with main roads. In the Shambles again only a small addition had been made because the area was thoroughly searched. In the Chase, where the examination was not so complete, high percentages have been added. In round figures the amended totals are as follows:

Vehicles and Guns

POCKET	- 1500
SHAMBLES	- 3500
CHASE	- 5000
Grand Total	- 10000

This figure, in view of the nature of the estimate for the "Chase", is an approximation which however is unlikely to be in error by more than 2000 either way.

(b) We have been unable to obtain a figure for the total number of mechanically-propelled vehicles that the German army had in Normandy, but there were known to have been 16 Infantry and 10 Panzer divisions. Had these been up to strength, which they certainly were not, the figure would have been about 45,000 without including non-divisional transport. It is, however, known from captured documents that they were up to 60% strength in artillery and it is therefore reasonable to assume that, including the great number of impressed vehicles used in the retreat, the Germans must have had at least 30,000 vehicles. It thus appears that two-thirds of this total was withdrawn to the far side of the SEINE and that had the number of casualties been doubled it would have made a considerable difference to the enemy's subsequent ability to retreat and resist.

2. COMPARISON OF CASUALTIES AND CLAIMS.

As it is of value to the army to know how many casualties the enemy had suffered and pilots' reports are the only immediately available source of such information, it is interesting to compare the casualties due to air attack with the claims made.

(a) Total claims.

In the Pocket casualties directly due to air attack have been quite accurately assessed at 359, with a possible addition on account of missed vehicles which might bring it up to 500. In the Shambles an estimate of 800 has been made. For the Chase only a very rough estimate can be made, but as many as 2000 would be reasonable. This yields a total of over 3000.

Details of sorties by Spitfires, Typhoon and Mustang aircraft of 2nd T.A.F. and by P-38s and P-47s of the IX U.S.A.A.F. together with claims for vehicles destroyed in the areas which we have covered have been provided by G.R.S., 2nd T.A.F., and L-2, IX U.S.A.A.F. respectively. The significant figures are as follows:-

Sorties flown	9896	2891	12787
Claims for MT dest.	3340	2520	5860
Claims for Armour dest.	257	134	391
Total claims	3597	2654	6251
Claims per sortie	0.36	0.83	0.48

Although our estimate of over 3000 for the total casualties due directly to air action only is very approximate, the total is certainly less than the total claims made by the two air forces. However, there is no difference of order between totals of claims and casualties, and it is therefore reasonable to accept the former as having been a fair measure of the latter.

(b) ~~Claims for labour.~~

The particular claims for destruction of armour cannot be upheld. Of the available weapons bombs, cannon, and machine gun can only be expected to destroy heavily armoured vehicles on exceptional occasions and had they been a common cause of tank casualties we could not have failed to have observed it. 222 claims for destruction of armour were made by Typhoon pilots and presumably fired Rocket Projectiles (R.P.), but out of a total of 456 heavily armoured vehicles (tanks and S.P. guns) counted 301 were examined in detail and only 10 found to have been destroyed by R.P. Even if armoured troop carriers are included, it is found that only three out of the 57 examined were destroyed by R.P. If armoured troop carriers destroyed by cannon or machine gun are included, a total more nearly approaching the claims might be obtained, but if such vehicles, which are readily distinguishable from A.F.'s, are claimed as armour, this should be discontinued as militarily they are only of minor importance compared to S.P.s.

It seems hardly to lie in our province to examine this discrepancy in further detail, nor from the military point of view is there much to be gained by doing so. The facts that remain are that 456 tanks and 8.8. guns were actually counted, and the total is certainly greater, while only about 250 are estimated to have crossed the SEINE. It follows that owing to the conditions imposed by the retreat, and with the present state of reliability of German armour, a very large proportion of that armour was lost.

3. EFFECTIVENESS OF 'ELPONS.

The principal weapons used for the direct destruction of enemy vehicles and equipment were cannon, machine gun, R.P., and bombs.

We have not been able to differentiate at all clearly between the relative effectiveness of the first two; both appear to have been very deadly to all except heavily armoured vehicles and the figures given in the preceding parts of the report speak for themselves. As indicated in 2(b) above, R.P. have not produced the results against armour which might have been hoped for, whilst against soft vehicles they are clearly less suitable than cannon and machine gun fire. It is suggested that R.P. in its present form suffers the grave disadvantage of being virtually a "one shot" weapon which even in the hands of the most skilful pilot has poor accuracy, whereas the protracted burst of fire from cannon or machine gun gives a far greater chance of scoring hits.

There was little scope for the really effective use of bombs as suitable area targets seldom presented themselves, but in the case of the one ideal target near ROUEN the results were highly satisfactory.

4. INDIRECT EFFECTS OF AIR ATTACK:

Statements of P.O.s have shown how traffic was disorganized by air action. The three principal effects appear to have been:

- (1) Movement was restricted to the night until congestion and haste positively impelled day movement.
- (11) Crews had to stop and take cover when aircraft appeared.
- (11f) Vehicles were driven off main roads on to the side roads.

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U.S.A.A.F.	TOTAL
2891	12787
2520	5860
134	391
2654	6251
0.83	0.19

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It is hardly possible to assess these effects numerically in terms of casualties, but the delay resulting from them must have been largely responsible for inability of the enemy to get away, and consequently for a large number of vehicles abandoned or destroyed by their crews.

5. INTERDICTION.

In three places the densities of casualties were particularly high, namely near the mouth of the SEINE near ROUEN and in the Shembles area. Elsewhere the casualties were fairly uniformly spread along roads, and, although it is known that temporary obstructions did occur, they could be cleared and so delayed rather than prevented the enemy's escape. Where the densities were high, interdiction of enemy movement was virtually established, in the first instance by the natural obstacle of the river SEINE, and in the last by the action of ground forces.

It is considered that the evidence points to interdiction as being the primary task to be performed against a rapidly retreating enemy so that his retreat can be stopped and the infliction of casualties should in the first instance be of importance only in so far as it contributes towards interdiction. Once the interdiction has been established congestion must result and casualties can be inflicted at a very high rate by any weapon that can be brought to bear.

If the policy of interdiction followed by destruction could be adopted, it is considered that the total casualties resulting would in the end be higher than if destruction alone were concentrated upon. In the particular retreat which has been considered, what was a very severe defeat might have approximated to a complete rout. It should however be borne in mind that unless the interdiction is successful the results will probably be less satisfactory than if the effort had been concentrated only on destruction.

APPENDIX K

TOTAL ENEMY LOSSES IN VEHICLES AND EQUIPMENT DURING THE RETREAT.

A. Totals found by No. 2 Operational Research Section.

CATEGORY	POCKET	SHAMBLES	CHASE	TOTAL
Tanks and S.P. guns	121	185	150	456
Lightly armoured vchs.	56	157	154	367
Lorries, cars and H/Cs.	1033	2447	3178	6648
Guns	60	252	165	478
TOTALS:	1270	3041	3545	7959

B. Estimated totals allowing for vehicles not seen.

Tanks and S.P. guns	169 (121 + 40%)	222 (185 + 20%)	240 (150 + 60%)	631
Lightly armoured vchs.	76 (56 + 40%)	165 (157 + 20%)	246 (154 + 60%)	512
Lorries, cars, and H/Cs.	1239 (1033 + 20%)	2592 (2447 + 10%)	4449 (3178 + 40%)	8380
Guns	72 (60 + 20%)	277 (252 + 10%)	232 (165 + 40%)	581
REVISED TOTALS:	1556	3179	5167	10104

ADDENDA to No. 2 O.R.S. Report No. 15.A. COMMENTS FROM 2ND T.A.F.

O.R.S. Report No. 15, "Enemy Casualties in Vehicles and Equipment during the Retreat from NORMANDY to the SEINE" has been studied by M1 2nd T.A.F. The following is a summary of the comments that have been made:

1. It would be wrong to regard the data provided in the report as yielding information on which to make recommendations for changes in weapons, tactics or operational doctrine, although the factual side of the report can itself be accepted.

2. Part V - Introduction.

Whereas the large scale withdrawal is stated to have been "enforced by land action", the ultimate cause of the withdrawal should more properly have been attributed to the factor of combined service action.

3. Part V - para. 2 (b).

(c) The air claims against armour are certainly too high if armour is interpreted as meaning A.F.Vs. However, in close country and under operational conditions, it is not agreed that armoured troop carriers are readily distinguishable from A.F.Vs.

(b) The circumstances of the examination did not make it possible to take account of the moral effects of R.P. A lack of effectiveness in causing material damage cannot be accepted as a reason for abandoning R.P. as a weapon against armour until it can be replaced by something better.

4. Part V - para. 4.

The demoralising effect of air action is not adequately stressed and the report should be considered as relating only to the limited aspect of the material effects of air action.

5. Part V - Introduction and para. 5.

No conclusion aimed at deciding "how even greater success might have been achieved with the resources available" can be based on examination of results of destruction alone. Other factors must be taken into account, such as weather, enemy flick, improper use of Red Cross and limitations of bomb line. In fact, a policy of interdiction was followed in so far as it was tactically possible, and, with suitable terrain such as the crossings of the SEINE, it was successful.

B. ADDITIONAL VEHICLES.

Reference Part V para. 1 (n) and Appendix K.

1. Since this report was published a census has been carried out by 197 Inf Bde Battlefield Clearance Group over an area almost identical with that which we named "the Shambles". The results of this census show that the percentages added for vehicles missed in this area were too small. The 197 Inf Bde results compared with the estimates given at Appendix K, part B, column 2, are shown below:

	<u>O.R.S.</u>	<u>197 Inf Bde</u>
Tanks and S.P. guns	222	358
Tracked vehicles, lorries, and cars	2880	4715
TOTAL:	3579	5644

2. As far as can be ascertained, the difference arises entirely from vehicles and equipment which we failed to discover in narrow lanes, orchards, farm-yards, and woods. Such vehicles were in almost every case abandoned, consequently the effect on the accuracy of the report is quantitative rather than qualitative.

3. The final estimate for total losses sustained by the enemy in the whole area, as given at Appendix K, should be amended to read "12369" instead of "10104".

C. MISSION.

Part V, para. 3 - Effectiveness of Weapons.

By an unfortunate oversight the following sentence was omitted from the final draft of the report:-

"Whenever an R.P. was found to have hit an armoured vehicle, that vehicle was invariably destroyed."

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JOINT REPORT NO. 1

AIR ATTACK ON GERMANY ARMOUR IN THE ARDENNES SALIENT

1. When No. 2 O.R.S. started on this investigation early in January 1945, the tactical situation was such that very few of the claims for the destruction of enemy armour by the allied air forces were within our lines. O.R.S./2 T.A.F. joined in at the middle of the month and, by that time, the snow lay so thick on the ground and covered the vehicles so thoroughly that the progress of the joint investigation was of necessity very slow. The location and identification of rocket craters and of patches of burnt ground resulting from Napalm fire bombs was impossible.

2. In the period 17th December, 1944, to 16th January, 1945, the three tactical air forces, 2 T.A.F., IX T.A.C. and XIX T.A.C., claimed the destruction of 413 armoured vehicles in the area; of these 324 were described as tanks. The claims were made at 154 different points throughout the Ardennes salient. At the time of writing it has only been possible to search the neighbourhood of 30 such points involving claims for the destruction of 66 tanks and 24 other armoured vehicles. These points are shown in the map at Appendix D. The detailed notes given at Appendix A show that on each within two or three kilometres of each claim was searched and, in the course of this, 101 German armoured vehicles were examined; all these lay in the northern half of the salient.

3. The table below shows the distribution as to causes of the 101 casualties to German armour which were examined.

CAUSE		ROYAL TIGER	PANTHER	MARK IV	S.P. GUN	LIGHT ARMOUR	TOTAL
AIR:	(Bomb	1	0	0	0	0	1
	(Possible air attack	0	3	0	2+	1-	6+
GROUND:	(A.P. shot	1	16	1	10+	8	36+
	(H.E. shell	0	3	0	1	4	8
	(Demolition	2	10	1	0	4	17
	(Abandoned	1	10	0	4	7	22
Other causes		0	0	1	1	0	2
Unknown		0	5	2	1	2	10
TOTAL		5	47	5	18	26	101

+ One S.P. gun had A.P. penetrations and a possible rocket strike and has been included under both counts.

4. In a number of cases bombs had been dropped among tanks that had already been destroyed by ground forces but even when they were as close as 15 yards from such "dead" tanks no extra damage had been caused.

5. 18 P.W. from armoured formations (see Appendix C) were interrogated to obtain their impressions of the effectiveness of air attack against armour and information about their recovery system. Unfortunately no members of tank crews from the area examined were contacted. Only one P.W. had seen or heard of a tank being damaged from air attack; he came from a workshop and quoted two cases of damage to gun barrels and three to engines by cannon fire and one direct hit by a bomb.

6. Information was provided that the enemy have an efficient recovery organisation (at least on paper), but that it is normally devoted to recovering tanks with slight damage or mechanical defects. Burnt out or destroyed tanks are almost invariably left. It seems unlikely, therefore, that completely destroyed tanks, such as those which received direct hits from bombs, would be recovered in preference to those with little or no damage, many of which were found in the area. Statements from a number of local inhabitants who had stayed in the area during the fighting confirm this.

7. Visits have been made to many Tank Destroyer Battalions and other American units involved in the fighting; all the Ordnance Evacuation Companies, who were responsible for clearing the roads and recording the location of allied and enemy vehicles on the battlefield, have also been visited. By collating the information gathered from all these sources it has been possible to arrive at an estimate for the number of tanks, S.P. guns and armoured vehicles lost to the enemy in the northern half of the salient. This estimate, which amounts to 300, is shown in detail at Appendix B together with several other facts of general interest which have emerged from the investigation.

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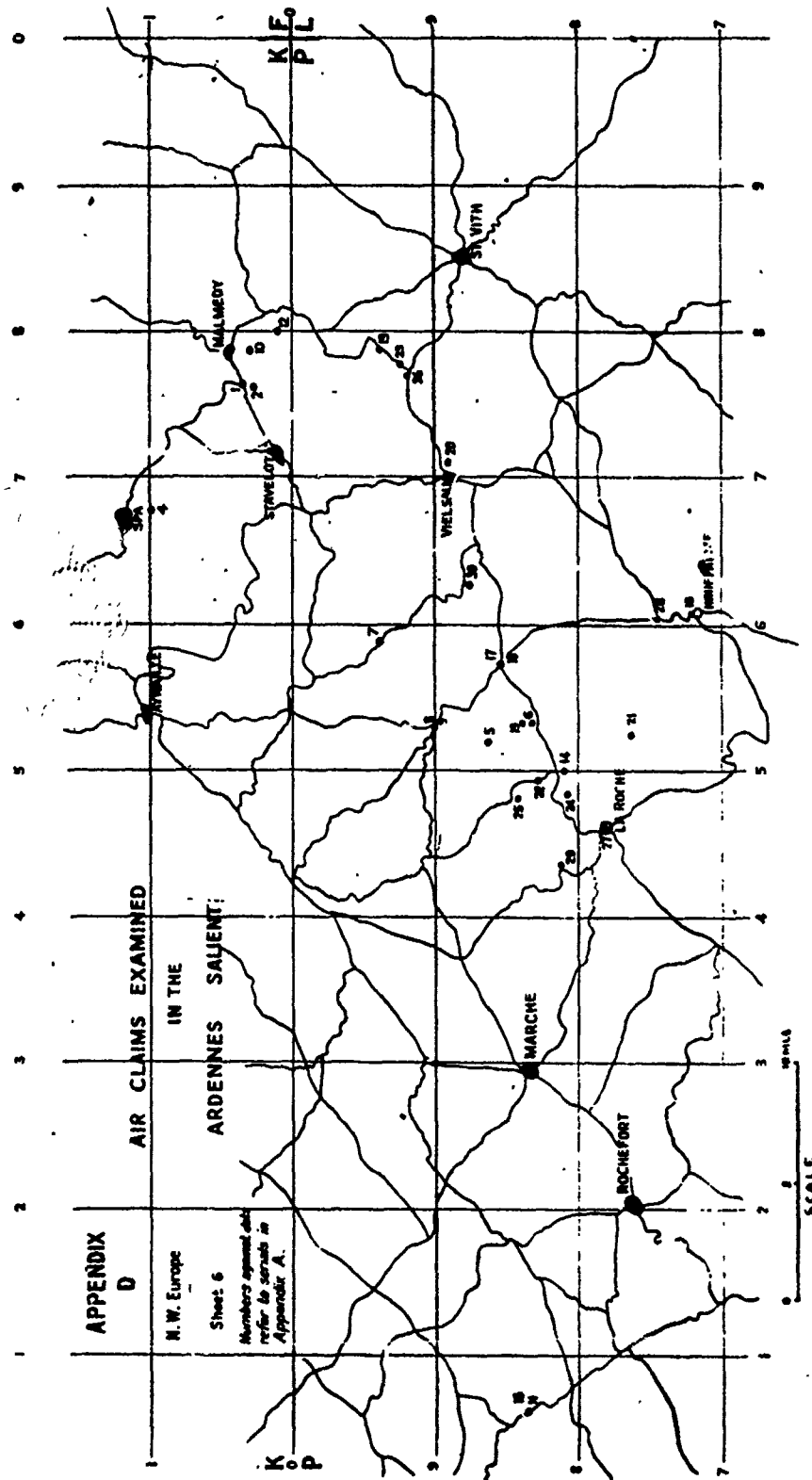
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8. It is believed by the writers of this report that the contribution of the air forces towards the stemming and final elimination of the enemy thrust into Belgium was very considerable, but that it was not by the direct destruction of armour, which appears to have been insignificant; but rather by the strafing and bombing of the supply routes, which prevented essential supplies from reaching the front. More evidence is being collected on this aspect of the air attack and a separate report will be issued later.

APPENDIX A

1. 18 Dec. 44. IX T.A.C.

4 P 47s with 8 x 500 lb G.P. bombs fused 8 - 15 secs delay.

AIR CLAIM: 4 tanks destroyed K.7603.

GROUND CHECK: In and around MALMEDY were found 4 Panthers, all disguised as Shermans by the addition of thin sheet metal superstructures. One of these had been destroyed by the crew and the others by American artillery.

2. 18 Dec. 44. IX T.A.C.

3 P 47s with 6 x 500 lb G.P. bombs fused 8 - 15 secs delay.

AIR CLAIM: 3 tanks destroyed K.7603.

GROUND CHECK: See serial 1 above.

3. 18 Dec. 44. IX T.A.C.

14 P 47s with 28 x 500 lb G.P. bombs fused inst., 1/40 secs.

AIR CLAIM: 12 - 15 tanks destroyed K 710003 - K 717025.

GROUND CHECK: At K 700000 was a Royal Tiger facing east; there were no visible signs of damage; no bomb craters found. The fighting compartment had been burnt out; it is possible that the fuel had run out. At P 685993 was another Royal Tiger facing east but its gun was pointing west. The rear half of the turret was smashed and the roof over the driver's and hull-gunner's compartment was stove in. A bomb crater, probably 500 lb G.P. with 1/40 sec delay, was found some 17 yards to the east of the tank. The complete absence of hatch remains suggests that the crew had bailed out on the approach of the aircraft. The destruction of this tank was seen by an officer of 740 Tank Bn which was being held up by the Royal Tiger; he said that it was hit by a bomb dropped from a P38 on 25th December, 1944.

4. 18 Dec. 44. IX T.A.C.

4 P 47s with 8 x 500 lb G.P. bombs fused 8 - 11 secs delay.

AIR CLAIM: 2 medium tanks destroyed K. 6810.

GROUND CHECK: Nothing found in the area.

5. 24 Dec. 44. IX T.A.C.

4 P 47s w/ 10 rockets and strafing.

AIR CLAIM: 12 armoured vehicles destroyed P.519862.

GROUND CHECK: At P 515875 were two Panthers both destroyed by A.P. shot, one through the side plating and the other into the engine compartment.

At P 513864 was a Panther destroyed by 4 75 mm. A.P. penetrations. There were bomb craters in the area.

6. 24 Dec. 44. IX T.A.C.

14 P 47s with 37 x 500 lb G.P. bombs fused 1/10, 1/40 sec.

AIR CLAIM: 1 tank destroyed P.533831.

92.

GROUND CHECK: At P 554837 was a 75 mm S.P. gun with two A.P. penetrations in the front plate; it was brewed up. There was also a large hole which had cranked the left half of the front plate; this hole was too large to have been caused by 75 or 90 mm A.P. and it is just possible that a High Velocity Aircraft Rocket with 100 lb head had done it. There were no craters nearby. Date of death on two German graves alongside were 1 and 5 Jan. 45.

7.

24 Dec. 44.

IX T.A.C.

11 P 47s with 22 x 500 lb G.P. bombs fused inst.

AIR CLAIM: 1 armoured vehicle destroyed, P-5993.

GROUND CHECK: At P 589937 was an Armoured Troop Carrier abandoned at the roadside with no damage whatsoever. At P 589936 a second A.T.C. was found overturned and with its machine gun damaged. A third had been collected by 462 Ord. Evac. Co from P 587938 in good condition. No bomb craters were found within the area. The actual square quoted in the claim is an area of precipitous hills covered with trees.

8.

25 Dec. 44.

IX T.A.C.

3 P 38s with 6 x 500 lb G.P. bombs fused inst.

AIR CLAIM: 2 tanks destroyed P-5390.

GROUND CHECK: In this area were found 11 Panthers in the conditions described below:

4 were almost completely undamaged although three tracks were off.
5 had no signs of external damage but had been burnt out.
2 had been destroyed by A.P. shots.
There were some bomb craters in the area.

9.

25 Dec. 44.

IX T.A.C.

12 P 47s with 23 x 500 lb bombs fused 1/10, 1/40 sec and strafing.

AIR CLAIM: 10 plus tanks destroyed P-5390.

GROUND CHECK: See Serial 8 above.

10.

25 Dec. 44.

2 T.A.P.

8 Typhoons with 60 Rockets.

AIR CLAIM: 1 A.F.V. destroyed K-7903.

GROUND CHECK: At K 7803 were four Panthers disguised as Shermans (see Serial 1).

At K 8002 was a 75 mm S.P. gun also disguised as a Sherman; this had been abandoned practically intact after an H.E. round had caused minor damage at the rear. No rocket craters could be found in the deep snow.

11.

25 Dec. 44.

IX T.A.C.

1 P 47 with 2 x 165 gallon Napalm Fire bomb.

AIR CLAIM: 1 tank burnt out P-0683.

GROUND CHECK: At P 065832 was a Panther with some damage caused to the muzzle-brake and superficial damage to the turret hatch. At P 064832 was a Mk. IV completely burnt out with 2 A.P. penetrations.

There were also 3 Armoured Troop Carriers abandoned undamaged.

12.

26 Dec. 44.

IX T.A.C.

10 P 47s with 17 x 500 lb G.P. bombs fused 1/10, 1/40 sec, and 4 rockets.

AIR CLAIM: 1 Medium Tank destroyed K-8001.

GROUND CHECK: At K 8002 was the 75 mm S.P. gun described in serial 10 above.

13.

26 Dec. 44.

IX T.A.C.

7 P 47s with 14 x 500 lb G.P. bombs fused 1/10, 1/40 sec.

AIR CLAIM: 1 Medium tank destroyed P-790937.

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GROUND CHECK: At P 780920 was a Panther which had probably been bogged down. There were no signs of external damage and it had been brewed up; destroyed either by crew or Americans. There was a bomb crater 40 yards away and another smaller one (either shell or rocket) only 15 yds from the tank. At P 779919 was another Panther. An A.P. shot had penetrated the driver's compartment and damaged the transmission as a result of which the tank was not a runner but its turret could be rotated; a track was missing and a tow rope attached.

At P 778918 was a brewed up Panther without tracks. A hole in the lid of the driver's compartment might have been caused by a rocket; about 15 yards away was a possible rocket crater.

At P 777919 was a 75 mm S.P. gun brewed up after four A.P. penetrations.

Note that no rockets were fired in this attack.

14. 26 Dec. 44. IX T.A.C.

10 P 38s with 20 x 500 lb G.P. bombs fused inst.

AIR CLAIM: 5 Tiger tanks destroyed P.5081.

GROUND CHECK: At P 506810 were 2 very large tracked personnel carriers; these might have been destroyed by bomb fragments and later removed from the proximity of the craters.

At P 516811 were 2 Panthers 50 yards from the road, very thickly covered by snow and in the middle of a minefield. The cause of their destruction is unknown.

15. 26 Dec. 44. IX T.A.C.

11 P 38s with 13 x 500 lb G.P. bombs and 7 x 165 gallon Napalm Fire Bombs.

AIR CLAIM: The town of NOUFFELISE was set on fire.
1 tank destroyed leaving the town P.6172.

GROUND CHECK: At P 607726 was a Panther on the road out of the town; this had been brewed up. The cover of the engine compartment was missing and the floor was blown out; there were cracks and bulges in the rear plating but the engine block was well preserved which suggests the use of several demolition charges rather than bomb damage. No bomb craters were found near the tank.

16. 26 Dec. 44. 2 T.A.F.

7 Typhoons with 53 rockets.

AIR CLAIM: 2 tanks destroyed P 0683.

GROUND CHECK: See Serial 11 above.

17. 27 Dec. 44. IX T.A.C.

9 P 38s with 10 x 500 lb G.P. bombs and 6 x 165 gallon Napalm Fire Bombs.

AIR CLAIM: 1 tank destroyed at crossroads, P 573857.

GROUND CHECK: At this point, a crossroads, were a number of Sherman tanks, American S.P. guns and some R.A.F. soft transport all destroyed by shellfire or their crews. Bomb craters were found around the crossroads. There was a German Armoured Troop Carrier at P 580849 which had been destroyed by fire.

18. 27 Dec. 44. IX T.A.C.

4 P 38s with 4 x 500 lb G.P. bombs fused inst. and 3 x 165 gallon Napalms.

AIR CLAIM: 2 tanks destroyed P.5785.

GROUND CHECK: See Serial 17 above.

19. 27 Dec. 44. IX T.A.C.

4 P 38s with 4 x 500 lb G.P. bombs fused inst. and 3 x 165 gallon Napalms.

AIR CLAIM: 1 tank destroyed P 5384.

GROUND CHECK: Nothing was found within 2 kilometres of the map reference given. Square P 5384 is completely wooded.

94.

20. 27 Dec. 44. IX T.A.C.

6 P 38s with 8 x 500 lb G.P. bombs fused inst. and 4 x 165 gallon Napalm.

AIR CLAIM: 2 tanks destroyed P 7109.

GROUND CHECK: Nothing was found except some bomb damage to the town of VIELSAUM which has also been visited by the mediums of 2 Group, R.A.F.

21. 27 Dec. 44. IX T.A.C.

4 P 38s with 8 x 500 lb G.P. bombs fused inst.

AIR CLAIM: 1 tank destroyed P 5276.

GROUND CHECK: At P 551740, between FILLY and MONTMONT, were two Armoured Recovery vehicles on Panther chassis; both had been abandoned and no bomb craters were found.

22. 27 Dec. 44. IX T.A.C.

4 P 47s with 8 x 500 lb G.P. bombs.

AIR CLAIM: 2 tanks destroyed P 495824.

GROUND CHECK: At P 497823 was a Panther brewed up; definitely blown up from the inside; both tracks were broken and the sprocket on one side was off thus giving the impression that repairs had been in progress.

23. 31 Dec. 44. 2 T.A.F.

8 Typhoons with 57 rockets.

AIR CLAIM: 2 tanks destroyed P 7092.

GROUND CHECK: At P 774920 was a brewed up Panther; part of the turret was blown out. It was impossible to determine the cause. Quite close was a 75 mm S.P. gun on a Mark III chassis; this was also completely burnt out. It had been hit by A.P. shots on the turret and lower hull. There were signs of cannon or machine gun strikes from the air though they had not penetrated. This S.P. gun was found only 15 yards away from the edge of a bomb crater.

24. 1 Jan. 45. IX T.A.C.

14 P 47s with 27 x 1000 lb G.P. bombs fused inst.

AIR CLAIM: 6 armoured vehicles destroyed P 485808.

GROUND CHECK: At P 471810 was an Armoured Troop Carrier in pieces at the roadside; it is suggested that engineers had demolished it to clear the road but it might well have been bomb damage had there been any other signs of bombing in the area.

25. 1 Jan. 45. IX T.A.C.

12 P 38s with 22 x 500 lb and 1 1000 lb G.P. bombs fused inst.

AIR CLAIM: 2 tanks destroyed P 485840.

GROUND CHECK: At P 479850 was an armoured troop carrier brewed up. It had been hit by an H.E. shell in the front and the surrounding trees were much cut about by shellfire.

26. 2 Jan. 45. IX T.A.C.

7 P 47s with 14 x 1000 lb G.P. bombs fused inst.

AIR CLAIM: 1 tank destroyed P 773918.

GROUND CHECK: For ground check see Serial 23, which refers to this area, where a bomb crater was found very near an S.P. gun.

27. 2 Jan. 45. IX T.A.C.

4 P 47s with 8 x 1000 lb G.P. bombs fused inst.

AIR CLAIM: 4 tanks destroyed P 450729.

GROUND CHECK: At this point were a number of small huts which might have been taken for tanks from the air. There were many bomb craters but Lt. ROCHE had also been bombed by 2 Group, R.A.F.

28. 5 Jan. 45.

IX T.A.C.

7 P 47s with 14 x 500 lb G.P. bombs fused 1/10, 1/40.

AIR CLAIM: 1 armoured vehicle destroyed P.605742.

GROUND CHECK: Lt P 604747 was a large tracked personnel carrier off the road for repairs after a hit in the radiator; bonnet and radiator had been removed. Then a large explosion had taken place in the engine compartment with a rocket strike or a demolition charge but not a bomb. Numerous cannon or machine gun strikes from above were observed in the bodywork. It is unlikely that the hole in the radiator had been caused by a bomb splinter as there were no other fragment strikes and the tyres were not punctured.

29. 2 Jan. 45.

IX T.A.C.

7 P 47s with 14 x 1000 lb G.P. bombs fused inst.

AIR CLAIM: 3 tanks destroyed P.4381.

GROUND CHECK: Bomb craters were found in this area which contained a number of brewed up Shermans but no German armour.

30. 5 Jan. 45.

IX T.A.C.

4 P 47s with 8 x 500 lb G.P. bombs fused 1/10, 1/40 sec.

AIR CLAIM: 3 armoured vehicles destroyed P.627877.

GROUND CHECK: Lt P 627879 was a Panther on its side at the foot of a steep embankment. Inspection plates were off, cylinder head removed and also several bogies off on the exposed side all suggesting cannibalisation afterwards. Otherwise no damage except what would result from falling down the slope. It is possible that it was unable to turn the corner when coming down the hill.

There were no craters in the neighbourhood.

APPENDIX B

1. An estimate of the armour lost to the enemy during the period 17th December, 1944 to 16th January, 1945 in the northern half of the ARDENNES Salient. As all duplications have been eliminated the figures quoted for the various units are less than they recorded.

SOURCE OF INFORMATION	Royal Tiger	Tiger	Panther	Mark IV	Other Tanks	S.P. Guns	Other Armour	TOTAL
Examined by G.R.S.	5	0	47	5	0	18	26	101
Recorded by Ord Evno Coys	1	0	18	12	5	12	10	58
Claimed by Tank Dest Bns	0	2	22	8	33	0	0	65
Claimed by Tk Bns	8	0	19	8	15	0	8	58
Claimed by 83 Inf Div	0	0	7	11	0	0	0	18
TOTAL:	14	2	113	44	53	30	44	300

* There were, no doubt, many armoured vehicles among those described as "half-tracks" but, except where definitely described as armoured, these have been ignored.

2. The claims for destruction of armoured vehicles by the tactical air forces were as follows:

	IN THE AREA EXAMINED			IN THE WHOLE SALIENT		
	Tanks	A.Vs.	Total	Tanks	A.Vs.	Total
IX T.A.C.	62	23	85	140	69	209
XIX T.A.C.	2	0	2	176	19	195
2 T.A.F.	2	1	3	8	1	9
TOTALS	66	24	90	324	89	413

3. In the attacks resulting in claim for the destruction of armour in the salient the following were used:-

	BOMBS			ROCKETS
	G.P.	Frag	Fire	
IX T.A.C.	1110	34	54	98
XIX T.A.C.	530	132	111	134
2 T.A.F.	-	-	-	340
TOTALS	1640	166	165	572

In addition many of the tanks claimed by IX and XIX T.A.Cs. were attacked by H.G. fire and some only by this means.

4. Among the non-armoured vehicles seen at the roadside there was an unusually high proportion of tracked and partially tracked vehicles. This was borne out by the findings of the Ordnance Evacuation Companies.

5. Civilians of some standing, such as the local "maire" or "cure", were interviewed in a number of villages in the LA ROCHE area. None had ever seen tanks on transporters but a few cases were reported of damaged tanks being towed back from the front by other tanks. The great age and poor quality of the M.T. in use by the enemy was noted by the Belgians who said that the Germans had great difficulty in climbing the many hills. Although this area was well forward there was a great amount of horse-drawn transport; one "maire" said that between 25 and 30 wounded horses were brought back to his village every day for veterinary treatment and subsequent evacuation to the rear. Trains of handcarts towed by Norwegian ponies were mentioned.

APPENDIX C

Summary of Interrogations of P.W. on the subjects of Air Attack on Tanks and the recovery of Damaged Tanks.

1. Urfs. L(103 Ps Abt.) had once been attacked 17 times in one day by fighters and fighter-bombers but his tank suffered only superficial damage.
2. Obergefreiter R. had driven tanks and S.P. guns for 4 years. He had been shot up on four occasions, 3 times by A.P. and once by H.E., but had not experienced a blow-up. Each time his A.P.V. had been recovered.
3. Urfs. R. (361 Ps Jager Bn.) had 5 casualties to his S.P. guns in ALBLCE, none due to air attack, and all had been recovered. He said that all tanks worth salvaging are recovered.
4. Obergefreiter P. was twice attacked by aircraft when on the move; both times the crew stayed in the tank and no damage resulted.
5. Obergefreiter B. (107 Ps Bde) had no experience of air attack.
6. Gefreiter A. (78 Regt.) had driven half-tracks. He saw 2 half-tracker hit by rockets near A.STONE and both were burnt out; five others, knocked out by ground forces, were recovered but the rocket victims were left.

7. Obergefreiter B. had been damaged.

8. Since D. attacked air forces he had seen.

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11. Obergefreiter Since D. He knew of cannon fire.

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7. Obergefreiter S. (3 Pz. Regt.) said that two of the 75 mm S.P. guns in his company had been destroyed by shellfire but he did not see either of them recovered.

8. Signaller W. (130 Pz. Regt.) said that, when conditions were favorable, they were attacked from the air as often as 3 times a day. No tanks had been put out of action by the air force. A bomb fell 10 metres from his tank but no damage was caused. Of the armoured cars he had seen, none had been recovered.

9. Feldwebel P. (33 Pz. Regt.) said that they took cover in woods during air attacks and suffered no casualties. Six of the 14 L.F.Vs. in one company were knocked out by ground forces and three of these were recovered.

10. Pte. S. (an S.P. gun unit) was only once attacked from the air - by 4 fighter bombers. He stayed in his A.F.V. and no damage resulted. Of 3 L.F.Vs. which he had seen knocked out by ground forces, two were blown up and not recovered but the third which did not catch fire was salvaged.

11. Obergefreiter H. (10 S.S.Pz. Regt.) was in the regimental workshop, which had 2 tank transporters and 3 x 18 ton tractors. He said that all but burnt out tanks were recovered. Since D day he had repaired nearly a hundred L.F.Vs. (mostly engine or transmission trouble). He knew of six tanks damaged by air attack, one direct hit from a bomb and 5 caused by 20 mm cannon fire; he knew of no tanks hit by rockets.

12. 2 Pz. (115 Pz. Bn) had never seen any positive results from air attacks on tanks.

13. Crew of a Mk. IV tank (33 Pz. Regt.) stayed inside their tank when attacked from the air. They had not seen any tank knocked out by aerial attack though they thought it just possible that their own had been so hit in the engine. They said that "brew-ups" were never salvaged.

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CHAPTER 4

FIGHTERS AND FIGHTER-BOMBERS AGAINST FORWARD TROOPS.

CONTENTS

Rocket-firing Typhoons in Close Support of Military
Operations. (Joint Report No. 3)

German Flak and Allied Counter-flak Measures
in Operation "VARSITY". (Joint Report No. 4)

JOINT REPORT NO. 3.

ROCKET FIRING TYPHOONS IN CLOSE SUPPORT OF MILITARY OPERATIONS.

INTRODUCTION.

1. An attempt has been made to assess the value of attacks by rocket-firing typhoons used in close support of military operations. The following aspects have been considered:-

- (a) Accuracy.
- (b) Material damage and casualties to the enemy.
- (c) Morale effects on the enemy.
- (d) Morale effects on our troops.

METHOD OF INVESTIGATION.

2. A number of targets in France, Belgium and Holland have been thoroughly examined. Prisoners of war captured after rocket attacks have been interrogated. Opinions have been collected from officers of units which assaulted positions that had been attacked by R.F. These units include 3rd Canadian, 3rd and 43rd British and 15th Scottish Infantry Divisions.

ACCURACY.

3. By far the best source of data for assessing and analysing accuracy would be photographic records made in the attacking aircraft. As such records are not yet available the method adopted has been to study the distribution of fall of shot in target areas or to obtain the percentage of strikes on specific targets.

4. Distributions of fall of shot have been obtained as a result of a detailed examination of 12 target areas in the BRESKENS Pocket. Some details of these attacks are given in Table 1, and maps showing the fall of shot are at Appendix A. In all cases the examination showed no clearly definable target and it is difficult to assess accuracy, as the aiming point is not known, nor whether individual pilots in one attack used the same aiming point.

TABLE 1.

TARGETS IN THE BRESKENS POCKET.

T A R G E T S			R O C K E T S				
Serial	Description	Map Ref	No. Fired	Craters and Unexploded bombs in T.L.	Probable strikes on buildings and in water	Total R.F. accounted for	Radius of 90% circle in yds +
1	Houses	018132	32	23	8	31	73
2	Cross rds & MG Post	024127	30	5	3	8	46
3	Def Posn & Guns	002174	30	17	4	21	39
4	Def Posn & Bldgs	997177	32	27	5	32	109
5	Def Posn & Bldgs	994183	24	10	1	11	35
6	Strong point Road junction	006180) 004185)	54	42	8	50	90
7	Strong pt in houses	007154	63	38	2	40	113
8	Def Posn & Str Pt in buildings	996167	64	30	10	40	103
9	Houses	975176	30	39	1	40	96
10	Houses	972172	32	19	5	24	115
11	Field gun & def posns	974164	96	52	12	64	78
12	Gun on roof	922158	32	15	1	16	55

+ The 90% circle includes 90% of the craters and unexploded bombs in the T.L.

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100.

5. Maps showing the fall of shot for attacks on the church towers at YERDAY and ONLOO are shown at Appendix B. In these cases the targets were clearly defined but, on account of their height, the distribution of shots on the ground exaggerates the actual dispersion about the aiming points. A further example of the distribution of shots about clearly defined though multiple aiming points is given in J.A.U. Report No. 14 on an attack on a German 4-gun site.

6. The numbers of strikes were counted on clearly defined though multiple targets in attacks at SOULOGNE and on MICHIEREN ISLAND. The results are as follows:

Target	No. of Rockets Fired	No. of Strikes	% Strikes
4 Large gun emplacements)	216	2	1%
6 Medium gun emplacements)			
3 Large gun emplacements)	104	9	9%
4 Medium gun emplacements)			
4 Medium gun emplacements	62	2	3%
4 Large gun emplacements	47	1	2%

7. These various results are analysed and compared at Appendix C. Although the data are insufficient to be able to give a precise assessment of the accuracy of R.P. in the attacks that have been examined, there is every indication the mean displacement was no less than 25 yds but was probably not very much more. This implies, as would be expected, that R.P. attacks are more accurate than bombing but fall far short of the precision of cannon and machine gun.

8. Average accuracy for all pilots in a number of squadrons whilst at Practice Camp is of the same order as that given in para. 7. The best attainable with the weapon as it is at present is probably represented by the performances of the four best pilots in each squadron; their mean error was about 20 yards.

9. The table below is reproduced from Appendix C and may serve as a practical guide to the effort required to obtain direct hits on typical targets.

TABLE II

Target	Size	Horizontal projected area (45° Dive)	shots hitting target	For 50% chance of hit	
				R.P. needed	Borties
Small gun position	5 yds diameter	19 sq yds	.2	350	44
Panther tank	22'6" x 10'9" x 9'10"	50 sq yds	.5	140	18
Large gun position	10 yds diameter	80 sq yds	.8	63	11
Army hut	60' x 30' x 20'	270 sq yds	2.8	24	3
Large building	120' x 34' x 50'	1000 sq yds	10.0	7	1

MATERIAL DAMAGE AND CASUALTIES.

10. Material damage and casualties are naturally closely associated with accuracy. What follows is principally concerned with what R.P. have done to the objects that have been hit; it supplements that has already been produced in an earlier report by 83 Group, R.A.F.

11. Observed results of strikes by 60 lb S.M.P. rocket are as follows:

(a) Wooden huts and barns are completely demolished.

(b) D

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(b) terrifying

(c) captured rockets

16. With immediate ten minutes with some effect on 15 minutes in no case found the enemy to

17. Some although the exact which has They had aircraft places

18. It and not casualties Appendix

MORALE EFFECTS

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350	4
140	18
88	11
24	3
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accuracy. What follows
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(b) Brick built houses and barns have a large hole knocked in the wall and considerable havoc is wrought inside.

(c) 20 mm AA gun blown to pieces.

(d) Height and rangefinder blown to pieces.

(e) Enemy tanks are knocked out and usually set on fire.

We have not yet found a case of a direct hit on a gun of larger calibre than 20 mm, but there is little doubt that it would be wrecked.

12. Pilots' reports and our own observations show that damage to heavy concrete structures such as gun emplacements or to thick masonry such as church towers is only superficial.

13. Except at CALAIS, where a Canadian M.O. docit with 70 German casualties, 12 of whom were said to have been caused by rockets, the evidence all points to the lethal effect on personnel having been small. This is only to be expected as the 60 lb S.M.P. head with delay fuse can only be seriously lethal if it happens to catch men inside a building which it penetrates; against troops in the open it penetrates too far into the ground to be dangerous. Judging from results of trials, the fragmentation head with instantaneous fuse which is now in use should prove far more dangerous to men in the open, but against troops in small slit trenches it is not likely to have any appreciable advantage. The fragmentation head should however prove superior to the S.M.P. against soft skinned vehicles and guns.

MORALE EFFECTS ON THE ENEMY.

14. About a hundred prisoners of war have been questioned about rocket attacks; approximately half of them had been in positions which were so attacked and all had at some time witnessed such attacks from distances of 1000 metres or more. They varied in morale and physique, from the lowest "Total Mobilisation" types to ex-aircrew personnel serving in a Parachute regiment.

15. Except for a few A.A. gunners, all who had been attacked by rockets expressed their dread of the weapon. The reasons generally given were as follows:

(a) R.P. is an unknown quantity, except to the A.A. gunners. (Exaggerated tales of its terrors have circulated among German troops and typhoons seem to rank with artillery in their disturbing effects).

(b) The noise of the plane as it dives is a danger signal and is, in itself, terrifying.

(c) The noise of the approaching rockets is frightening. In addition, one P.W. captured at WHILE near Boulogne insisted that the most terrifying moment was when the rockets left the plane; he considered it was extremely shattering to watch.

16. With the exception of the G.M.P. A.A. gunners, P.Ws. stated that they always took cover immediately the typhoons started to attack and remained there for times varying from one to ten minutes afterwards; they expected the planes to circle round and strafe their positions with cannon fire. It seems that a succession of attacks suitably timed have a very great effect on morale; if, for instance, three flights of 4 attack a position at intervals of 15 minutes, there is probably a period of 10 to 20 minutes afterwards during which enemy are in no condition to offer stiff resistance to attack by the ground forces. It has even been found that the very presence of our aircraft over the battlefield is sufficient to cause the enemy to remain under cover.

17. Some tank crew prisoners have also been interrogated on the subject of air attacks; although none of them had been subjected to rocket attacks, their statements are of interest. The experienced crews stated that when attacked from the air they remained in their tanks which had suffered no more than superficial damage (cannon strikes or near misses from bombs). They had great difficulty in preventing the inexperienced men from bolting out when our aircraft attacked. Large numbers of undamaged tanks have often been found abandoned at places where air attacks had taken place.

18. It appears quite definite that it is the nature of the attack that upsets the Germans and not the physical damage which it causes. None of the prisoners had seen any damage or casualties caused by the attacks which had so scared them. The incident described in Appendix D is an interesting illustration of the morale effects of rocket attacks.

MORALE EFFECTS ON OUR OWN TROOPS.

19. When asked what they think of rocket-firing Typhoons, Infantry officers have without

* Among the hundreds of abandoned and knocked out tanks that have been examined, no instance has been recorded of a tank that had been hit by R.P. and escaped major damage.

exception been very enthusiastic. They say that the effect on our own troops of a flight of Typhoons diving at the German F.D.Ls. is most marked; it seems to raise their morale even more than it lowers the enemy's. Our troops are impressed by the accuracy with which rockets are fired at targets only a short distance in front of them. So much reliance is placed on the effectiveness of these attacks that when, for reasons not always obvious to the front line troops, a request for close support Typhoons has to be turned down, a feeling of dissatisfaction is apt to arise.

20. The following incident, which occurred near OVERLOOK (E 7632) on 13th October, illustrates the morale effects of rockets.

A battalion in 3 Dr Inf Div was lying along the south side of a wood approximately 300 yards from the enemy who were holding the northern edge of the next wood. During the morning the battalion tried to advance but were driven back across the intervening open ground. Air support was requested and a squadron of Typhoons was ordered to attack the wood at 1400 hrs with R.P. This attack took place as planned and the battalion advanced across the open ground immediately afterwards without opposition. The C.O. of the battalion said that not only had the R.P. successfully unnerved the enemy but they had also put new vigour into his own men who were somewhat disconsolate after the casualties and reverses of the morning.

CONCLUSIONS.

21. The greatest effect of attacks by rocket firing Typhoons in close support is morale, both on the enemy and our own troops. The effect on the enemy is of short duration only and therefore needs to be closely coordinated with military operations.

22. Except against concrete or heavy masonry the destructive effect is satisfactory, but owing to limitations of accuracy a considerable effort is required to obtain hits on small targets.

23. Where destruction is required some guide can be given as to the effort required (Table II).

24. As enemy troops almost invariably take cover when attacked by Typhoons, casualties to personnel in field positions are rare.

APPENDIX C.

1. The large volume of data on dispersion of R.P. has been obtained from the examination of target areas in the BRESLENS Pocket. However, the use to which these data can be put is limited on account of the following:

- (a) the actual aiming points are not known;
- (b) it is not known whether successive pilots in any one attack used the same aiming point.

Analysis of the fall of shot in these attacks yields a figure of 46 yards for the average displacement of the shots from the mean point of impact (M.P.I.) for each individual attack. It also shows that the distribution of all shots taken together with their M.P.I. superimposed is approximately normal.

If the M.P.I.s were close to the aiming points and these were the same for each pilot in any one target area, then the figure of 46 yds would be a good measure of the operational accuracy in these attacks. Introduction of the displacement of the M.P.I. from the aiming point were it known would increase the figure; allowance for the use of several aiming points in any one attack would reduce it. It is only possible to make an educated guess as to which of these unknowns would have had the greater weight, but the likelihood is that the operational accuracy was certainly no better than a mean error of 46 yds.

2. For the attacks on the church towers at VERNLEY and ORLOO the following data can be extracted:

	Displacement of M.P.I. from centre of tower.	Mean displacement of shots from centre of tower	Mean displacement of shots from M.P.I.
VERNLEY	64 yards	111 yards	97.5 yards
ORLOO	62.5 yards	99 yards	72.6 yards

TARGET I.

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TARGET I.

Scale: 23 Yds = 1 inch

M.N.

Wooden Army
Huts

Map Ref
to Grid

H O U S E S

Church
(Hit)

House
(Hit)

House
(Hit)

House
Hit

Barn
Hit

House

H O U S E S

H O U S E S

H O U S E S

Pond

TO OOSTBURG

VILLAGE OF ZUIDZANDE

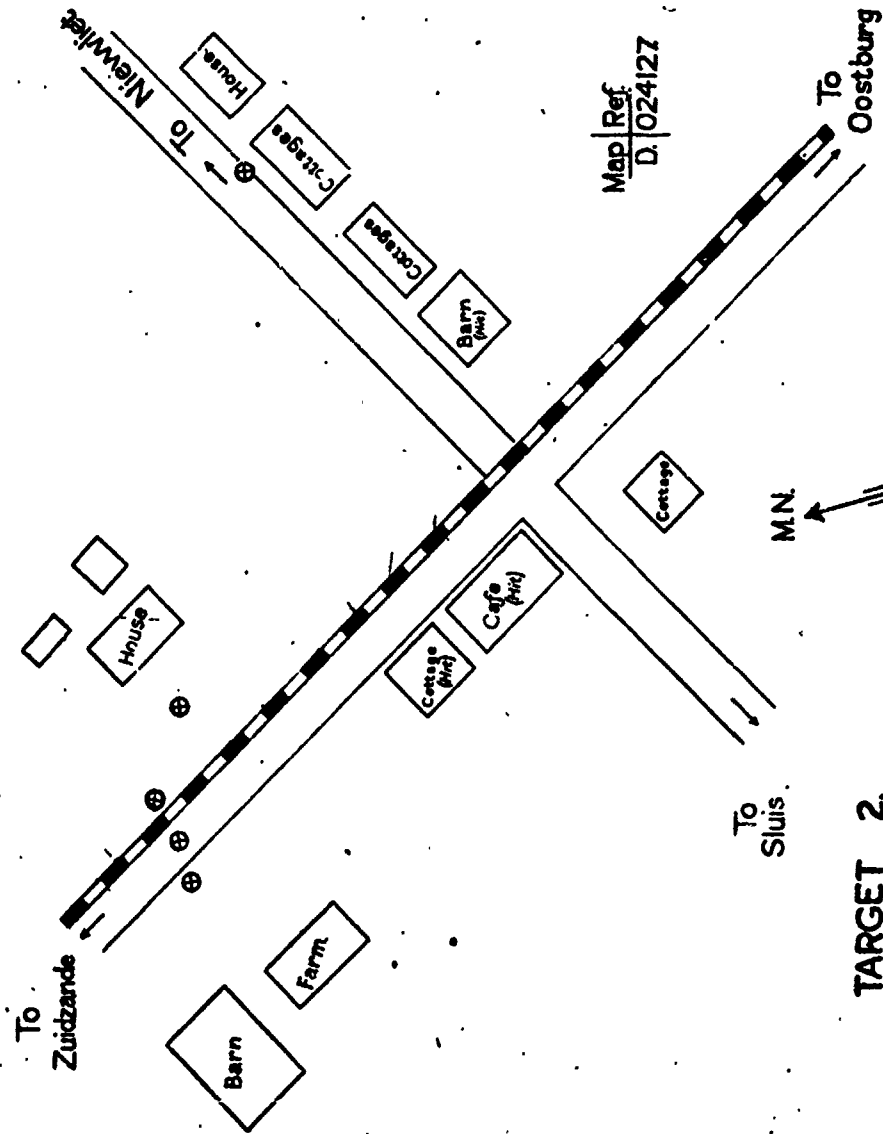
APPENDIX
A

Rocket Crater
Unexploded Rocket

TO NIEUW-AMSTERDAM

To Cadzand

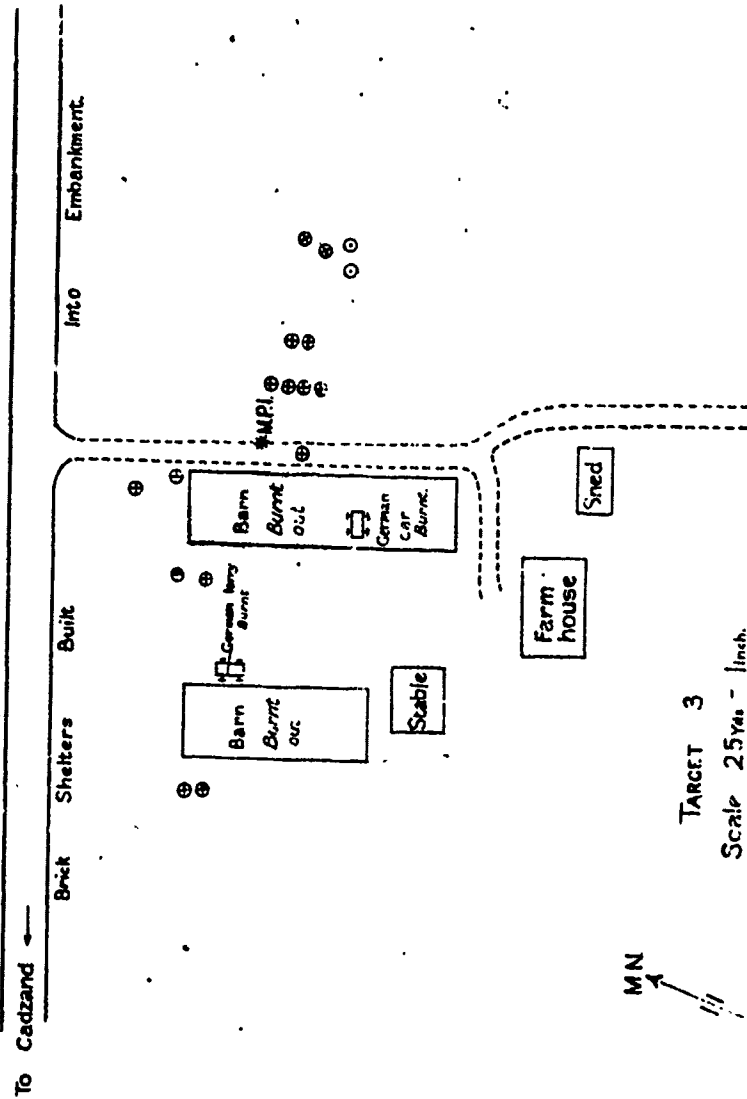
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TARGET 2.

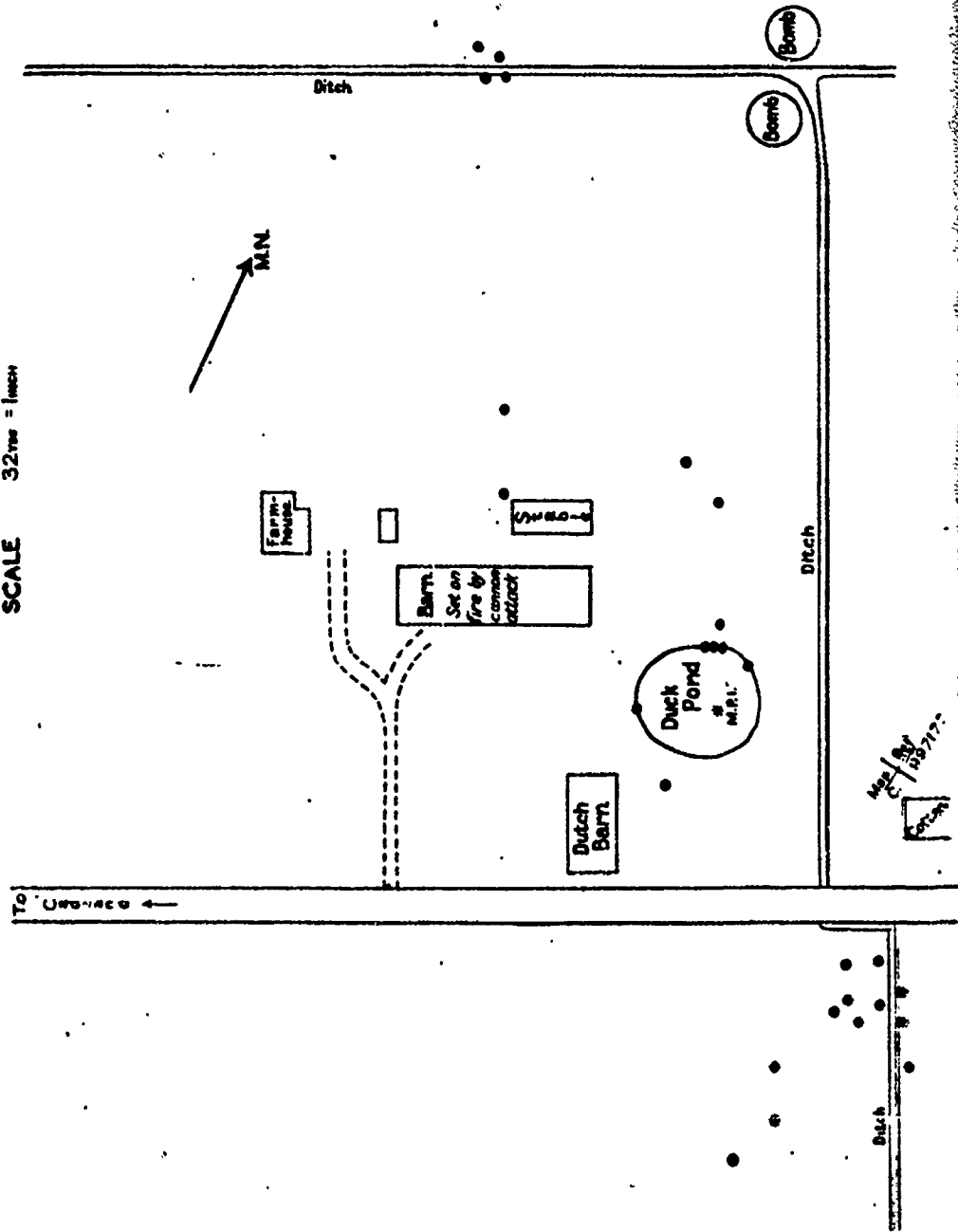
SCALE 20YDS = 1 INCH

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TARGET 4

SCALE 32mm = 1 inch



Sand
Dunes.

R
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M.P.I.

House
Hr.

Barn.

Strong
Point.

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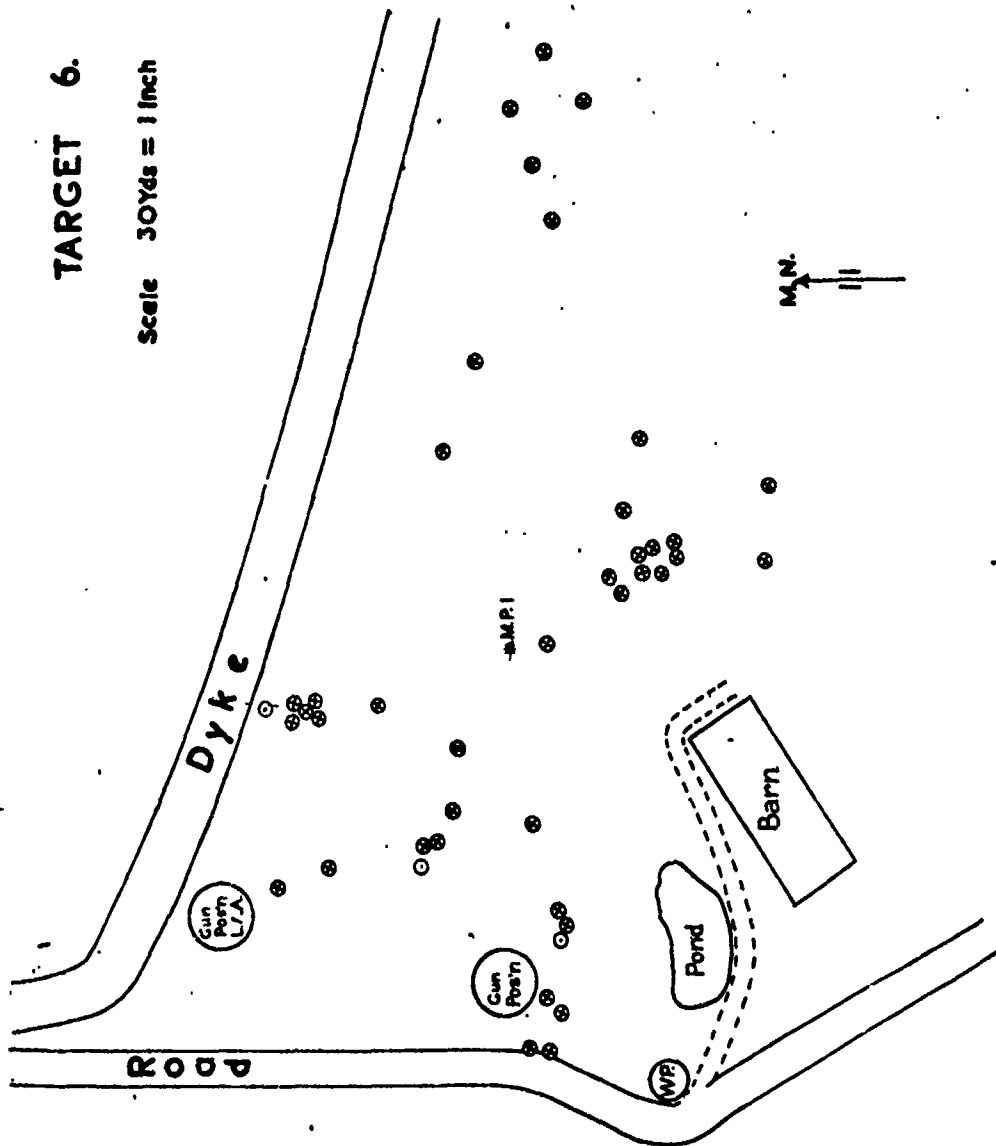
TARGET 5.

Scale 25Yds. = 1 Inch.



TARGET 6.

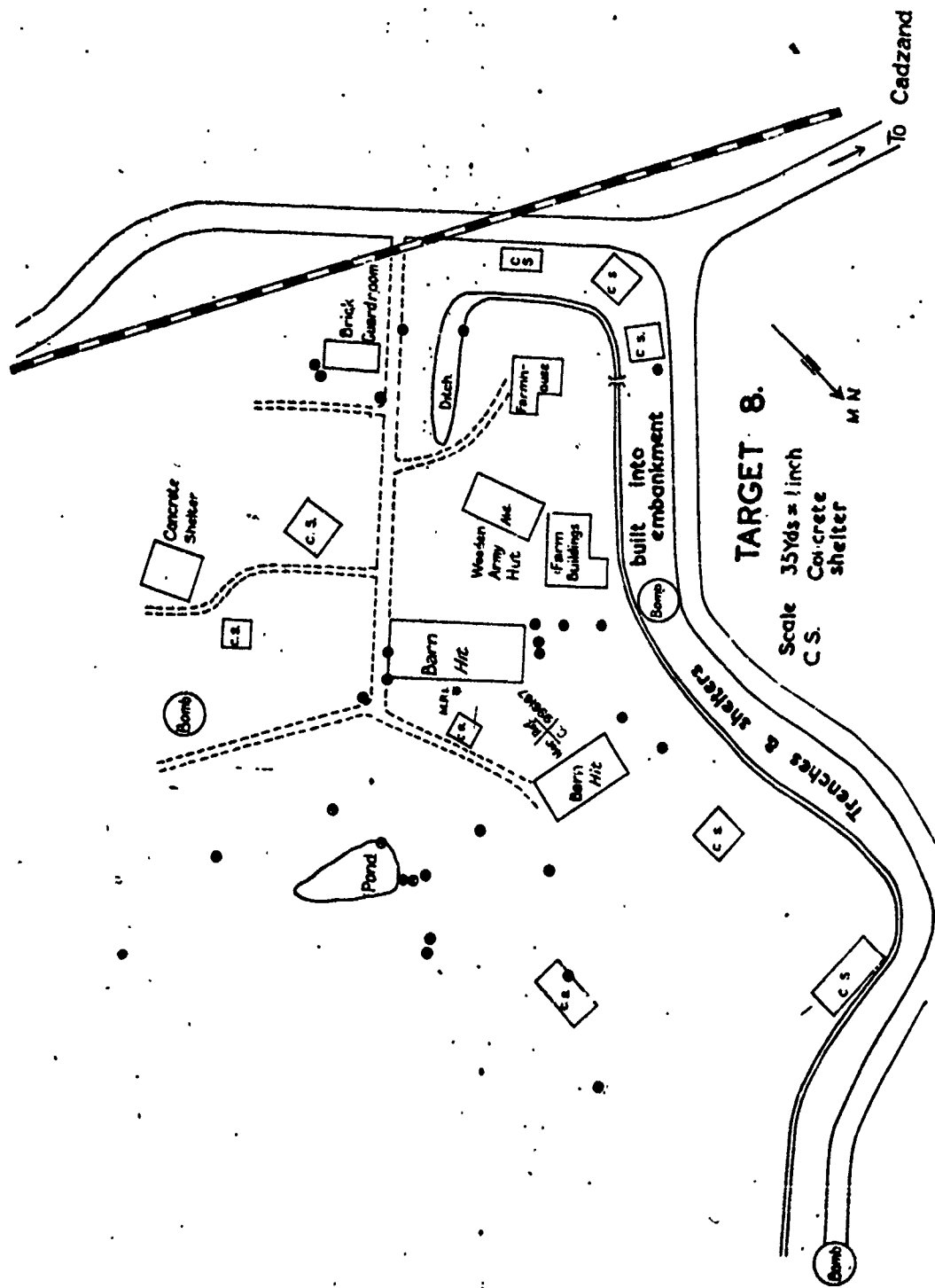
Scale 30Yds = 1 Inch



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26

26



SEA DYKE

Many strong points

Coast road

Timber store

Strong Point

Cottage

M.M.L

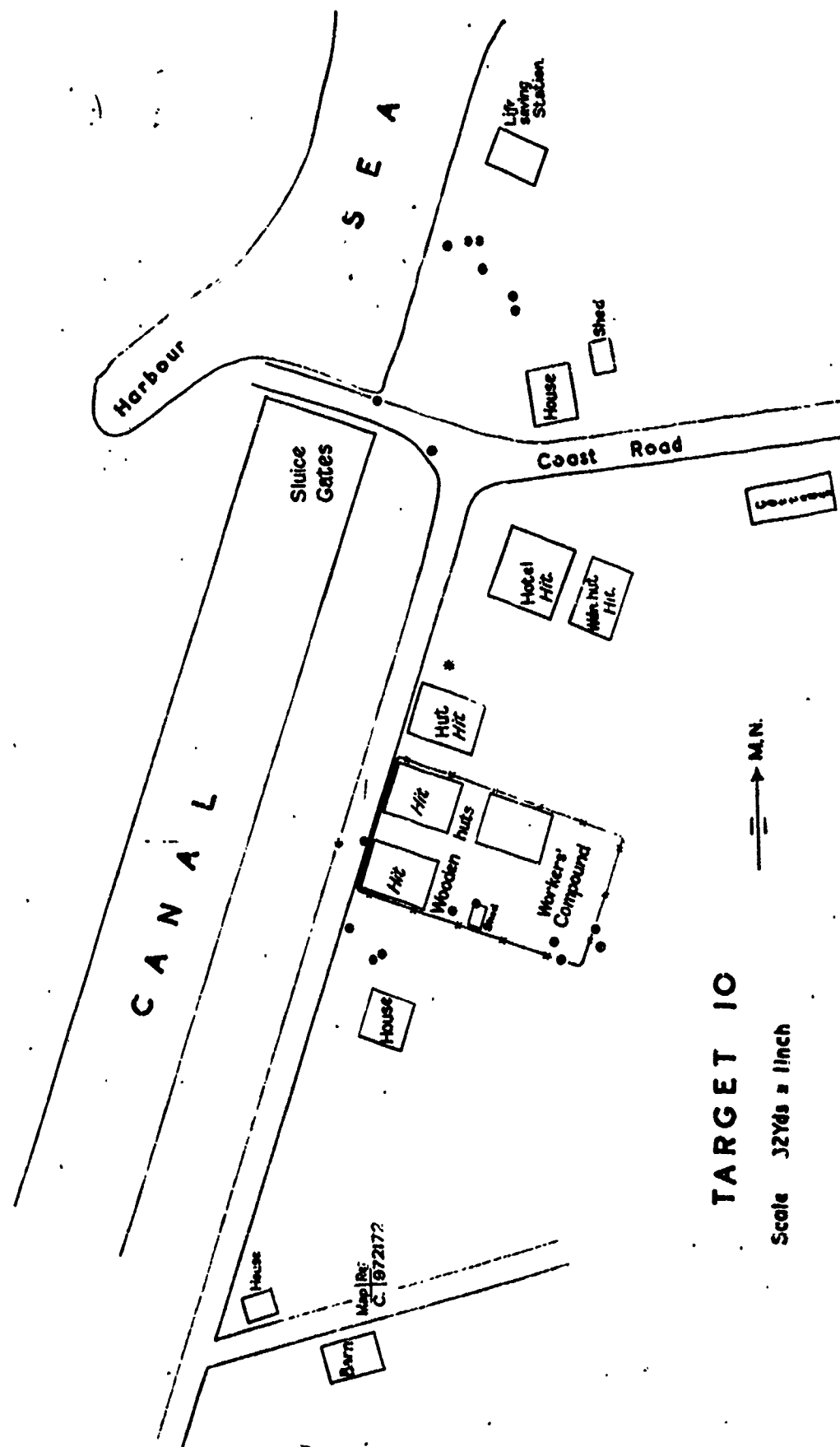
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M.N.

TARGET 9

Scale 27Yds = 1 inch

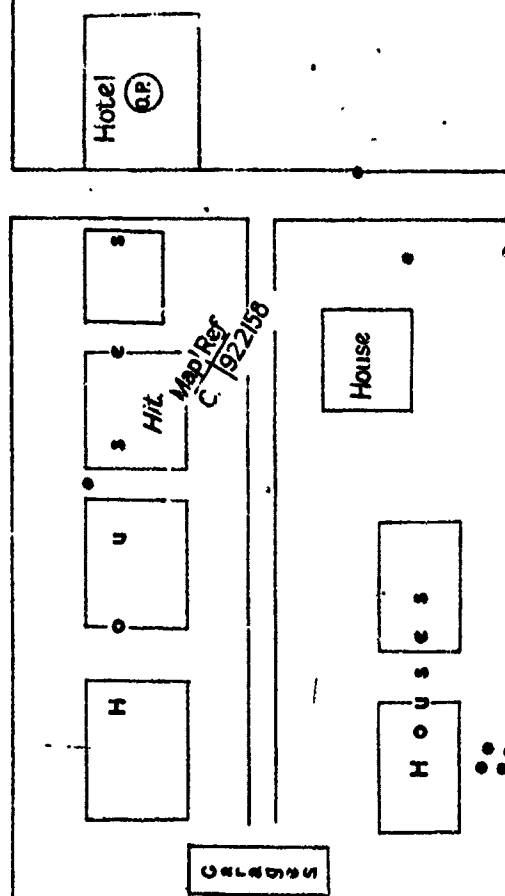


TARGET 10

Scale 32 Yds = 1 inch

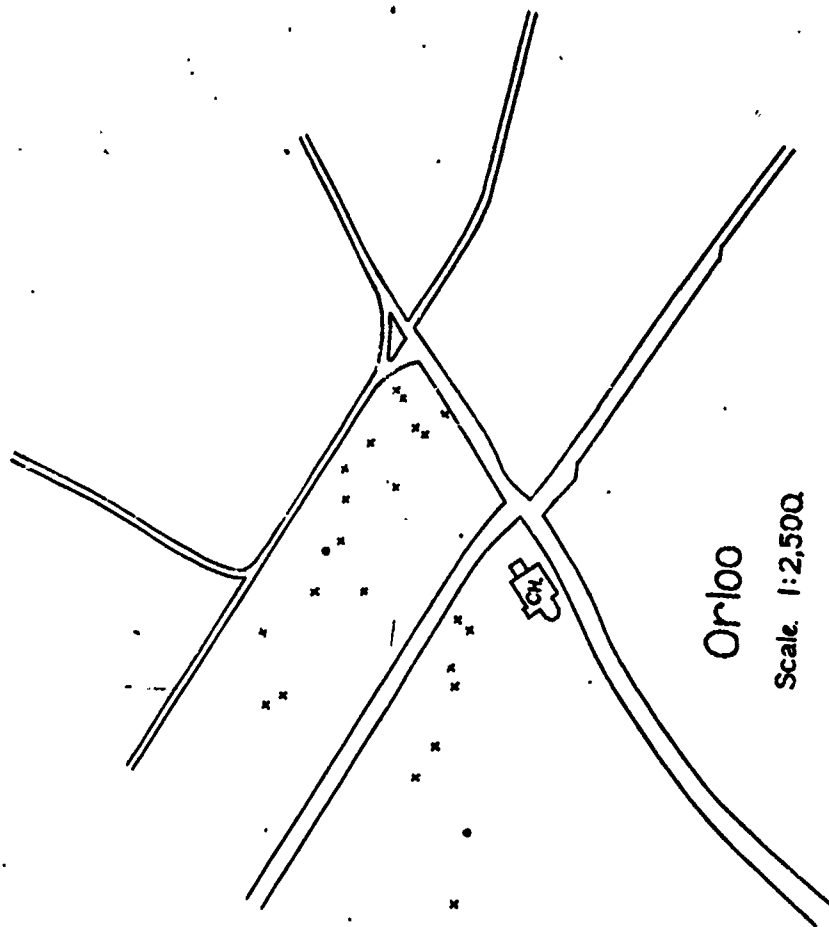
S E A

P r o m e n a d e



TARGET 12

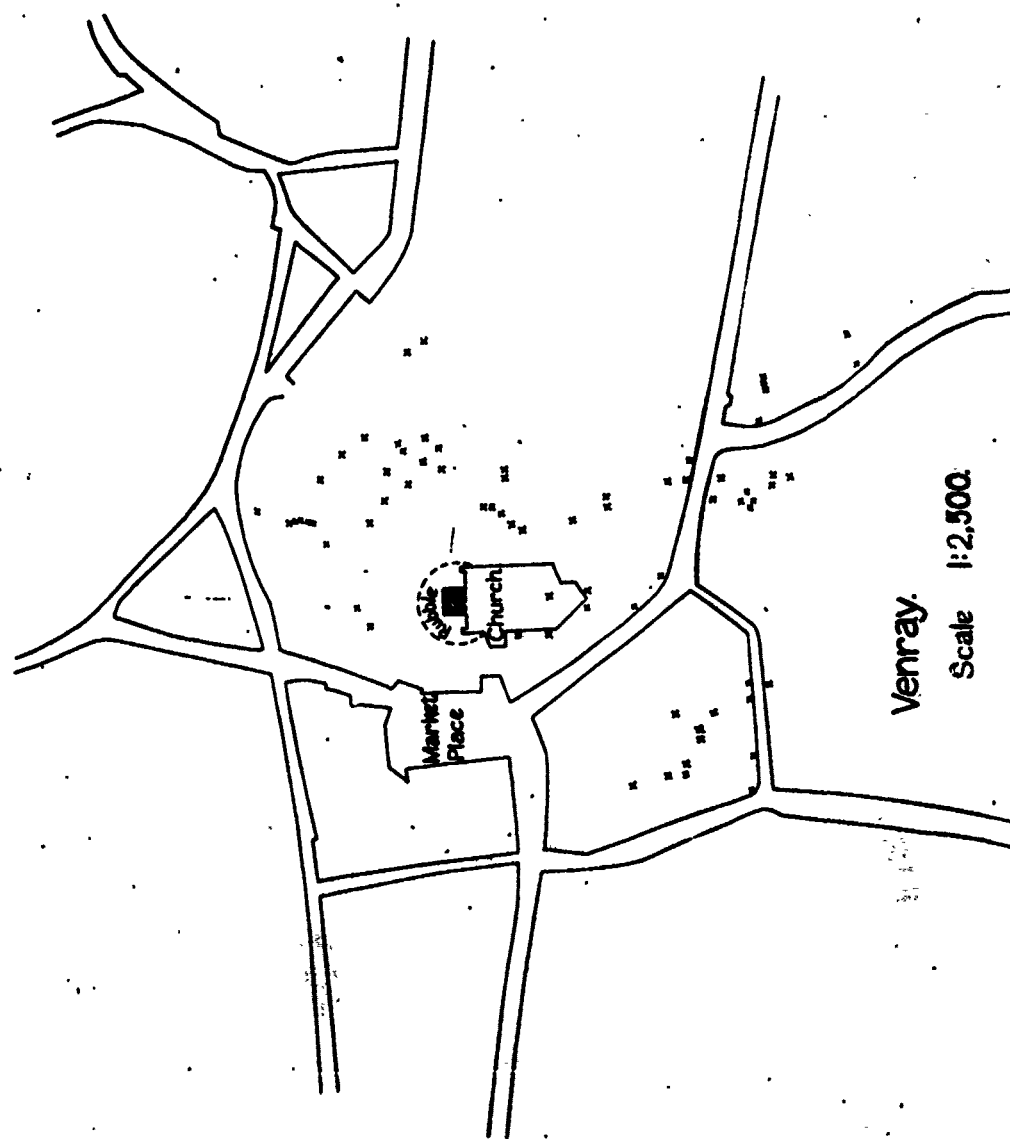
Scale 25Yds = 1 inch



Orloo

Scale 1:2,500

Appendix
B.



Venray.
Scale 1:2,500.

Part of the dispersion can be accounted for by variations in the direction of attack, heights of aiming point and angles of dive. The displacements of the M.P.s. on the ground can also be partly accounted for if the attacks were made predominantly from one direction at an elevated aiming point. However, no amount of juggling with the figures can produce a mean displacement of shots from aiming marks as low as the 46 yards which was the best that could be added in the case of the attacks in the DRESKING Pocket.

3. In the target area studied by the J.A.U. were 4 gun positions approximately in line and 60 yds apart and some magazines. It is possible that some shots which fell at a considerable distance from the guns were aimed at one or other of the magazines. Ignoring these shots and assuming each of the remaining 70 to have been aimed at the gun position nearest to which they fell the mean displacement of strikes from the aiming point comes to 65 yards. This is the most flattering assessment of the accuracy of this attack that can be given.

4. If we take a radial mean error of 40° and a normal distribution the chances of obtaining at least one hit on targets of different sizes can be calculated. For example, the chance of hitting a horizontal area $10' \times 10'$ is 1.06%. The results of such calculation as applied to some typical targets are set out in the table below:

Target	Size	Horizontal projected area (45° Dive)	shots hitting target	For 50, chance of hit	
				RP needed	Sorties
Small gun position	5 yds diameter	19 sq yds	.2	350	44
Panther tank	22' 6" x 10' 9" x 9' 10"	50 sq yds	.5	140	18
Large gun position	10 yds diameter	80 sq yds	.8	88	11
Army hut	60' x 30' x 20'	270 sq yds	2.8	26	3
Large building	120' x 54' x 50'	1000 sq yds	10.0	7	1

In the case of the two largest targets in the above table the figures may be optimistic on account of abnormality of distribution. Several cases have been noted of elms groups of strikes on the ground which have clearly originated from one aircraft. In the circumstances in which these groups occur, the chance of getting at least one hit is reduced, though the chances of multiple hits are increased.

5. Detailed analysis of the strikes on gun emplacements at DOULON and on WALCHEREN ISLAND is not possible. The percentages given in para. 6 of the main text of this report are not inconsistent with those given in the above table.

APPENDIX D.

A loadspeaker caravan was taken up to the forward lines of a battalion of 15 Scottish Division at about 1000 hrs on 28th September, 1944. The Divisional I.O. crawled forward, and at 1045 hrs started talking to the Germans holding a wood 300 yards ahead. The subject matter of this talk was the overwhelming superiority of the allies in aircraft and artillery. At 1055 hrs, exactly at the minute arranged, a squadron of typhoons appeared and circled the area for five minutes, during which time the I.O. spoke about the deadly accuracy of these aircraft. At 1100 hrs the rocket attack began and the I.O. gave a running commentary, after which he called upon the enemy to surrender. Two Germans from an outpost on the flank came forward; then a fighting patrol went into the wood and found a number of men wearing white handkerchiefs. When told to come out they attempted but in vain. Fire from further inside the wood prevented them, and the patrol retired. A second typhoon attack took place at 1200 hrs, and more men deserted by crawling forward on their bellies. One of these P.W.s stated that a house which was being used as an O.P. was hit, and that the occupants pulled out immediately. Another P.W. stated that after the first attack the company was temporarily withdrawn into the middle of the wood to prevent further desertion. Although the battalion never took the wood (they moved 2 days later), they had a large number of German prisoners and deserters who testified to the shattering effect of the typhoon attack.

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JOINT REPORT NO. 4.

GERMAN FLAK AND ALLIED COUNTER-FLAK MEASURES IN OPERATION VARSITY.PART I - INTRODUCTION.

1. An attempt has been made to assess the effectiveness of the counter-flak measures in reducing the enemy activity during the landing of 6 Ar and 17 US Airborne Divisions on the east side of the Rhine on 24th March, 1945.
2. The information set out in this report has been obtained from the following sources:-
 - (a) Direct observation of the operation from high ground on the west bank of the Rhine.
 - (b) Examination of flak positions.
 - (c) Interrogation of local civilians.
 - (d) Examination of gliders on the landing zones.
 - (e) Interrogation of prisoners from flak batteries.
 - (f) Debriefing reports of British and American glider pilots.
 - (g) Visits to Headquarters of 6 Ar A/B Div, 17 US A/B Div, IX US Troop Carrier Command, 35 Group (T.A.F.) and 1 Wing Glider Pilot Regiment.
 - (h) 2 T.A.F. "Daily Logs" and Ops Flashes.
 - (i) IX US T.C. Ops Flashes and Ops Raps.
3. There were four ways of reducing the activity of the German flak batteries, namely -
 - (a) Attacks by medium bombers of IX US Bombardment Division and 2 Group (2 T.A.F.). These took place between 0745 and 0930 hrs on D day, P hour being 1000 hrs.
 - (b) Counter-battery fire during the night of D-1/D and an artillery bombardment between P-30 min and P hour.
 - (c) Attacks during the operation (P-30 to P+210 mins) by Typhoons of 85 and 84 Groups (2 T.A.F.) with rockets and fragmentation bombs.
 - (d) Assaults on the flak positions by the airborne troops themselves.
4. The number of enemy L.A. guns of all calibres deployed throughout the "Varsity" area was considerable. The Second Army Hostile Battery List, compiled up to 2359 hrs 23rd March, 1945, contained 157 positions in two lists. List A, consisting of targets in the Artillery Zone (roughly between the Autobahn and the Rhine, see map at Appendix A), gave 106 positions which were shown as having 231 L.A. and 108 H.A. guns in all. List B, batteries beyond the Artillery Zone, had 251 flak positions containing possibly 668 L.A. and 78 H.A. guns. Subsequent examination of the ground and interrogation of local civilians showed that about half of these positions were unoccupied on the day of the operation.
5. Over 150 prisoners from these flak positions were interrogated and documents found on the sites were scrutinised; as a result it has been possible to form a clear picture of the Order of Battle of Flak formations in the "Varsity" area (See Appendix B). This shows that, had all units been at full strength, there would have been 562 L.A. guns in the area, 78 heavy and 484 light. As many of the L.A. guns were tripling or vierling "and as it is known that a number of mobile 2 on vierling were also operating in the area at the time, it appears that the number of barrels that could be fired at the airborne armada was not far short of a thousand.
6. Some of the flak units had been brought into the area as late as D-1 and prisoners stated that the airborne landing was expected at the time and place at which it did occur. The discovery of a marked German map suggests that some leakage of information had taken place. In spite of the reinforcements which were probably brought in as a result of such leakage, the number of guns in the area was still very much less than that shown on the Hostile Battery Lists. There were very few rock gun positions which did not figure in these lists. Although the counter-battery intelligence work was very difficult owing to bad weather and to the fact that the Germans refused to disclose their positions by firing before D day.

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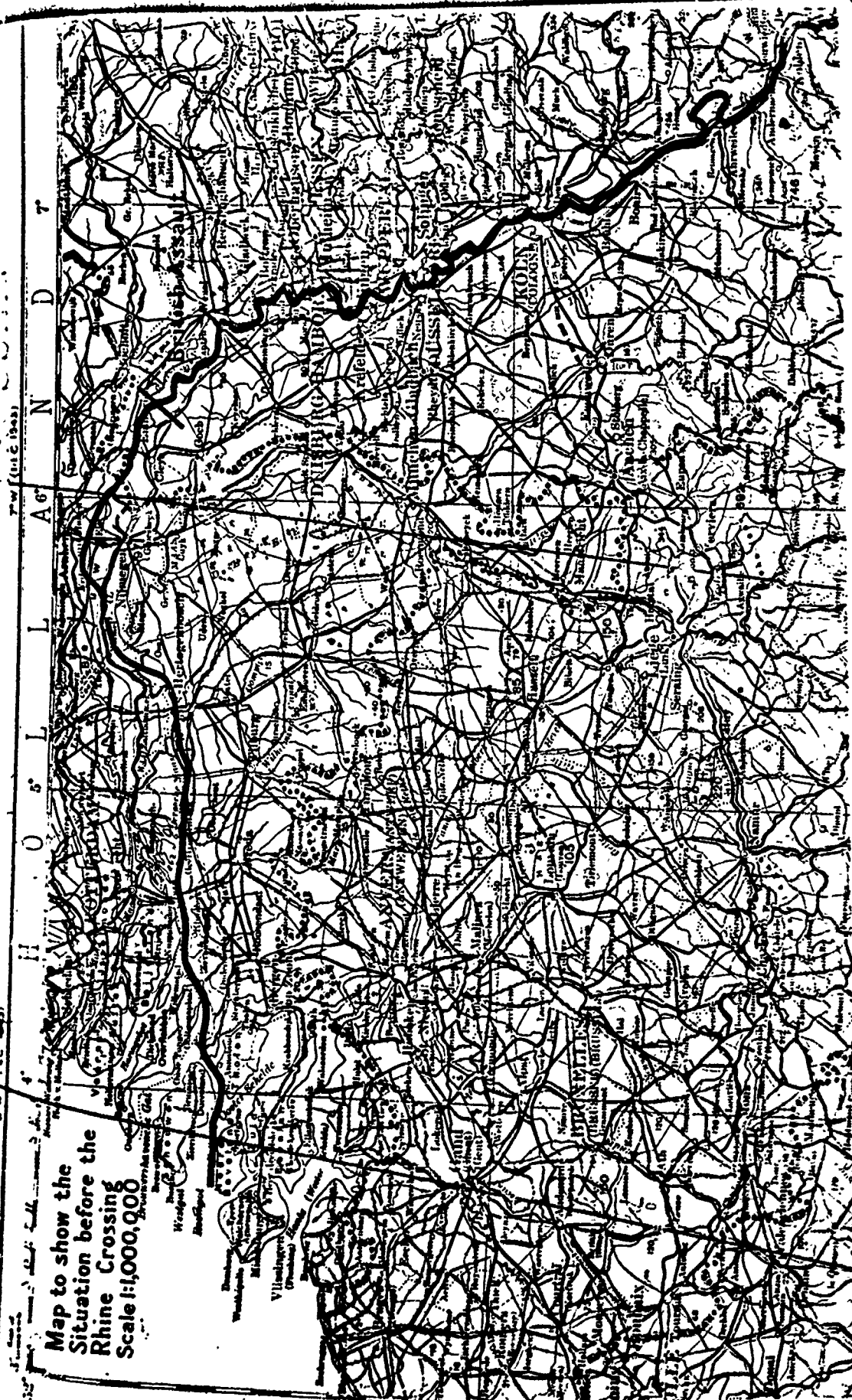
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PART II - COUNTER-FLAK ACTIVITY.

Medium Bombers.

7. Twelve positions were attacked by mediums on the morning of D-day, eight by IX Bombardment Division with 260 lb fragmentation bombs and four by 2 Group with clusters of 20 lb fragmentation bombs and a small number of 500 lb HC bombs (fused nose instantaneous). Details of these attacks will be found at Appendix C.

8. The aiming of the 260 lb F bombs was very good and their fragmentation pattern most impressive but, although some damage was caused to buildings and equipment associated with one flak battery, no hits were scored on any guns. When the small area of a gun pit is considered in relation to the pattern of bombs dropped by a formation of some 30 mediums, the chances of a direct hit are seen to be very slight. This was demonstrated in these attacks where an average of over 500 bombs was dropped on each battery but only one landed in a gun pit and that an unoccupied one.

9. The 20 lb fragmentation bombs released from the No. 17 Clusters were also well aimed and high concentrations were achieved in the target areas, but not sufficiently dense to give many hits in gun pits. Where men were caught in the open, casualties were inflicted, but not on a sufficient scale to reduce the effective fire power. Details of these attacks are fully described in a paper entitled "Field Investigation on Fragmentation Cluster Bombs. Wesel - Bocholt area, Germany, April 1945". (Ref: 2 T&F/8.31100/19/Lm).

10. The attacks by the medium bombers had little effect by direct destruction, but it is probable that such accurate and concentrated attacks had some temporary morale effect. This may account for the fact that, although the German gunners had orders not to open fire before the airborne operation began for fear of disclosing their positions, they disregarded these instructions to the extent of damaging 58 of the 336 medium bombers involved. It is unlikely that this morale effect continued after P hour because the medium bombing programme had to be concluded by P-30 mins to allow the dust to settle down before the arrival of the paratroops.

Artillery.

11. The counter-battery fire of the night D - 1/D was not specifically directed against flak positions as such, but several of them were engaged and where damage was done this was then included in the part played by the Artillery in reducing the fire power available to the enemy during the airborne operation. Full details will be found at Appendix D.

12. Between 0930 and 0952 hrs on 24th March, 1945, some 24,000 rounds (442 tons) were fired at flak positions in the "Varsity" area. 12 Corps fireplan "Casper" was the engagement of 79 points, each by a single battery for 25 minutes, and the 30 Corps programme "Raptor" was the engagement, scale 2 or 3, time on target, of 22 points. Where the points were very close together or coincident they have been grouped together and the total number of targets thus arrived at is 95. The amount of fire with which the targets were to be engaged varied from 16 to 1000 rounds with an average of 242 rounds per target. (Corresponding average figures in other operations were "Switchback" 427 and "Veritable" 1117 rounds per target).

13. All but three of the 95 positions engaged by 12 and 30 Corps were visited a few days after the operation and those cases where signs of damage were discovered are fully described in Appendix D. 39 of the positions were probably unoccupied on the day in question and 24 of these had been engaged in the fire plan. A further 23 with no evidence whatsoever of occupation were also engaged.

14. As was the case with the medium bombing (see para. 10 above), the physical damage inflicted by the artillery was very small but it is considered that there was some temporary lowering of morale. Prisoners from flak positions in the Artillery Zone stated that several 2 in guns were jammed by the dust which the shelling raised. The diagram at Appendix E shows that the effectiveness of the opposition met by the first squadrons of troop-carrying planes was very much less than that encountered by later arrivals; this would seem to suggest that gunners, who had gone to ground during the artillery programme and the medium bombing, did not return to their guns immediately the airborne attack was sighted.

Fighter-Bombers.

15. In addition to the provision of fighter protection for the numerous formations of troop-carrying and glider-towing aircraft and the maintenance of stranding patrols over Caen, airfields, the Second Tactical Air Force had four wings of Typhoons permanently employed on anti-flak patrols over the "Varsity" area. Between them these four wings kept an average of 37 aircraft over the area throughout the vital 4 hours, P - 30 to P + 240 mins. At times the number of Typhoons rose to over sixty. Details of the attacks made by aircraft of 43 and 64 Groups during the operation are given at Appendix F together with the findings of the ground investigators.

16. The Typhoons were armed with either rockets or cluster bombs in addition to their normal complement of 12 cannon shells. Each flight was given an area of operation with instructions to attack any flank position seen to be firing and, if, during the course of the patrol, no fire was observed, there was always a prearranged target known to be a flank position which was to be attacked before returning to base. The briefing also provided for a large scale ground-strengthening attack to precede the arrival of the first paratroops but unfortunately it was never carried out because the Dakotas arrived 2 minutes early.

17. The British glider-towing aircraft were flying at 2500 ft at the time of release and climbing to much greater heights for the return journey so the Typhoons on anti-flank patrol had to remain about 4000 ft for the purpose of observation. There was a thick ground haze and a very considerable amount of the ground smoke and dust associated with a battlefield; it is not surprising therefore that some of the pilots reported having seen no guns firing. The poor visibility also accounts for the rather vague map references given for the points that they did attack, as map reading under such conditions cannot have been easy. A special note about the visibility will be found at Appendix K.

18. Most of the positions claimed to have been attacked by the fighter-bombers were visited shortly after the operation. One rocket was found to have scored a direct hit on a 3.7 cm LAA gun, causing complete destruction; two multiple LAA guns showed signs of damage to individual barrels which were not incompatible with the results of ground-strengthening by Typhoons. Fires had broken out at a 10.5 cm LAA battery after a rocket attack but the guns themselves were not damaged until the Germans destroyed them before surrendering. One of the 20 lb fragmentation bombs from a No. 17 Cluster Bomb had landed inside an 88 mm pit and had killed the crew but the gun itself was destroyed by the enemy at a later date. It is just possible that some of the attacks for which inaccurate map references were given might have yielded results had the investigators been able to locate the targets on the ground.

19. When unoccupied sites were found local inhabitants were consulted and in this way it was frequently established that guns had been in position on the Saturday morning and that they had fired. On one occasion when no gun site was to be seen the local farmer volunteered the information that he and his family had filled in the pits soon after the Germans had taken the guns away.

20. Except in the case of the mobile 2 cm vierlinge which were known to have been operating in the area it is considered highly improbable that any guns damaged by the Air Force or the Artillery would have been removed from their sites as the Germans were very short of transport, relying almost entirely on horses.

21. The authors have already shown in their Joint Report No. 3, entitled "Rocket-firing Typhoons in Close Support of Military Operations" that the chances of landing rockets inside gun pits are very small (not better than 1 in 700 for an emplacement 5 yds in diameter). It was only to be expected therefore that, even where they were very accurately aimed, rockets rarely hit the target; they did however land sufficiently close to achieve considerable if temporary morale effect. The same is true, to a different degree, for cluster bombs. For such effect to have lasting value the attacks require to be repeated at intervals of not more than 15 minutes throughout the operation. If, for the sake of numerical example, it is assumed that an effective attack would be one aircraft per position and that each aircraft could attack twice during a sortie, the 251 positions in the Hostile Battery List B would have required four times the effort actually employed. In fact very few batteries were attacked more than once and a large number were never attacked at all owing to the limitations imposed: no batteries west of the Autobahn were scheduled for R.A.F. attack because they were in the area of the D.Z.s. and L.Z.s. very near to the east of that line were too close to our own troops and the bad visibility prevented pilots from seeing some of those which they might otherwise have attacked.

22. In many previous battles the very presence of a flight of Typhoons in the neighbourhood has had a considerable effect on the enemy but there are several reasons for thinking that on this occasion it was not very great. Firstly, owing to the poor visibility and the height at which they were flying, they were not readily seen. Secondly, the vast number of Dakotas and bombers at low altitudes would tend to drown the noise of the fighters' engines. Thirdly the sight of descending gliders loaded with airborne troops would probably exercise the minds of gunners far more than the threat of a rocket attack, great though their fear of such attacks is known to be. The diagram at Appendix C shows the number of Typhoons over the area at any time throughout the operation. The lack of correlation between this and the diagram showing aircraft hit by flick (Appendix E) confirms the theory that the mere presence of the Typhoons had little effect on the flick.

Assault by Airborne Troops

23. The diagram at Appendix E shows that, after the first half hour, there was a progressive decline in the number of aircraft hit by flick and a similar trend is seen in the figures for seriously damaged gliders (see Appendix J); this suggests that some reduction of fire power was being brought about. The possibility of ammunition shortage has been investigated but only on the site was any evidence of such a shortage discovered. It has already been shown that the effect of the Typhoon anti-flank patrols was not great and so it would appear that some other influence was at work.

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24. In a number of cases gliders were found to have landed within 50 yds and loss of anti-aircraft batteries and, although some of the gliders were only burnt-out wrecks, others were undamaged. This evidence confirms the stories contained in the de-briefing reports where glider pilots described how they and their passengers eliminated flak batteries before unloading and proceeding to their R.V. Owing to the lack of definite map references it is not possible to state exactly how many batteries were overrun by airborne troops during the period of the glider landing but it was probably between ten and fifteen, which is an appreciable proportion of the batteries in the immediate vicinity of the dropping and landing zones.

25. As was to be expected the destruction of flak positions by the airborne troops exceeded that caused by the artillery and air forces combined.

Prisoners.

26. The flak prisoners interrogated averaged between 20 and 30 years of age and appeared fairly intelligent and reasonably fit. Only 36 of them had been captured within 24 hrs of the anti-flak programme and these were the only ones who could be interrogated before subsequent events had muddled their impressions. Of these 36 men, 18 had excellent morale; they were very secure and seemed pleased to have done us some harm. Only 6 appeared to be really shaken and were insecure, the remaining 12 giving no particular indications. Compared with infantry and other PW captured during the same operation the 50% of good morale is a very high figure.

27. The outstanding impression of all PW was excitement and fear at the sight of the airborne landings. None of them had experienced the medium bombing which preceded the landing. Whilst many expressed dislike and fear of our fighter-bombers they did not seem especially impressed by them on the day in question (24th March). None had been shaken by the artillery to the same extent as were PW taken after the heavy barrages which opened some of our earlier set-piece attacks.

28. Prisoners from 15 positions outside the Artillery Zone were interrogated. In 10 cases the men said that they had been attacked by fighter-bombers and five of these attacks were considered to be the direct result of firing their guns. In these 10 cases of Typhoon attacks the prisoners maintain that they fired back at the fighters; this is consistent with claims made by flak prisoners from previous operations (see the authors' Joint Report No. 3). In 4 out of the 5 positions which reported no Typhoon attack the guns had not fired during the operation because the gliders and accompanying aircraft were out of range. Although 15 is only a small proportion of the batteries in the "R.M.F. Area" these facts show that the Typhoons were not without effect. There is no PW evidence from other batteries in this area but it seems probable that there were several more positions which did not fire during the operation owing to the fact that they were too far away. There can be little doubt that it was the flak batteries inside the Artillery Zone which inflicted most damage.

PART III - EFFECTS OF THE FLAK.

Glanders.

29. The principal effect of the flak on the operation was the destruction of gliders. In many cases the same guns which fired at them whilst in flight were able to continue the action when the gliders had landed, because they were well sited for the dual role. The casualties to glider pilots and their passengers, though by no means light, were not sufficient to affect the course of the battle but the loss of equipment was serious. Figures for damage and loss quoted in this report must be considered as being much too low because only some 1200 out of 1400 glider reports are available and it is feared that most of the remaining 200 were damaged or destroyed.

30. The number of seriously damaged gliders reported was 153 and those not unloaded or the unloading of which was delayed for considerable periods of time amounted to 173. The causes were:-

- (a) Crash landing due to flak damage.
- (b) Fires due to flak or mortar.
- (c) Crews being pinned down by artillery, mortar or sniper fire on the landing zone.

The German flak batteries were therefore in a large measure responsible for the loss of the equipment so badly needed for the operation.

31. A secondary effect of the flak was the disorganisation caused by damage to towline planes. Two instances occurred: when glider formations, still on tow, were violently broken by a plane diving through them hopelessly out of control; also at least 20 gliders had to drop off when their towlines were hit. The result of such happenings was that gliders landed well away from their appointed LZs and were separated from others of their formations so that guns arrived with no jeeps to tow them (this latter applies only to American gliders).

32. It was planned that British gliders would be released at 2500 ft and American gliders at 700 ft. According to debriefing reports American gliders were released at very varied heights. The figures in Table 1 below show the percentage of the gliders, released at various levels, which suffered flick damage:

Table 1

Height of release	Percentage hit
A. American gliders	
Below 1000 ft	41.6
1000 ft - 1500 ft	44.1
1500 ft - 2000 ft	50.5
over 2000 ft	69.4
B. British gliders	
2500 ft	59.5

Many of the American glider pilots complained of the great height at which they had to cast off and they attribute their losses to that fact.

33. To discover any differences that may have existed between various L.Zs from the point of view of flick, an analysis of flick damage by L.Zs was made as is shown in Table 2 below:

Table 2

Flick damage to gliders

Landing Zone	Minor damage	Serious damage +	Total damage	No flick damage	Total
A. American					
L.Z. #3 ^a	197 (75.4%)	56 (10%)	253 (45.4%)	304 (54.6%)	557
L.Z. #4 ^a	102 (34.5%)	26 (8.8%)	128 (43.3%)	168 (56.7%)	296
Total	299	82	381	472	853
	35%	9.6%	44.6%	55.4%	
B. British					
L.Z. #1 ^a	16 (35%)	20 (45.5%)	36 (70.5%)	10 (21.5%)	46
L.Z. #2 ^a	27 (31.8%)	8 (9.4%)	35 (41.2%)	50 (58.8%)	85
L.Z. #3 ^a	28 (57.2%)	17 (22.8%)	45 (60%)	30 (40%)	75
L.Z. #4 ^a	29 (44%)	15 (22.6%)	44 (66.6%)	22 (33.4%)	66
Total	100	60	160	112	272
	36.8%	22%	58.8%	41.2%	

^a Serious damage is interpreted as meaning damage involving some loss of control.

The figures in this table and in the diagram at Appendix J, where the time factor is also considered, show that American glider damage due to flak was remarkably consistent round about the 45% mark. British gliders with approximately the same proportion of "minor damage" suffered more serious damage, the amount of which varied greatly from one L.Z. to another. L.Z. #4 where damage was least was the furthest westward and to reach L.Z. #0 where most damage was suffered gliders had to fly within range of many more guns as will be seen from the map at Appendix L. (The difference between times of landing at these two L.Z.s was not significant).

Fires in Gliders.

34. Of the 860 American glider pilot reports only 23 mentioned destruction by fire, three while in free flight, five while still rolling on the L.Z. and the rest during the first hour or so after landing. In only one case was it possible to remove the load before the fire. The cause of fire in the 23 cases recorded is equally divided between mortar and L.Z. fire. Other gliders were burnt out after their pilots had left them and were not therefore reported; even so the proportion is very much lower than in the case of British gliders where at least 40 out of 327 examined by the salvage party were found to have been burnt. The load had been removed from 8 of these gliders before the fire destroyed them.

35. There were many cases of S.A.A. and even L.Z.L. shells passing through the covering of the Waco and causing no more damage than a tear in the fabric; in such circumstances an incendiary bullet would have little effect. The more solid wooden construction of the Horsa and Hamilcar is such that resistance would generally be offered and incendiary bullets could be expected to start fires irrespective of the nature of the load. The four burnt out Horsa gliders, the loads of which are recorded, all carried Jeeps but would not be safe to assume from this that all the other 19 fires were due to the presence of Jeeps although apart from the load there is very little inflammable material in a Waco glider. There were however 23 instances in which Jeeps carried in American gliders had been damaged by flak, including petrol tanks and oil pipes perforated, and one of these caused an outbreak of fire.

Damage to Aircraft.

36. No aircraft were hit before dropping their paratroops and not many before releasing their gliders, thus damage to aircraft can have had little direct effect on the course of the battle. Table 3 below gives the salient facts.

TABLE 3.

AIRCRAFT DAMAGED AND LOST.

	Height over Target	L/C Sorties	No. Damaged	No. Lost
1. Br planes towing gliders	2500'	440	32 (7.3%)	7 (1.6%)
2. US planes towing gliders	varied between 700' and 2500'	609	169 (27.8%)	14 (2.3%)
3. US planes with Br paratroops	700'	240	77 (31.6%)	14 (5.8%)
4. US planes with US paratroops	700'	298	79 (26.5%)	18 (6.0%)
Total		1587	357 (22.4%)	53 (3.3%)

37. Table 1 shows that gliders released at "over 2000 ft" suffered damage rate of 69% whilst for those released "below 1000 ft" the rate was 42%. Table 3 shows what the corresponding figures for loss of aircraft were 1.6% and 5.8%. Considering aircraft damaged the percentage at the lower height is certainly greater but these aircraft all were glad to fly home whereas most of the damage to gliders involved serious loss of equipment. It thus appears that the low release is the more efficient.

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of controls.

32. Altogether 316 anti-flak sorties, involving 92 attacks on gun positions, were flown by Typhoons of 53 and 84 Groups during the operation. The total damage suffered was 2 aircraft lost, 7 aircraft damaged and 2 pilots lost. In addition, one Tempest and four Typhoons (with their pilots) were lost over the area; these were not attacking gun positions but their loss was due to flak.

Casualties.

33. It was unfortunately impossible to obtain casualty figures for either 6 Br. or 17 US L/S Divisions for the period of dropping and landing; however the first 24 hours of the operation produced the following figures for 6 Br. L/S Divisions:

TABLE 4.

	No. Involved	Killed	Wounded	Missing	Total
1. Paratroops	4400	125 (2.8%)	264 (6%)	49 (1.1%)	438 (10%)
2. Glider troops	3800	216 (5.7%)	477 (12.5%)	51 (1.3%)	744 (19.5%)
Total	8200	341 (4.2%)	741 (9.0%)	100 (1.2%)	1182 (14.4%)

Glider Pilot Casualties:

TABLE 5.

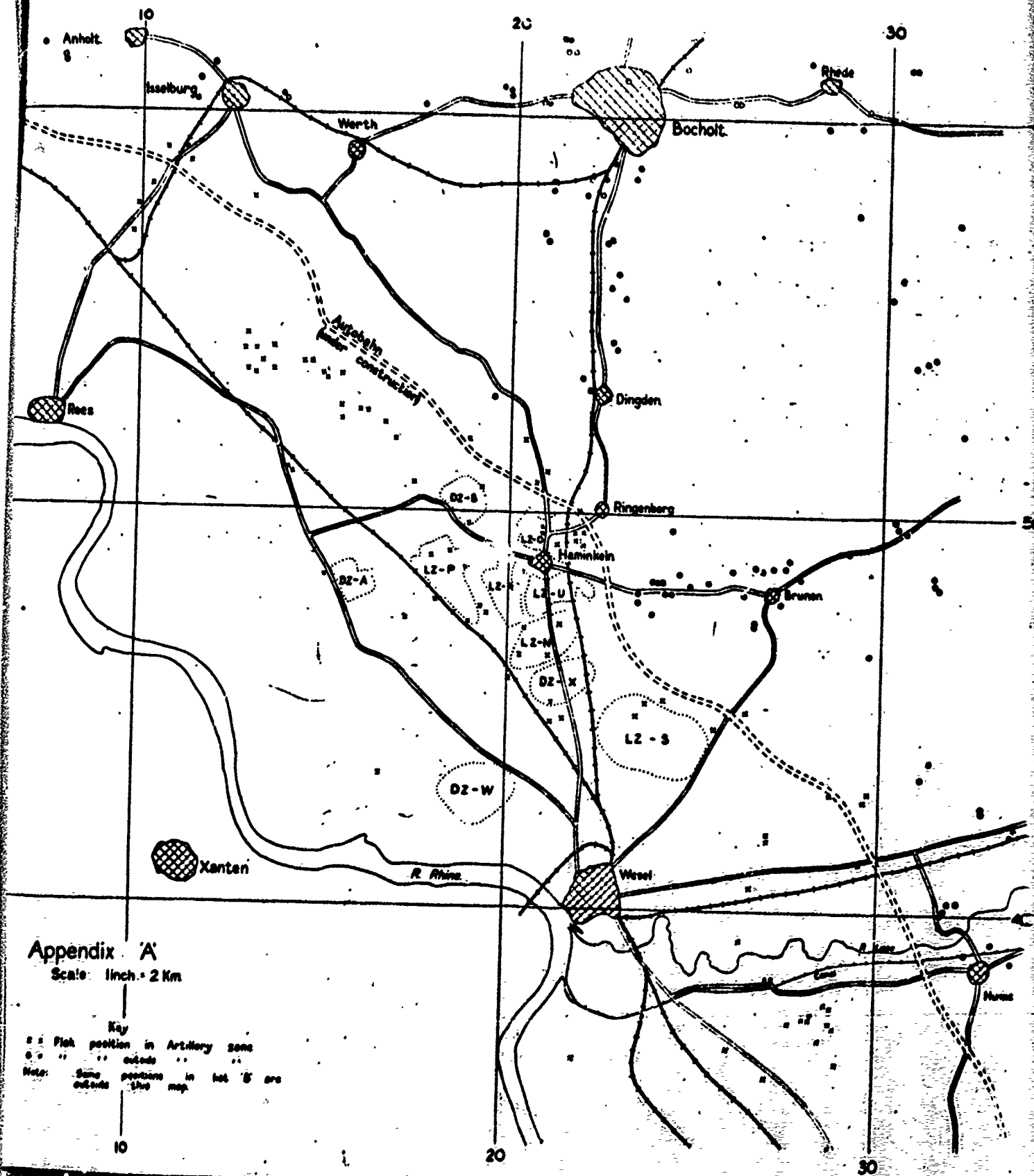
	Despatched	Killed	Wounded	Missing	Total
1. British	800	38 (4.8%)	77 (9.6%)	135 (16.8%)	250 (31.2%)
2. American	1816	33 (1.8%)	106 (5.8%)	55 (3.0%)	194 (10.7%)
Total	2696	71 (2.6%)	183 (6.8%)	190 (7.1%)	444 (16.3%)

40. Figures extracted from glider pilots' reports, which are of necessity incomplete in that where both pilot and co-pilot borne casualties no record is available, yield the following information concerning killed and wounded in the air and immediately after landing. They refer to pilots and their passengers.

TABLE 6.

Glider troops	Killed	Wounded	Total
1. British	47	151	198
2. American	67	202	369
Totals	114	433	547

Although some of these casualties were caused by S.A. and mortar fire the majority are attributable to either light or heavy flak used in anti-aircraft and ground-roles. Table 4 shows that in proportion to their total numbers British glider troops suffered twice as many casualties as the paratroops, and Table 6 shows that 30% of these occurred in the air or immediately after landing.



CONCLUSIONS.

1. Although the operation succeeded, the anti-flak programme contributed little to its success. Flak was not appreciably damaged by artillery nor by air attack, and there were substantial casualties to gliders, their crews, and their loads.
2. Material damage to gun positions, though slight, was as much as could have been expected, considering the weights of the air and artillery bombardments.
3. PW interrogation suggests that attacks on flak positions by typhoons had a discouraging effect on the ground gunners.
4. The only marked reduction in flak intensity was brought about by capture of gun positions by airborne troops.
5. The extent to which aircraft and gliders were damaged depended on height; the higher the gliders were released the more damage they suffered but aircraft releasing gliders at 2500 ft lost only 1.6% whilst those flying over the area at 700 ft lost 6.0% and had a high damage rate.
6. Visibility was poor, principally owing to fires, but it is not proved that this contributed substantially to damage, because, although it made difficulties for the pilots, several thought that the smoke screened them from the ground gunners.

APPENDIX B.

OUTLINE OF ENEMY A.A. ORDER OF BATTLE AND DISPOSITIONS IN
AREA: WEDEL - DÄTTE - BRUNEN - BOCHOLT - WILDERN on 24 MAR 45.

1. GENERAL.

The area was part of that controlled by VI AA Corps, and 4 AA Div (H) DUISBURG appears to have controlled most of it. The principal local static formation was AA Gruppe WEDEL, but parts may have been under command of Gruppen EMERICH or DORSTEN. Also present in the area were a number of units which had crossed the Rhine in the retreat, the AA Bns of two para divisions, and a good deal of Army AAA, possibly brought in to fulfil an anti-paratroop role and under command 100 AA Regt. It is probable that the static Ws directed and co-ordinated the disposing of all units and that Para AA Bns and other units under command of local army troops probably had to conform to the general AA plan.

2. UNITS PRESENT

Unit	Organisation	Disposition
6 Para AA Bn, 6 Para Div	Three by 2, two light tps	Gen area REER.
7 Para AA Bn, 7 Para Div	Three by, two light tps (incomplete)	Gen area OBERDICKSHOF
11 Bn 21 AA Regt	Three by 2, two light tps	Gen area NANKINLEN AIRFD
1 Bn 157 AA Regt	Four by 2, two light tps	Gen area BOCHOLT
366 Mixed AA Bn	Four by, two 80.5, two 1t	Over whole area, especially NANKINLEN-DÄNEN Road.
415 AAA Bn	Four light troops	Gen area BRUNEN
1 Bn 305 Army AA Bde	Four light troops	Gen area NANKINLEN-DINGEN
716 AAA Bn	Four light troops	Gen area WILDERN
3/748 AAA	Three light platoons	South of NANKINLEN

Cont'd.

Unit	Organisation	Disposition
819 Army LAA Bn	Four light troops	Area LOIKUM HUSSUN
838 Inf Field Bn	Three light troops	Area North of MEHEL
5/88 LAA	Five light platoons	Area NORTH of MEHEL
Totals - At least elements of eleven battalions	Possibly 17 Heavy tps and 34 light troops +	

+ i.e., the following guns:

10.5 cms	12
8.8 cms	66
3.7 cms	75
vierlinge	44
trillinge	96
8dr 2 cm.	269

Total, all types 562

Extra barrels for multiple guns 360

Total possible barrels - 922

APPENDIX C.

ATTACKS BY MEDIUM BOMBERS 24TH MARCH, 1945.

A. IX U.S. Bombardment Division.

TARGET LOCATION	TIME OVER TARGET	NUMBER OF AIRCRAFT	BOMB LOAD		TONE OF BOMBS	GROUND SURVEY
			250 P	500 GP		
A 208604	0744	33	636	4	75	Believed 2 HCs and 3 wagons destroyed. Guns removed after having fired 24th March.
A 161566	0744	36	553	4	63	Not visited: had been erased from Hostile Battery List.
A 258603	0747	39	733	4	87	Site unoccupied on 24th March 1945.
A 199570	0750	31	451	8	54	Not visited: had been erased from Hostile Battery List.
A 210583	0802	31	543	4	64	Accurate attack on unoccupied posn 300 yds away from on native site.
A 208570	0853	31	534	4	63	4 x 88 mm guns removed by Germans before 24th March, 1945.
A 232583	0903	29	448	4	53	Bombs hit houses round site. 4 LAA guns fired 24th March and removed later.
A 198606	-	35	468	8	56	4 x 88 mm guns had fired much 24th March. No damage. Removed by retreating Germans.
		265	4366	10	517	

D.

T.RON
LOC:77

A 3254

A 3243

A 2154

A 2674

C.

C.D.
Number

191 19

258 29

228 21

205 25

230 24

338 24

296 20

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113.

D. 2 Group (2nd Tactical Air Force)

TARGET LOCATION	NUMBER OF AIRCRAFT	BOMB LOAD		TONS OF BOMBS	GROUND SURVEY
		20 F	500 HC		
A 326423	24	-	94	21	No sign of 500 HC bomb craters. 3 L.M. positions: no damage.
A 324397	12	1872	-	17	Not visited.
A 245481	17	2652	-	23 1/2	Good concentration over area containing several positions. Some casualties but no damage to guns.
A 267405	18	2184	32	26 1/2	Good concentration round A.P.
	71.	6708	126	88	

C. Combined Effort

336 planes dropped 11242 bombs weighing 605 tons on 12 gun positions.

APPENDIX D

ARTILLERY TARGETS

95 targets were engaged in the Counter-flick programme.

92 of them were visited by the ground investigators.

11 of these showed signs of damage or casualties that
might be attributed to artillery, though not
necessarily the Counter-flick programme.

C.D. Number	Map Reference	Weight of Bombardment	Findings of Investigators
191	16655217	133 rds Mod (4.8 tons)	One of three 2 on Vierlinge still in position but destroyed by Germans. Position heavily shelled, probably mostly by observed fire.
258	25654467	133 rds Mod (4.8 tons)	Three 2 on guns. No damage. One dead German. PW said that communications were out but this did not prevent them from firing.
228	21184521	600 rds 251b A /burst and 400 rds 251b HE shells	Four pits with dummy guns but signs of recent occupation. One German grave dated 24th March. No craters found but airburst splinters in all 4 pits.
205	26574406	133 rds Mod (4.5 tons)	Several craters near gun pits. Guns moved 500 yds on 24th March because of shelling, said PW. Burnt out 3/- track the carrier found on site. Artillery out 200 yds but did not stop firing.
230	242400	100 rds Mod (4.3 tons)	8 German graves dated 24th March 1945. PW said both cluster bombs and Artillery killed men but guns continued to fire.
338	240483	100 rds Mod (4.3 tons)	One German grave dated 24th March.
256	20704303	133 rds Mod (4.8 tons)	Unlocated German graves. No signs of recent occupation.

Cont'd.

C.D. Number	Map Reference	Weight of Bombardment	Findings of Investigators
1031	238474	400 rds 251b HE shells (4.5 tons)	One German grave dated 24th March, 1945. No signs of damage.
1016	25603911	1200 rds 251b airburst	Many craters found, including craters in 2 gun pits.
221	21824935	200 rds Mod (8.5 tons)	One gun pit probably hit by arty. 4 dead Germans on site.
101	21935007	100 rds Mod and 40 rds in CG programme (5.8 tons)	Two gun pits received arty hits. Guns destroyed by Germans. 2 dead Germans found on site.

APPENDIX F

DETAILS OF FIGHTER-BOMBER ATTACKS

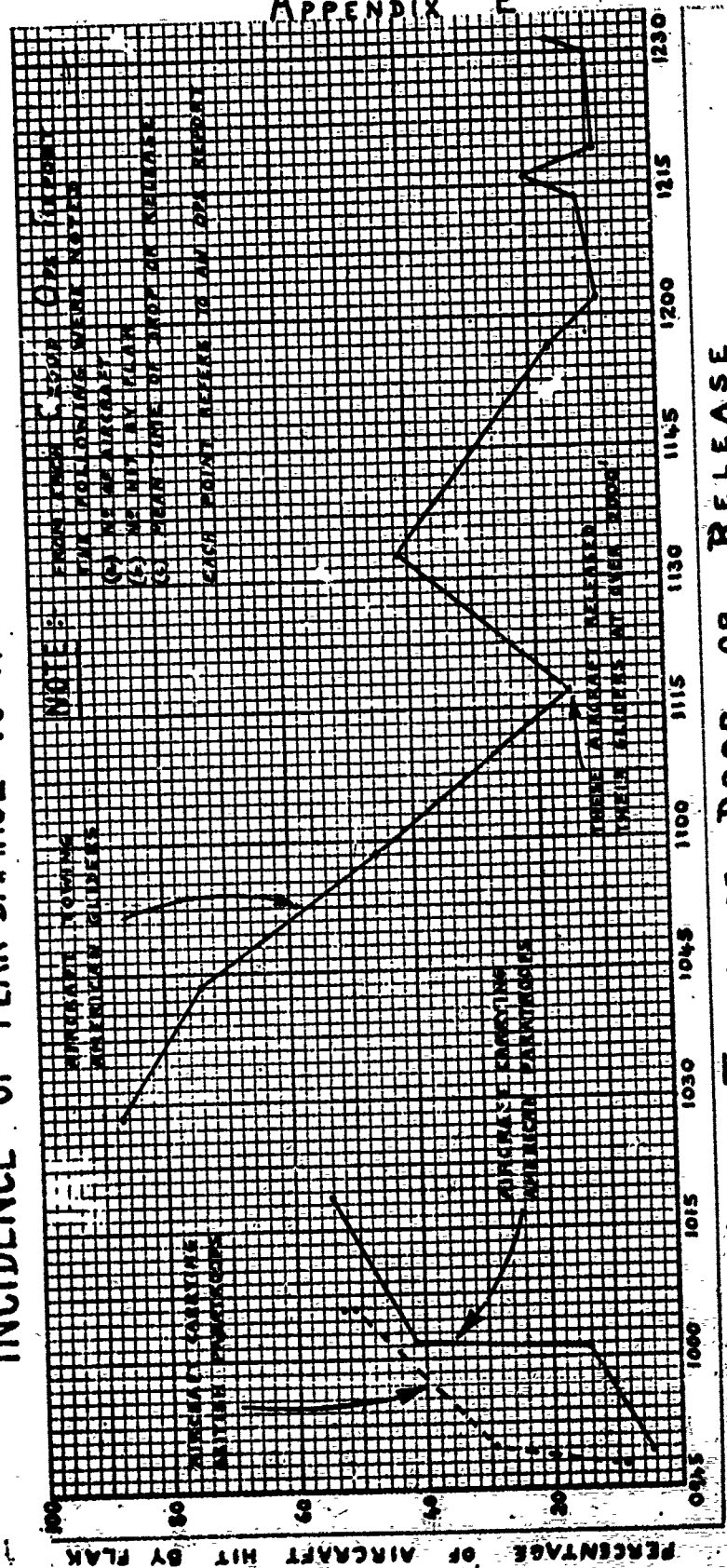
C.D. Number	Map Ref	No. of r/o	Attacked with	Claim	Finding
-	144606	4	28 R.P.	Att probable gun posn as "Line-Jules" directed	No gun posn but R.P. hit from 200 yds from pin point.
QA	20835700	10	70 R.P.	4x88 gun pits observed 2 selves D/H. Appeared unoccupied.	Guns had been removed 21st March 1945. Accurate attack on unoccupied position.
-	109589	3	6 x 500 lb Clusters	Att intense LAL posn 109589 directly after rockets. Sillon-ood flick posn A 1050.	4 x 60 mm had fired from posn at 109509 on Saturday 24th March 1945. No sign of cluster bombs in the vicinity.
-	2847	4	16 R.P.	Att 6 LAL guns	No gun posns or rocket craters in the area.
-	2247 and 2148	4	22 R.P.	2 guns dest. and 1 gun dest.	6 triple 20 mm guns at 219464. Possible RP craters 500 yds away. 6 Triple 20 mm guns at 213492. Possible RP craters 400 yds away.
-	232515	8	55 R.P.	Flick posn dest.	At 233517 was unoccupied posn with 4 RP craters very near. At 227516 2 RP craters near LAL gun pits, bullet embedded in one barrel (strafing?).
-	274465	4	8 x 500 lb clusters	Nonbed accurately. "Line-Jules" reported "guns out"	At 275467 were 3 LAL posns that fired on 24th March 1945. No sign of cluster bomb attack.
205	2945 and 264460	4	23 R.P.	4 guns 2945 att. NRO. and 2645 LAL posn att. NRO.	No sign of guns or R.P. in this square (wooded). 3 LAL guns were at 264460 and later moved to 269460 because of arty shelling. No rockets.

Cont'd.

INCIDENCE OF FLAK DAMAGE TO AMERICAN AIRCRAFT

INCIDENCE OF FLAK DAMAGE TO AMERICAN AIRCRAFT

APPENDIX 'E'



MEAN TIME OF DROP OR RELEASE

PERCENTAGE OF AIRCRAFT HIT BY FLAK

1. P. hit from point.

2. 21st Air Group attack on 10th.

3. 21st Air Group attack on 10th.

4. 21st Air Group attack on 10th.

5. 21st Air Group attack on 10th.

6. 21st Air Group attack on 10th.

7. 21st Air Group attack on 10th.

8. 21st Air Group attack on 10th.

9. 21st Air Group attack on 10th.

Cont'd.

C.S. Number	Mcp Ref	No. of a/o	Attacked with	Claim	Finding
HK	297451	4	24 R.P.	3 x 88 mm firing at 291434 att and silenced. Large fire left burning.	4 x 105 mm guns at 297451 had fired 24th March 45. Distr. by Germans. Several fires had broken out. No sign of rocket craters or debris.
	and 331195			L/LA posn farm-house att building partly demolished.	6 triple 20 mm guns had fired from here, removed later. Rockets hit farm but not gun position.
-	172999	4	31 R.P.	Flick posn att. L/LA. Guns not visible.	At 172602 were well constructed L/LA posns (never occupied). 8 RP craters in NW corner of position.
-	2456	4	31 R.P.	L/LA posn A.2456 silenced.	At 232564 were 4 L/LA sites (never occupied). Accurate attack but no guns.
-	309410	4	32 R.P.	Att L/LA posns at 309410. N.R.O.	3 unfinished gun pits. No signs of occupation. RP craters in middle of position.
	311409			and 311409. N.R.O.	At 311407 was L/LA posn and telephone exchange. RP 200 yds away.
	314408			314408. N.R.O.	3 L/LA gun posns. No sign of RP.
154 177	2158	4	24 R.P.	Att probable flick posn 2158. LRTA.	At 210583 were 2 x 20 mm posns. RP hit building near L/LA guns and killed Germans. Locals said also 4 L/LA guns only 100 yds away had fired 24th March 45. No damage.
284	173600	4	24 R.P.	Att 6 L/LA guns at A.173600 and digging N side of target. LRTA.	At 173603 6 L/LA posns apparently empty since Dec. 8 RP very near misses. No damage.
-	268463 and 269465	4	20 R.P.	Att flick posns A.268463 and A.269465.	No sign of flick posn. Probable RP craters in vicinity. No flick posn. Attack on houses at 269468 with RP; badly damaged.
-	261512 and 269506	4	30 R.P.	Att flick posns 261512 (firing) and 273906 (firing)	No flick position. 8 probable R.P. craters. No flick position. 4 RP craters. Some signs of mobile guns having entered wood at 259517.
-	214575	4	31 R.P.	2 L/LA gun pits 214576 soon and hit.	At 214577 3 x 20 mm guns fired on 24th March. Possible RP craters but no damage. At 215577 2 x 20 mm guns also fired 24th March. RP craters near guns but no damage.
-	2163	4	8 x 500 lb Clusters	D/J 8 gun posn. A.2163 both firing. Spits. Guns silenced.	No gun posns in area except 2 x 16 in 20 mm guns at 251546. No sign of cluster bombs.
-	2748	3	20 mm cannon	Strifed gun posn N edge of JUNEZ. N.R.O.	Gun posn N edge of JUNEZ has been attacked by everybody. No signs of damage by strifing.

Cont'd.

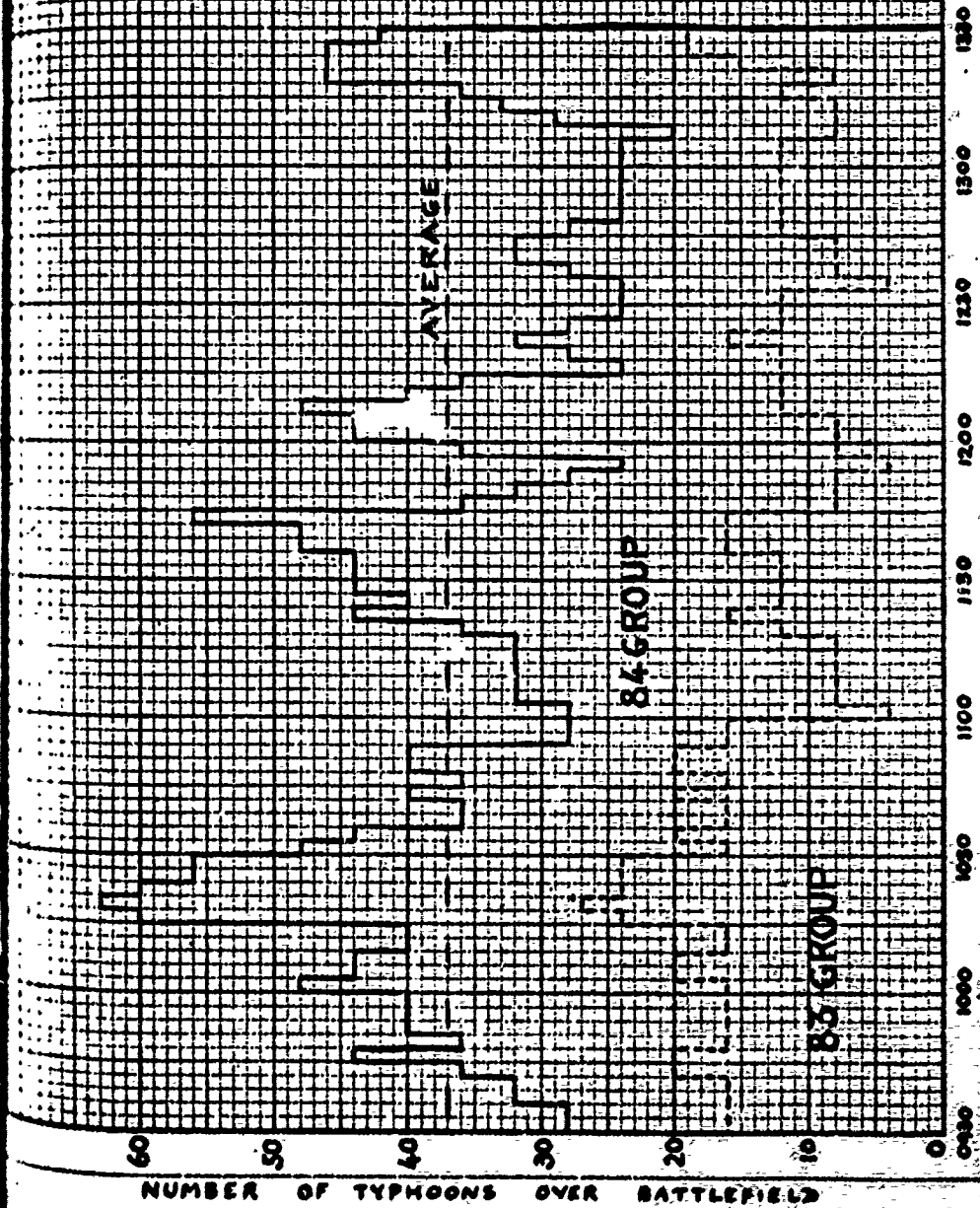
C.S. Number	Map Ref	No. of a/c	Attacked with	Claim	Finding
-	24453	4	32 RP	Att with RP and cannon A 24453 guns firing. Hits thought to have been scored; large flash seen.	2 single barrel 20 mm guns on edge of wood. Nearest RP crater 150 yds. No damage.
123	24643	4	24 RP	On open gun emplacements A24643. JRTL	6 L.L. positions. One 3.7 cm gun completely destroyed by rockets; others not hit.
311 315	32542	4	5 x 500 lb Clusters	Gun posn A32542. JRTL	Nearest posn 32542 had 6 cluster tails and many 20 lb F craters. No damage to guns which locals say did not fire due to lack of ammunition.
-	JRTL 2152 to 2445	4	32 RP and Cannon	Intense L.L. area 2152 - 2445.	At 223518 were 12 triple 20 mm guns. At 227516 were 6 more trillings, one damaged by strafing RP craters very near gun pits.
413	25547	4	29 RP and Cannon	Guns 29547 not firing.	3 x 20 mm whirling had fired from A 297465 24th March 45. One salvo very near gun pit. One German grave. No damage.
72	225467	2	16 RP	L.L. posn 225567 firing at gliders. One salvo between 2 guns.	At 225569 one of 4 x 88 mm guns still on site damaged (probably arty, but possibly RP). RP craters very near.
-	251477	4	5 x 500 lb Clusters	40 mm posn firing at spits. JRTL.	No sign of cluster bombs at this point but 500 yds away was posn hit by 2 Group with many 500 lb Clusters. Also L.L. battery at 246473 had been attacked with Clusters and 11 men killed.
-	257475	4	32 RP and cannon	No flashes. Att 4 gun posn 257476. JRTL.	No position at this pinpoint and no RP craters. Possibly same L.L. site as referred to in previous entry, but no RP craters found.
-	223509	4	31 RP and Cannon	Gun posn native. JRTL.	No sign of any emplacement. Possible RP craters found, may have been fired at an RP gun.
167	233585	3	6 x 500 lb Clusters	Dropped slightly E of L.L. posn	Found some distance away from gun positions.
195	234582	1	2 x 500 lb Clusters	Bombs right on L.L. posn.	No signs of ammunition remains found on site.
-	253479	4	6 x 500 lb Clusters	One cluster right on non-native gun posn.	No sign of gun emplacement. Cluster bomb tails found.
-	324419	2	16 RP	Att native gun posn in wood.	No gun position at this site but 1200 yds away 8 RP craters were found very near 3 gun pits where recent activity suspected.
-	322457	2	15 RP	Native gun posn. 4 RP direct hit on one gun.	Signs of 4 RP craters near one pit. Guns had been removed therefore probably undamaged.

A
HISTOGRAM
ON ANTI-A
AREA SET

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NUMBER 0

APPENDIX G

HISTOGRAM TO SHOW NUMBER OF TYPHOONS ON ANTI-FLAK PATROL OVER 'VARSITY' AREA BETWEEN P-30 AND P+210 MINS.



mm guns on edge
P crater 150

one 3.7 cm
destroyed by
hit.

had 6 Cluster
to P craters.
which locals
to look of

triple 20 mm
to 6 more
aged by strafing
or gun pits.

had fired from
45. One salvo
One German

x 88 mm guns
god (probably
RP). RP

bombs at this
away was seen
many 500 lb
battery at
cracked with
n killed.

s pinpoint and
sibly some
ed to in
t no R- craters

placement. Possible
may have been

no any from gun

ter remains found

placement.
found.

this site but
craters were
gun pits where
expected.

ters near one
n removed there-
buried.

C.B. Number	Map Ref	No. of a/c	Attacked with	Claim	Finding
194	210569	4	8 x 500 lb Clusters	L.L. att but NRO.	Remains of Clusters found on site but locals say guns removed 21st March, they then filled in gun pits and planted corn. Accurate attack on empty site.
	202528	4	8 x 500 lb Clusters	4 L.L. guns in wood. LRL.	No sign of position nor of cluster bombs.
392	279489	4	6 x 500 lb Clusters and 2 x 500 HE	Gun posn direct hit with 500 HE	Nearest cluster bomb 25 yds from 3 L.L. guns (281487). No damage 500 HE were 100 yds away.
405	318484	4	8 x 500 lb Clusters	7 lt flick guns and trenches. D/N but guns continued firing.	L.L. posn at 318485 had been accurately attacked with Cluster bombs but no sign of damage.

In addition 23 other attacks on gun positions were made by Typhoons of 83 and 84 Groups during the operation but it has not been possible to visit the sites, many of which were only 4 figure map references.

APPENDIX H

NOTES ON VISIBILITY IN THE REBEL - BOCHOLT AREA 24th MARCH 1945.

The meteorological conditions were such that any dust or smoke that rose was liable to be held in the lower atmosphere, thus some form of haze was only natural. When little wind there was none from the SE and brought with it smoke particles from the Ruhr industrial area, which was still functioning at the time. The smoke and dust from the medium bombing and the half hour's artillery bombardment no doubt added their quota to the general haze.

This haze reduced the general visibility, but aerial photographs taken during the operation show that its effect was as nothing compared with the smoke which in places was so dense that many pilots declared it was a definite smoke screen put out by the Germans to confuse the landing. This suggestion has been investigated and seems to be unfounded. The aerial photographs showed many sources of smoke which were thought worth examining but in every case a perfectly genuine fire was found to be the origin; the inhabitants were questioned about the time and cause of such fires and nothing suggestive of intentional fire-raising for smoke generation emerged from the investigation. Although the ground survey party spent two weeks scouring the whole neighbourhood of the landing zones no trace of smoke generators was found, nor did interrogation of German prisoners yield any evidence.

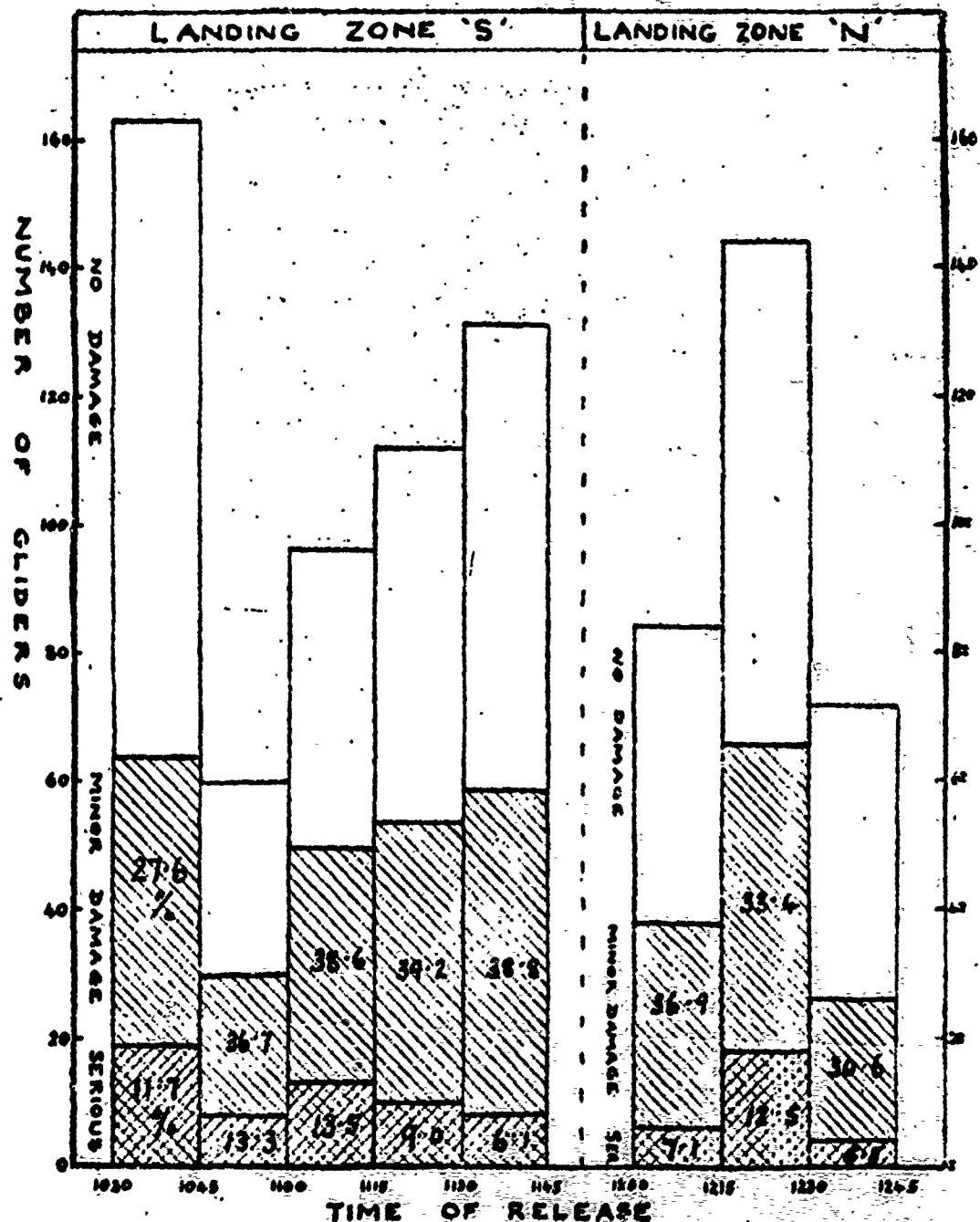
Although the smoke and haze made the task of the Typhoon pilots very difficult (see Part II para. 17) and although glider pilots were not able to locate their landing fields very well, quite a number of them stated that the smoke was more of a help than a hindrance because it tended to hide them from the German gunners; one German glider pilot went so far as to say that their losses would have been doubled if there had been no smoke.

APPENDIX 'J'

FLAK DAMAGE TO AMERICAN GLIDERS

NOTE :-

GLIDER PILOTS' REPORTS WERE ARRANGED IN ¼ HOUR GROUPS ACCORDING TO THE TIME OF RELEASE ; THEN, FOR EACH ¼ HOUR GROUP, THE NUMBER IN EACH DAMAGE CATEGORY WAS EXPRESSED AS A PERCENTAGE OF THOSE OPERATING



CHAPTER 5
MISCELLANEOUS AIR MATTERS

CONTENTS

Effect of Various Forms of Fire Support on the Western Defences of Walcheren.	(Report No. 25)
Use of Mobile Radar Control Posts for Air Support of the Army.	(Report No. 26)
The Effect of 90 lb Fragmentation Bombs.	(Report No. 9)
Effects of Bombing on Wet Ground.	(Memo No. 5)
American Incendiary Bombs	(Memo No. 4)
Unloading gliders in Operation Overlord.	(Memo No. 6)

REPORT NO. 25.

THE EFFECT OF VARIOUS FORMS OF FIRE SUPPORT
ON THE WESTERN DEFENCES OF WALCHERENIntroduction.

1. Operation INFATUATE II, the assault on WALCHEREN, was selected for study as it appeared to constitute a good opportunity for examining the effectiveness of various methods of fire support.
2. All positions in the flooded area were found to have been out of action as had been foretold by A.P.I.S., and only those on the coast have therefore been considered.

Method.

3. The following sources of information have been used:

- (a) Interrogation of P.W.
- (b) Conversation with the Commander, Officers, and O.As. of 4 S.S. Bds.
- (c) Study of air photographs.
- (d) Examination of the ground.
(The ground was not unfortunately accessible until some weeks after the operation).

Heavy Bombing.

4. The principal effort directed against the defences prior to D day (1st November) was by heavy bombers. Although some raids had taken place earlier, the main effort took place on 28, 29, and 30 October, and details and results of these raids are shown in Appendix A. The positions of the targets are marked on the map at Appendix B.

5. There is nothing remarkable in the results. In view of the fact that the majority of the principal guns were in casemates, only direct hits or very near misses could have been expected to have any effect, and this proved to be the case. The result of a direct hit at W 15 is shown in Photo 1. The density of errors around the targets is in accordance with the weights of attack. The total damage done to the principal defences was:

2 guns out of action out of a total of 26

1 casemate destroyed (but unfortunately empty)

1 command post destroyed

1 radio location set destroyed.

Within the limits of error occasioned by such a small sample, the rate of destruction accords well with what would be expected from the crater densities that were measured.

6. Photographic interpretation by A.P.I.S., 21 Army Group, of the damage was largely correct, but was optimistic as to the extent of probable damage by near misses. The interpretation left no ground for supposing that the principal defences were not substantially intact.

7. Damage to line communications was considerable, but in some cases there had been time to improvise new lines and there was evidence that advantage had been taken of the time.

8. Weather conditions did not permit any bombing on either 31st October or 1st November or more damage could have been inflicted. It is considered that only a very large effort (at least 1000 Heavy Bombers) as soon before H-hour as possible could have produced a really substantial success. Such an effort could materially have increased the destruction and also have been more effective from the point of view of morale. The evidence of P.W. showed that they had been upset by the attacks that did take place, but had had time to recover sufficiently to man their guns. It may well be impracticable, with the methods available, to put on so great a weight in one attack on a precision target; the possibility of sending in successive smaller attacks is likely to depend on flack conditions.

Naval Bombardment.

9. According to the evidence of P.W., naval bombardment inflicted the following damage and casualties:

- W 15 : Direct hits on two casemates, putting them out of action. 30 men killed and at least as many wounded.
- W 13 : 1 gun put out of action.
- W 17 : No serious damage.

From other sources it appears that P.W. had over-estimated the damage and casualties at W 15, but it was nevertheless extremely likely that two guns were silenced. The gun hit at W 13 appears to have been the same one that was already out of action due to bombing.

LoCoG. (H).

10. The pillboxes (W 267 and W 268) that had been engaged at short range by 17 pdr shot from British LoCoG. (H) were examined. Both had been hit frequently, but it was not possible to say exactly how often.

11. W.267. The pillbox had been hit about 12 times, but the angles of attack were oblique and all the shots but three appeared to have ricocheted. One shot had penetrated 5 feet of concrete, but had done little damage inside. Two were found embedded in the earth on the roof. Photos 2 and 3 show the nature of the damage; in each case the shots have passed from right to left across the pillbox. The entry hole of the shot that penetrated is under the overhanging portion in photo 2, but is obscured by shadow.

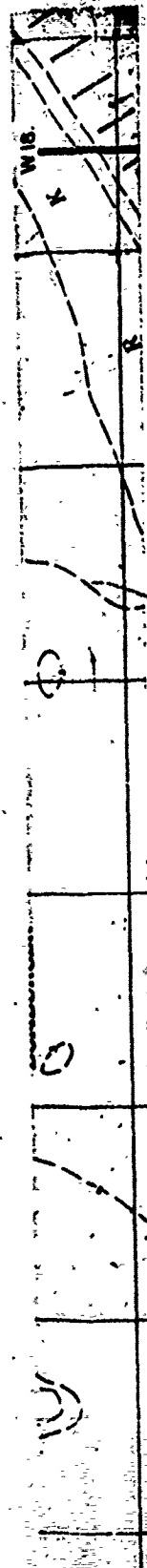
12. W.268. Only a concrete protecting wall, 6 feet thick, was hit. The wall was damaged but not penetrated. The damage is shown in photo 4. One shot was found embedded 2' into the wall, but owing to the extent to which the wall had been chipped away, it was not possible to determine the actual thickness of concrete that had been traversed.

Other Bombardments.

13. Evidence of attacks by other naval craft and by rocket firing Typhoon aircraft had been too much obscured by blown sand for any reliable record to be made. The command post at W 11 had a direct hit from a 5.5" shell which destroyed the rangefinder.

P.W. Interrogation.

14. A summary of information obtained from P.W. is attached at Appendix C.



HEAVY BOMBING IN OPERATION "W.F. 2.10.47" in

2200 H. 21
70 03/10/48 DATED 2400 HOURS

Target	WFO Ref	Date of Bombing	No. of Planes	No. of bombs in load	No. of aircraft over target	Circiter Directly around target, bombs per acre	Guns on the site	Damage due to bombing	Remarks
W 19	104404	28 Oct	38	308	145	3-55	5 x 3.7 Br 44 - 3 in concrete and 2 in open points.	One enemy concrete destroyed	All guns intact, only the two in open points fired on D-day.
W 17	09379	-	-	-	-	Very low	1 x 150 mm in concrete.	nil	One fired on D-day.
W 17	055376	28 Oct	34	317	222	5-0	4 x 220 mm in open concrete emplacements	One gun point destroyed. Command post destroyed	5 out of 4 guns fired on D-day.
W 15	018349	28 Oct	35	364	97	4-45	4 x 3.7 Br 44 (in concrete) 2 x 3 Br 44	One 3.7 destroyed. Communications cut.	3 out of 4 3.7 guns & both 37 fired on D-day
W 13	034318	28 Oct	35	364	54	Low	4 x 150 mm, 2 x 75 mm, all in concrete	One 150 mm gun out of action due to heavy fire obliterated. Communications cut.	5 out of 6 guns fired on D-day
W 11	071278	28 Oct	25	305	148	2-68	4 x 150 mm, all in concrete	Communications cut	All 4 guns intact but did not fire on D-day
W 18	076388	29 Oct	25	483	160	5-8	1 x 50 mm	all	Guns intact.
W 16	043372	28 Oct	34	317	160	Low	6 L. 44, guns	2 positions destroyed	All guns intact.
W 5	053374	29 Oct	25	483	215	5-0	1 x 4.7 cm	Communications cut	Guns intact; did not fire.
W 281	043368	30 Oct	25	349	120	7-45	1 x 50 mm PzK	2 concrete buildings destroyed	Guns intact.
W 222	036364	29 Oct	25	329	20	Very low	none	all	All guns intact.
W 283	030361	29 Oct	25	329	71	6-2	3 x 50 mm	all	All guns intact.
W 284	022357	29 Oct	25	329	51	4-6	none	all	All guns intact.
W 286	019336	29 Oct	25	370	not measured	not measured	none	all	All guns intact.
W 285	026331	29 Oct	25	370	100 +	6-6	2 x 75 mm	all	All guns intact.
W 286	029325	29 Oct	25	370	60	Low	none	all	All guns intact.
W 287	042312	29 Oct	25	329	60	Low	none	all	All guns intact.
W 288	055304	29 Oct	25	329	60	Low	none	all	All guns intact.

NOTES: 1. The fact that guns did not fire was considered to be due to the fact that they could not be brought to bear.
2. In addition, about 10 guns on field cartridges were found not associated with any particular position. They were mostly 75 mm infantry guns and 50 mm PzK.

INTERROGATION REPORT ON 20 PW OF 202 NAVAL COAST DEFENCE ARTILLERY
BATTALION, AND 1, 2, & 3 COYS, 1 FORTRESS BATTALION, CAPTURED AREA
DOMBURG - WEST KAPPELLE - ZOUTELAND BETWEEN 1 AND 4 NOV 44.

1. GENERAL.

No perceptible effort was made by P.W. to be secure and the account of events, as given by them, appears to be truthful.

2. TYPE AND MORALE OF P.W.

(c) Only one of twenty P.W. interrogated was under thirty years of age, and two were fifty, having served long terms in the last war. There was no marked difference between naval and army P.W. In this respect, nor did any of the P.W. give the impression of being 100% fit. The following factors appeared chiefly to have influenced morale.

(b) Favourable effects: The knowledge that, in preventing us from using ANTHEP, they would achieve a positive advantage for Germany, and the fact that the war generally did NOT appear to be going only as the Allies desired that it should.

(c) Adverse effects: The certainty that the garrison of WILCHEREN had been left, cut off, with a meagre hope of survival - old men with families are scarcely attracted by the glory of a do or die last stand; the power of the Allies is clearly demonstrated by the down bombing, and the heavy bombing of their positions; the knowledge that the principle M.G.s in FLUSHING had been abandoned; the knowledge that, despite a momentary improvement, the general trend of the war was NOT favourable to Germany.

(d) P.W. evinced that lack of relish for close-quarter fighting which appears normal with German troops - but, in that there were factors calculated to increase morale, they were slightly more formidable than the troops encountered at BOULOGNE and CALAIS.

3. ENEMY STRENGTHS, DISPOSITIONS, LOCATIONS, AND DEFENCES.

(a) The coastline from DOMBURG to ZOUTELAND was held by elements of two German units: 1 Fortress Bn and 202 Naval Artillery Bn, both with M.G.s. at DOMBURG.

(b) The area from DOMBURG to WEST KAPPELLE was held by 2 Coy 1 Fortress Bn, with elements of 1 Coy in DOMBURG itself; this amounts to approximately 200 men, with either 2 or 4 7.5 field guns in casemated positions on the coast. A platoon of 20 men found itself responsible for approximately 1 km of coast. In addition, the M.G.s. of both units with attendant supply and administrative services were in DOMBURG - this amounted to a further 200 - 250 troops.

Two C.D. batteries were occupied: W 17 at 055376 (5 Bty 202 Naval Arty Bn - 4 x 22 cm, 1 x 15 cm) and W 15 at 018348 (6 Bty 202 Naval Arty Bn - 4 x 9.4 cm (British 3.7 L.A.?) guns) - each battery was protected by its own L.A.A., in position along the dunes. Approximate strength per battery: 120 men.

(c) The area from the breach in the dyke at WEST KAPPELLE to incl ZOUTELAND was held by 3 Coy 1 Fortress Bn with two 7.5 cm guns in casemats on the shore - strength approximately 160 men - one platoon held as much as 1 1/2 kms of coastline.

One C.D. battery was active in the area: W 13 at 034318 (7 Bty 202 Naval Arty Bn - 4 x 15 cm naval guns, 2 x 7.5 cms, 3 x 2 cm Flak) - strength approximately 120 men. Two L.A.A. guns belonging to 6 Bty were stationed at 023334.

(d) Infantry and gun positions were in the dunes close to the sea, and were above the flood level. The air raid shelters were of the normal 24 metre concrete type, and infantry positions were apparently similar to those met elsewhere in the Atlantic Wall - the infantry, except for the 7.5 cm guns already mentioned, appear to have been armed exclusively with M.G.s. and rifles. The naval batteries had some mortars (7 Bty had two, P.W. from other batteries were NOT sure).

4. P.W. ACCOUNT OF THE BATTLE.

At approximately 0700 hrs 1st November, 1944, the alarm was given. By 0800 hrs an arc of 15 ships was visible lying off the WEST KAPPELLE headland just beyond the range of the shore batteries (which nevertheless engaged them) - and numbers of landing craft were visible, which were also engaged. P.W. were NOT aware that they had achieved any unusual success.

(a) 5 Bty at W 17: A naval bombardment opened, and British warships laid a smoke-screen between the line of ships and W 17. The battery claimed to have hit one of these ships, but thereafter became involved in a duel with the KANSITE, which, however, was able to shell it from beyond the range of its guns. The 22 cm guns do NOT appear to have stood up well to the continued firing - No. 1 gun developed a pull; No. 3 twisted on its mounting, and of the other two one had been destroyed by a bomb - the main trouble to the assault force was caused by one 22 cm, which continued to fire throughout the day, and the 15 cm field gun, which fired about 100 rds all in the direction of landing craft off WEST KAPPELLE.



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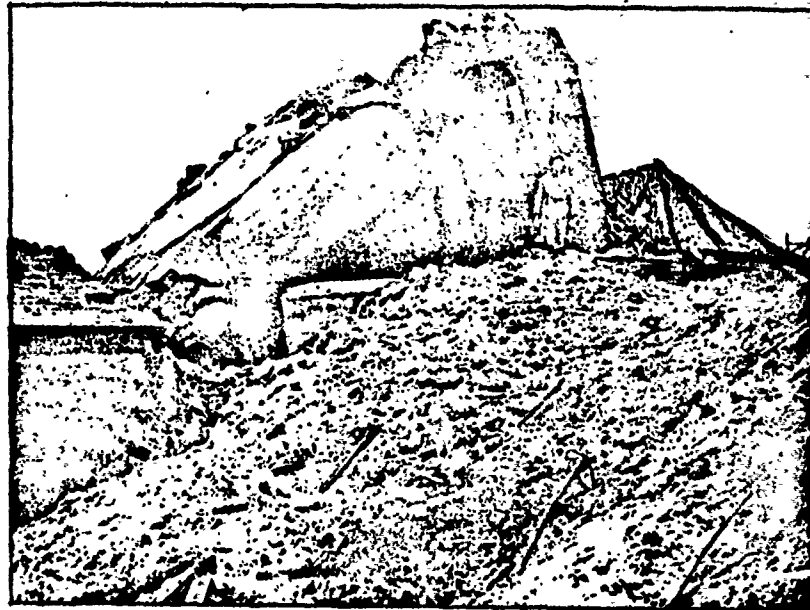
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Photograph I - Direct hit on a casemate



Photograph II - 17 pdr. shot on a pillbox

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Photograph III - 17 pdr. shot in a pillbox



Photograph IV - 17 pdr. shot on a pillbox

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123.

The fire control tower of the battery had been destroyed by a bomb and, therefore, the guns were fired from the gun position. The accuracy of this method seems to have been doubtful, as men from 6 Bty at W 15 said they had been shelled by the guns of W 17.

W 17 was overrun during the early hours of 2nd November, 1944 - the L.A. weapons were intact and were used against our infantry. One P.W. complained that he had asked him to bring up another 60 rounds for the 15 on - only to be captured when the job was completed - most inconsiderate of "Tommy".

(b) 6 Bty at W 15 started the action with three out of four guns still intact. The fourth gun, the fire control tower, and an ammunition store, had been destroyed by the bombing.

All morning on 1st November, these three guns engaged our landing craft - though the crews were uncertain about results. During the afternoon two of the elements received direct hits (P.W. thought they were from the WASPITE). The battery suffered heavy casualties - 30 dead and at least as many wounded. The remaining gun continued to fire until overrun.

(c) 7 Bty at W 13 had all its guns intact at daybreak on 1st November, and became involved in the action at approximately 0800 hrs. P.W. claimed to have seen two landing craft on fire two miles to the NORTH of the position, but were NOT aware of any outstanding success.

During the day one gun was put out of action by a naval shell - the others were said to have fired continuously. P.W. states 200 rounds per gun.

Firing only ceased when the ammunition supply was exhausted. That the supplies could be exhausted, having regard to the large stock normally carried by all G.C. Batteries, was due to the battery having frequently shelled targets on the other side of the SCHLOTT during the Canadian attack on the pocket.

(d) Infantry.

The story of the infantry is NOT interesting - NONE of P.W. interrogated had made any attempt to resist - NOR is this surprising when it is realised that 20 men were "holding" up to a mile of coast.

5. EFFECT OF WEAPONS.

(a) Bombing.

W 17 - 055376. Bombed by heavy bombers on 23 September and 28th and 29th October. Fire Control Post, 1 gun, 1 ammunition bunker destroyed..... morale effect NOT seen as to render the personnel incapable of fighting on the day of the attack. No casualties. 1 radio communications destroyed.

W 15 - 018346. Fire control room and one gun destroyed. One man killed. Severely frightened the Garrison, and seems to have been a factor in deciding the 1st G.C. Battery to give up with their men. One sergeant stated that he had been in Russia, and at VERDUN in the last war, but that he had never experienced anything as terrible.

W 13 - 034318. No destruction. Lines destroyed. Morale definitely lowered.

(b) Naval Gun Fire.

W 17 - NONE of the P.W. interrogated had seen any actual damage - although the 15 inch shells of the WASPITE were landing well inside the position. It was clear that the heavy guns only fired intermittently, and that various causes, possibly attributable to near misses put one or the other of them out of action at the time it is fired. It was the type of attack expected by P.W., and therefore morale effect was NOT as great as in the case of bombing..... Also the possession of the means to hit back was favourable to morale.

W 15 - In a duel with the battleship on 1st November, 1944, the heavy guns of the battery received direct hits, so that by the evening of 1st November, 1944 only one heavy gun was left in the battery. 30 Germans were killed.

W 13 - 1 gun knocked out 1st November, 1944.

Infantry positions in DORLING. One P.W. had seen a 15 inch shell land only 30 metres away from him in the open, but on account of the wetness of the ground the blast and splinters seemed to have been absorbed.

Infantry positions in ZOUTELANCE. One P.W. described how one shell had fallen 20 metres and another 30 metres from him. He was on a shell and described the effect as "disappointing".

• When examined only communications were found destroyed.

124.

(c) R.P.

No physical damage was noticed by the P.W. though nearly all had been in the area of R.P. attacks.

One P.W. described the actions of himself and his comrades during an attack. First they took cover, then after the attack had passed they waited up to ten minutes to see if the plane would return and machine gun them. Then they carried on as usual.

P.W. readily distinguished R.P. from any other form of air attack.

6. EFFECT OF FLOODING.

As the floods spread the number of infantry on the ground was reduced - both on account of the lack of room and the relative worthlessness of the ground.

Positions were NOT flooded, but in some cases low lying living quarters and ammunition lockers were rendered inaccessible.

Most units could still be supplied via the road DOMBURG - WEST KAPELLE - ZOUTELANDE, which was usable up to 30th October, when it was bombed out the road approximately 1 1/2 miles from ZOUTELANDE.

Some L.L. and infantry positions in the stretch from O4 EASTING to WEST KAPELLE had to be supplied by rowing boat.

7. SUPPLIES.

In spite of difficulties, food had always been available, and every unit had 60 days supply in stock.

BRIEF OUTLINE

1. The air tracking of plotting the track to can arrange direct the computers, calculate the pilots.

2. The radio: form the normal.

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ADVANTAGES

5. The air

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(d) 1 requirement

6. The aircraft target, the have always close, as the former accuracy. that are the use of accuracy.

POSSIBLE U

7. Although bombing is dangerous by the Ma crossing, just cross is that it

REPORT NO. 28.

"THE USE OF MOBILE RADAR CONTROL POSTS FOR AIR SUPPORT OF THE ARMY."

Part I.

BRIEF OUTLINE OF OPERATION.

1. The essential equipment of a Mobile Radar Control Post consists of an accurate radar tracking device (SCR 584) and two-way R.T. communication. The controller sees presented on a plotting table (scale 1 : 100,000) the immediate plan position of the aircraft which is being tracked to within ± 100 yards in range and $\pm 1/10$ degree in bearing. By means of the radio he can arrange any changes in height, course or airspeed that may be necessary; he can therefore direct the aircraft towards the target on a course and at a height of his own selection. His computers, making due allowance for speed, height, wind and terminal velocity of bombs, calculate the exact point over which the bombs must be released and, as this point is approached, the pilots are warned and finally ordered to drop their loads.
2. The radar equipment is capable of following either a single plane or a box flying in close formation; 12 Spitfires, 8 Typhoons or 6 medium bombers (Bostons or Mitchells) have been the normal sizes of formations, but 48 medium bombers have been controlled.
3. In order to check drift due to wind which may differ from that forecast and to ensure that the planes are flying straight towards the target at the moment of bomb release, it is necessary for the Controller to "take over" the formation some 20 miles from the target. This, together with the calculations required, at present limits an M.R.C.P. to dealing with four to six formations in an hour.
4. The M.R.C.P. is connected by telephone with the Forward Control Post and the Group Control Centre and the controller receives therefrom all the necessary information about the target, the planes attacking it, their call sign and bomb load and their E.T.C. and height over the rendezvous point. The briefing of the pilots is remarkably simple as they have only to reach the R.V. at the correct time and height and to report over the R.T. to the controller.

ADVANTAGES AND DISADVANTAGES OF THE SYSTEM.

5. The advantages of the use of the M.R.C.P. for Direct Support are considerable.
 - (a) As the pilots can be completely guided by the ground controller, operations can be carried out on days when, without its assistance, they would be impossible. The only requirements being sufficient visibility at the base for take-off and landing and a minimum of rain-clouds as these can cause interference with the Radar.
 - (b) The task of the aircrew is reduced by the M.R.C.P. to flying on instructions received, and therefore personal errors of navigation by aircrews are eliminated.
 - (c) The investigations described in Part II of this report show that the accuracy with which bombs can be dropped by M.R.C.P. controlled planes is such that targets can be accepted closer to our own troops by this system than by any other radar means.
 - (d) Unlike many other radar sets the SCR 584 is not very exacting in its station requirements.
6. The chief objection which has been raised against the use of the M.R.C.P. is that the aircraft are required to fly straight and level for several miles in their approach to the target, thereby presenting an easy target for anti-air guns. As the M.R.C.P. controlled planes have always attacked from 8000 to 10,000 ft they have been beyond the range of light flares also, as most of the sorties have been flown above thick cloud, the enemy anti-aircraft, which in the forward areas are visually controlled, have seldom been able to fire with any hope of accuracy. It is normal to arrange when necessary for a counter-attack force, in this instance that are within range. It should be possible, then further expansion has been made in the use of the M.R.C.P., for some measure of weaving to be introduced without loss of accuracy, but the amount of weaving is necessarily limited by the tightness of formations.

POSSIBLE USES OF THE M.R.C.P.

7. Although in recent operations the M.R.C.P. has only been used for straight and level bombing from above cloud, there are other possible uses. In fine weather, when a flight of Typhoons or Spitfires sets out to attack a target, they can be "picked up" and followed out by the M.R.C.P. There is no need for the controller to direct the planes along a course of his choosing, but from time to time he can give the pilots useful information, such as "The enemy is just crossing over the River X; there is a village five miles away to starboard. The target is that little wood one mile along the railway beyond the village." In this way the formation

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leader is free to attack from whatever direction he likes but he is given valuable assistance in locating the target. This applies equally to strafing, dive-bombing and rocket attacks.

8. In most cases work as well by night as by day single planes can be controlled at night for flare dropping, night bombing or photography. Formation flying is not possible.

9. Within the range limitations of the apparatus there are good possibilities of the M.R.C.P. being used for supply dropping. If the new high-level approach with delayed opening parachutes is introduced for supply-dropping, an M.R.C.P. could be of great assistance in ensuring the arrival of supplies for formations cut off from the main force. However, as shown in para. 10 below, low flying aircraft cannot be followed for.

RANGE OF OPERATION.

10. The range to which planes can be followed by the radar set at the M.R.C.P. depends on size of the formation and the height at which it flies. For example, it has been found that a group of 8 Typhoons which can be tracked to 30 miles when flying at 10,000 ft is usually lost at about 22 miles when flying at 5000 ft.

11. It can be seen that the amount of air support that can be controlled by one M.R.C.P. is limited partly by the time factor (say, 4 formations per hour) and partly by the effective range of the equipment. As it takes about a day to dismantle the station, move to a new site, re-erect the equipment and accurately to survey the new site, it is desirable that two M.R.C.Ps. should be able to keep-free forward as the battle advances.

PART II*

1. From 8th February, 1945, the opening day of Operation 'VERIFIABLE', up to 5th March, 1945, No. 1 Mobile Radar Control Post has controlled 409 planes, medium and fighter bombers, which have dropped 1472 bombs (345 tons) on targets requested by the army. During the early days of the operation the M.R.C.P. was near Main H.Q. 30 Corps at HILBERT (E 6858) and later moved forward to a site near Main H.Q. 2 Cdn Corps at MATERNBORN (E 8755). At both places it was possible to find a good radar site within a mile of the corps with which the M.R.C.P. was co-operating.

2. The 54 missions controlled by the M.R.C.P. were flown in conditions when, without radar aid, they would not have been attempted. On at least two days the radar-controlled sorties were the only ones flown, so bad was the weather.

3. As most of the bombs were dropped from 10,000 ft above 10/10 cloud, results were very rarely observed. On 12 occasions pilots reported seeing bomb bursts through gaps in the clouds and in six cases they were said to be right on the target. Wherever possible ground checks have been carried out and the results are set out in the table below.

Results of Accuracy Checks

Date	Aircraft	Bomb Load	Aiming Point	Displacement of M.P.I.	Remarks
9 Feb	12 Spitfires	250 & 500 lb	X-rds in TILL (E 979528)	486 yds	All in fields S of village. (B on photo I)
9 Feb	12 Spitfires	250 & 500 lb	X-rds in HOVLAND (E 968516)	160 yds	2 houses destroyed. Nearest bomb 50 yds from X-rds. (D on photo II)
11 Feb	8 Typhoons	500 lb G.P.	X-rds in HOVLAND (E 968516)	518 yds	All in fields NW of village. (E on photo II)
11 Feb	8 Typhoons	1000 lb & 500 lb G.P. and No. 17 Clusters	X-rds in TILL (E 979528)	433 yds	Fields N of village (A on photo I)
			-C-	100 yds	Around cross roads (C on photo I).
12 Feb	6 Typhoons	500 lb G.P.	X-rds in M.88UM (E 848437)	nil	Clustered around the X-rds. 2 houses destroyed.

* This Part will also be issued as a Joint Report by GNS/21 Army Group and GNS/2nd S.F. entitled "Note on the Accuracy of the M.R.C.P."



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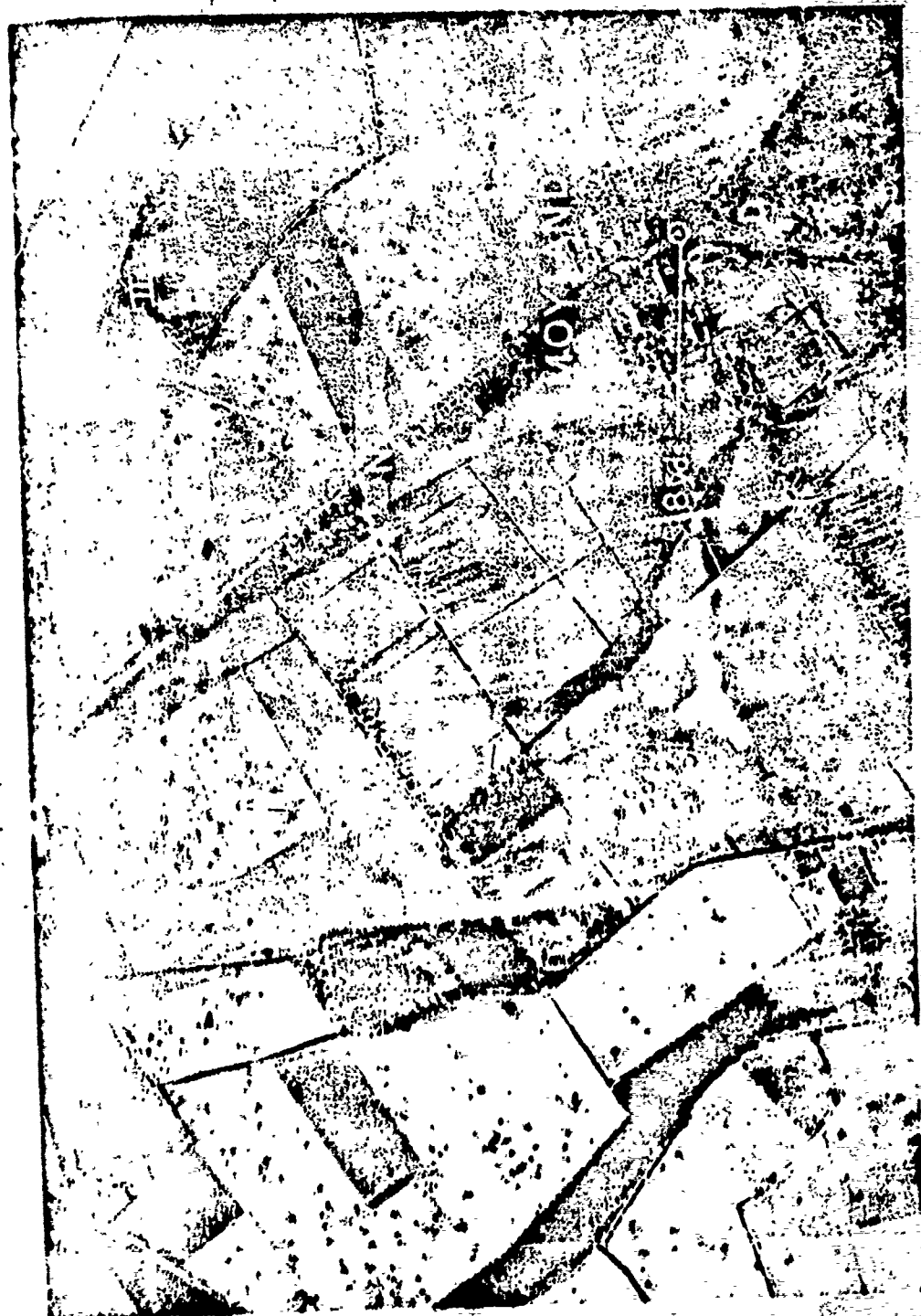
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Date	Aircraft	Bomb Load	Aiming Point	Displacement of H.P.I.	Remarks
3 Mar	6 Bostons	500 lb H.C.	X-ras in KEVELMER (E 967327)	100 yds	Bombs hit town but SW of the pinpoint.
3 Mar	6 Bostons	500 lb H.C.	X-ras in KEVELMER (E 967327)	150 yds	Bombs hit town but just E of pinpoint.
5 Mar	42 Mitchells	500 lb H.C.	Rail Dr. WEEL (A 211405)	450 yds and 480 yds	Only 2 boxes checked by photographs. (Not ground checked)
5 Mar	36 Mitchells	500 lb H.C.	Road Dr. WEEL (A 218392)	400 yds and 480 yds	Only 2 boxes checked by photographs. (Not ground checked)

4. ACCURACY.

The average displacement of the H.P.I. from the aiming point was found to be 340 yds. The maximum displacement for line was 300 yds and that for range, though not certain, was considerably less. No single bomb was found more than 550 yds from the aiming point.

5. DISPERSION.

Owing to the very close formations kept by planes under H.R.C.P. control the spread of bombs on the ground is small. A formation of 12 Spitfires have dropped 24 bombs in an area 150 yds long by 75 yds wide and a box of 6 medium bombers have dropped 42 bombs in an area about 300 yds by 150 yds.

6. CONCLUSIONS

The conclusions that can be drawn from the limited number of operations that have been studied so far are:

1. Bombing accuracy achieved with the H.R.C.P. are many compared with those obtained by visual methods in level bombing.
2. The accuracy is such that targets can safely be engaged closer to our own troops than by any other existing radar means.

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REPORT NO. 9.

THE EFFECT OF 90 LB FRAGMENTATION BOMBS.

1. INTRODUCTION.

Between 115 and 145 hours on 8th August 1944 two formations of Flying Fortresses, about 20 planes in all, dropped 90 lb fragmentation bombs on areas to the east and south-east of CAEN. The total casualties resulting from this incident were, as far as can be ascertained, 86 killed, 218 wounded, and 7 missing; the equipment damaged or destroyed amounted to 83 vehicles (mostly M4 type) and 7 guns. One of an ammunition dump was hit and all the stock in that section was either destroyed or rendered unfit for issue. Most of the units concerned were visited just after the occurrence and in some cases a detailed study of the effects of the bombs was made.

2. MATERIAL EFFECTS.

1. In most cases the craters were very small, only 2' 6" in diameter and about 6" deep. Where the bombs had fallen in fields the cross was completely removed over a radius of 7 feet from the point of impact and, for a radius of some 11 or 12 yards, very distinct fragment tracks could be seen in the ground. There were a few craters of a different pattern which suggested a direct hit in the forest; these were some 6 feet across and of an almost uniform depth of 9 inches, the radiating fragment tracks only reaching about 4 yards from the centre of the crater. Some damage was observed from a second type of crater but it was as nothing compared with the havoc wrought by the first.

2. At the north-west end of the village of CORNELLIS (U 0565) were the Festoon H.Q. of 3 Canadian Infantry Division, and Main H.Q., 2 Canadian Armoured Brigade. The former dispersed around the field marked "A" on the appended map and the latter in the large house and wood on the other side of the stone wall. The writer visited this area immediately after the incident. The western half of the 3 Division field had 20 bombs, which works out at something over 6 per acre. In 2 Armoured Brigade's wood only one crater was found but the damage done and the fragment strikes observed would suggest that quite a number of bombs had burst in the air as a result of striking the trees. The large house was gutted by fire which was caused either directly or indirectly by the bombing.

3. In 3 Division's camp 7 vehicles and a motor cycle were parked round the sides of the field and all except one were destroyed. It is not known how many vehicles were at 2 Armoured Brigade's camp at the time but 4 were definitely destroyed. The casualties at the H.Q. 3 Division were 4 killed, 10 wounded (including the G.O.C.) and 7 missing; in 2 Armoured Brigade H.Q. there were 6 killed and 29 wounded. The exact numbers of men present at these H.Q.s at the time is unknown but the casualty rate seems to have been very high indeed.

4. Jeeps 1 and 2 in field "A" (see appended map) were completely burnt out though they were at least 12 yards from the nearest crater in each case; it appears that the fires were caused by bomb fragments hitting the tyres. The half-track in the corner suffered a direct hit and large pieces of the skirting plates were found to have been blown 55 yards away from it; it caught fire and was gutted. The motor cycle was burnt out, probably due to a burning piece of wreckage being blown out of the half-track. The 15-cwt truck (1) which was burnt out was riddled with fragment strikes, many of them quite low down on the vehicle. Jeeps 3 and 4 were both destroyed by the collapse of the 12 ft high stone wall.

5. In the wood were 2 half-tracks, a signal van, and a 3-ton lorry; all were burnt out and holed by fragments. As mentioned above it was not possible to determine where the bombs had fallen owing to the air burst effect caused by the trees.

6. A considerable column of transport was using the main road through CORNELLIS when the bombs were dropped. Though the damage and casualties are included in the totals (see Appendix 1), as they concerned units which also had losses in other parts of the area at the same time due to the bombing, it is not possible to quote figures for this particular locality.

7. A large amount of heavy and medium artillery was deployed in the open ground to the north of CORNELLIS; bombs fell across this area and caused considerable damage. 28 Heavy Battery had 8 men wounded (all in one troop) and three vehicles destroyed. The density of bombs over their battery area was 6 to the acre. With the exception of one stock, all the ammunition belonging to this battery had been buried so that the lids of the boxes were at ground level. Bombs had fallen within a yard of such stores and had not damaged a single round but the one stock which was above ground, although 30 yards from the nearest crater, was destroyed by fire resulting from fragment strikes. 3 Heavy Battery R.A. occupying the airfield on site lost 5 men killed and 17 wounded. One 7.2 Howitzer received a fragment strike in the tyre; this caused a fierce fire as a result of which the whole frame of the gun was damaged. Their other 7.2 was slightly damaged by a strike inside the mouth of the barrel, but it was able to repair the damage in two hours. Bomb density both here and in the next field was about 3 per acre. Canadian Medium Regiment (none known) which was in this

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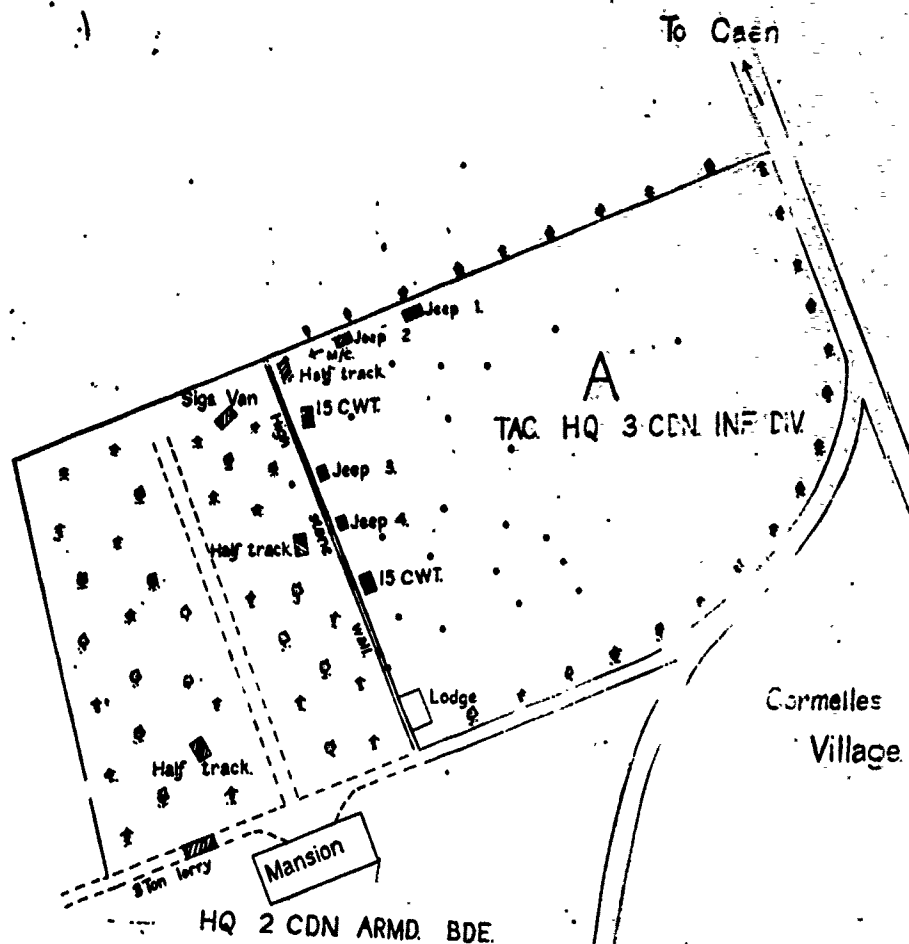
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• Crater of 90lb bomb

Scale (approx) 50yds = 1inch

next field suffered heavy casualties in men and material. They had moved to a fresh location when the writer visited the site on the following day but the appearance of their gun positions was one of chaotic destruction.

5. On the main CAEN - FALAISE road due west of CORNELLES a column of transport, including the Polish Armoured Division's L.A.A., was hit by a small number of bombs. In the fields just off this road 30 "B" vehicles were burnt out in an area only 300 yards square yet no more than 8 craters could be found in this area. Either fragments had inflicted damage at very considerable distances from the bomb bursts or else the fire had been spread by burning wreckage hurled through the air; patches of burnt grass lead one to the latter conclusion.

6. At COLONNELLES (U 0769) the 2 Canadian Corps Ammunition Dump, some 3 miles long by 1/2 wide, had several bombs dropped across its southern end. 5 fatal casualties occurred here. All the ammunition in this part of the dump was either destroyed or rendered unfit to issue but the dump is so extensive that damage at one end did not effect supplies to the front. It was noted that the American type of ammunition packed in wooden boxes was particularly susceptible to damage in an attack of this sort. It was quite impossible to determine the number of bombs which fell in the dump as it had been shelled and bombed so much in the past and, in addition, the ammunition blowing up made many more craters.

III. CONCLUSIONS.

1. The number of casualties inflicted on our troops by this relatively small weight of bombs was due to the fact that hardly anyone took cover till it was too late, for bombing was the last thing they expected when the sky was full of friendly planes. This disastrous accident clearly illustrates the high lethality of 90 lb fragmentation bombs against troops in the open.

2. The preservation of the ammunition at 28 Heavy Battery where it was placed in shallow trenches (see para. 4 above) shows that a slit trench is proof against all but a direct hit from these bombs.

3. Motor transport on the roads is very vulnerable to attacks with these fragmentation bombs; there is, however, just a slight possibility that the synthetic rubber tyres on the German vehicles might not take fire so readily as our own.

4. Judging from the havoc wrought in that part of the ammunition dump where some of these bombs fell, it is imagined that even a very small density of fragmentation bombs evenly distributed over a German ammunition dump would have a very useful effect as the enemy's sprang and staking arrangements are said to be the same as our own.

5. The effect of the fragmentation bombs falling among the trees at H.Q. 2 Canadian Armoured Brigade suggests that, whereas these bombs are of little use against slit trenches in open country, they might well be very effective against Germans entrenched in a wood.

APPENDIX A.

CASUALTIES AND DAMAGE.

Formation or Unit	Killed	Wounded	Vehicles Destroyed	Guns Destroyed	Location
W1 2 Cdn Armd Bde	8	20	4	0	048653
Tac W1 3 Cdn Inf Div	4	10	7	0	049654
2 Cdn Svy Bde	6	12	5	0	-
10 Cdn Armd Regt	8	45	30	0	048648
CWO 2 Cdn AGRA	2	2	2	0	-
1 Hvy Regt R.C.A.	7	21	6	1	-
3 Med Regt R.C.A.	4	2	0	0	-
4 Med Regt R.C.A.	20	30	0	0	-
7 Med Regt R.C.A.	3	30	4	3	058657
5 Cdn & Tk Regt	2	6	1	0	076657
31 Fd Coy R.C.A.	1	5	0	0	067675
Q.O.R. of C.	0	1	6	0	-
R de Chaud	0	3	0	0	-
N. Shore Regt.	0	40	0	0	047657
2 Cdn Corps Am Bde	5	0	2	0	048657
1 Polish Armd Div	8	20	4	1	047647
Middlesex Regt.	0	3	2	0	048653
5 Hvy Bty R.A.	5	13	4	2	058655
28 Hvy Bty R.A.	0	8	3	0	058656
148 R.A.C. 33 Armd Bde	3	15	3	0	-
TOTALS:	86	286	83	7	

NOTE: Casualties for Q.O.R. of C, R. de Chaud, and N. Shore Regt are listed as wounded but they include an unknown number of killed. Figures obtained from these regiments were divided into Officers and Other Ranks but not into killed and wounded.

MEMORANDUM NO. 5.

NOTES ON THE EFFECTS OF BOMBING ON WET GROUND

PART I.

INFORMATION FROM THE AMERICAN SECTOR

1. Nature of Soil and Sub-Soil.

The areas over which U.S. Tactical Air Force have been operating recently have had heavy loam surfaces. These are generally different from the sandy soils we find in most of the low-lying ground in HOLLAND, though the change from one type to the other, begins south of VRELO.

2. Effects of Bombing with Delay Fuses.

The American experience is that craters are slightly larger in wet ground than in dry ground. The effect is unlikely to be marked because at the depth at which delay fused bombs burst, the moisture contents cannot be expected to undergo any marked seasonal variation. The American opinion is that .025 sec is still the best delay for producing maximum cratering.

3. Effects of Instantaneously Fused Bombs. (Only nose-fused have been used - there is no evidence of the effects of bombs fused tail, no delay).

The Americans stated that crater sizes increased progressively the wetter the ground. Craters 10 - 12 ft in diameter were examined and are thought to have originated from 500 lb bombs. The craters were full of water and thought to be about 3 ft deep. Although a loose parapet had been thrown up around the craters, the fragment grooves were still plainly visible in the ground beyond this parapet, indicating that the anti-personnel effects of the bombs had not suffered appreciably.

4. Nature of Targets in wet Areas.

Silt trenches and pits were mostly very shallow (it is for consideration whether in some areas in HOLLAND it is possible to dig down at all owing to the water table being so near to the surface). Defences were generally based on villages or factory buildings where waterproof underground emplacements could be more readily contrived. Opinion was that only delay fused bombs were of any use against such defences.

5. Traffic Ability.

There was no indication that bombing had had any adverse effect on the traffic ability of ground, apart from the actual craters themselves. It was suspected that the craters of even instantaneously fused bombs would be impassable to all but Churchill Tanks, but it is thought that this effect will be less seriously on sandy soils. The American attitude to craters was that if they caused obstructions, they just filled them up. One instance was recorded where a drainage channel had been stopped and a considerable area had been flooded in a few hours.

PART II.

ADVICE IN THE PLANNING OF OPERATION "VERITABLE".

1. The type of ground between the Meuse and the Rhine in the "Veritable" area consists principally of three main types. Their principal characteristics are as follows:

(a) Flood plain.

A thin layer of loam on a sub soil of fine sand. There are numerous drainage channels. When not flooded the water table will only be a few feet below ground level.

(b) Lower terrace.

A fine sand gradually changing with depth into a fine gravel.

(c) Higher ground.

Consists of varying mixtures of sand and gravel.

2. Many sources of information have been consulted as to the effects of bombs on these types of ground when wet and there is great disparity between them. However, coupling this information with the results of examination of craters in ground that is known to be similar, it appears that there is not likely to be any significant difference in crater sizes from those found in NORMANDY.

3. Bombs fused .025 secs delay.

Deep craters will be formed. The area over which each bomb can do damage will be more closely limited to the extent of the crater as there will be little, if any, heavy debris that can do damage beyond.

Bombs dropped in the flood plain may obstruct drainage channels, but this should do no more than produce local flooding owing to the porous nature of the sub-soil. This presupposes that the ground is not flooded already.

4. Bombs fused nose instantaneous.

Provided the fuses function correctly only shallow craters should result and the fragmentation pattern near the ground should be good. Obstruction of tracked vehicles should be negligible, but wheeled vehicles will naturally be adversely affected by soft patches of sand and this will be made worse by even the shallow craters. Unless there are good reasons to the contrary, it is recommended that as a precaution no bombs fused nose instantaneous larger than 500 lbs be used.

5. Bombs fused tail no delay.

These bombs may easily produce craters deep enough to obstruct tracked vehicles, especially in the flood plain (presupposing that vehicles can go there at all). Their fragmentation pattern is also likely to be poor near the ground. It is understood that 2nd T.A.F. never use bombs so fused, but other forces have used them on occasion. It is recommended that they be not used in any circumstances.

6. Pent.

The trace shows some small areas as containing pent. Abnormally deep craters are likely to be formed in these areas by all types of bomb, but it is anticipated that they are impossible to vehicles in any case and contain no defensive positions.

PART III.

INFORMATION OBTAINED FROM MINISTRY OF HOME SECURITY.

1. There are many factors which can contribute to the diversity of crater sizes, the following are the most important:-

- (a) Type of Bomb, e.g., 500 lb G.P., 500 lb M.C. Mk I to IV, 500 lb U.S.A.
- (b) Type of fuse, e.g., 44 Pistol, 27 Pistol, Tail No Delay.
- (c) Speed and height of aircraft at time of release.
- (d) Type of explosive used.
- (e) Nature of soil.
- (f) Humidity of soil.

2. The variation in the type of bomb means that size, weight, centre of gravity, thickness of casing and charge/weight ratio are all liable to fluctuation.

3. The 44 Pistol acts by pressure built up between ground and a diaphragm and the bomb bursts above ground. The 27 Pistol is a nose impact device with delay of .002 seconds. Tail no delay is .006 seconds.

4. Speed and height of aircraft determine the angle of strike and velocity of strike and therefore the depth of penetration before explosion. 30 mph. at 2,000 ft gives 49.5° and 536 f.p.s. whereas 200 mph. and 20,000 ft gives 12.9° and 1034 f.p.s.

5. Type of explosive used causes variations from TNT and mistel as unity to Minol at 1.2 and P.A.C. at 0.7.

6. Soil factors vary from clay as unity to gravel at 0.71.

7. Humidity varies with type of soil but can apply a correction of nearly 100% in some cases.

8. The table given below serves as an indication of how 500 lb bombs with "Instantaneous" fuses can give different craters in the same type of soil (sand). It by no means exhausts the possible permutations and combinations.

Table 500 lb bombs dropped from aircraft flying at 200 m.p.h. into sand.

DETAILS	CRATER		DEPTH (ft)	
	DIAMETER (ft)		Dry	Wet
(a) 500 lb G.P. Mk IV (Mantol filling) fuse 002, dropped from 6,000 ft	4.3	8.0	3.0	1.4
(b) Ditto, dropped from 10,000 ft	5.7	10.4	3.3	1.7
(c) 500 lb G.P. Mk IV (Mantol filling) fuse T.N.D. (006), dropped from 6,000 ft	10.4	16.0	4.3	2.6
(d) Ditto, dropped from 10,000 ft	11.3	18.0	4.5	3.1
(e) 500 lb M.C. Mk II (Mantol filling) fuse 44 pistol, dropped from any height.	3.6	6.0	1.9	1.1
(f) 500 lb M.C. Mk IV (Mantol filling) fuse 44 pistol, dropped from any height	3.0	5.0	1.3	0.8
(g) 500 lb M.C. Mk II (Mantol filling) fuse T.N.D. (006), dropped from 6,000 ft.	16.1	24.6	6.3	4.2
(h) Ditto, dropped from 10,000 ft	17.9	27.4	7.0	4.9

9. Above figures give apparent depth of craters but the zone of disturbed earth is greater especially with the longer delays and may be as much as four times the apparent depth when using 0023 sec delay fuse.

10. Little is known about the effects of freezing but it is suggested that if only the surface layer of 1 ft to 18 ins is frozen it will behave like a rock surface and have little effect on any but the shortest fuses. If however, freezing goes down to 6 ft or so results might well be the same as for rock and little cratering should occur.

11. On the question of reliability of fuses the 44 pistol is regarded as very good but American fuses are liable to be affected by moisture and consequently not very good.

12. It will be seen that the craters observed by Capt. Sergeant (12' diameter and 3' deep) could easily be caused by 500 lb M.I. bombs. The variation of crater sizes in a stick dropped across a valley or down a slope might well be due to outcrops of various strata.

13. The fragmentation pattern from 500 lb bombs will differ with the conditions of soil except when using the 44 pistol which causes the bomb to burst before penetration.

14. It is considered that 500 lb bombs fused T.N.D. (006) or longer will block ditches 4' wide by 2' deep and only a few such hits would cause considerable difficulty if the water table were near the surface but, under drier conditions, an enormous number would be required to have any serious effect.

15. Finally it is pointed out that in wet soil the spoil from the bombs is likely to have as great a bearing down effect as the craters themselves.

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MEMORANDUM NO. 4.

AMERICAN INCENDIARY BOMBS

1. The following information has been obtained from Ordnance, Chemical Warfare, and Operational Research Sections of IX U.S.T.A.F.

2. There exist at the moment in this theatre:

- (a) M-76. 500 lb aimable incendiary bomb.
- (b) M-47. 100 lb aimable incendiary bomb.
- (c) Droppable gasoline tank.

3. The M-76 is a GP bomb weighing 473 lb and containing 180 lb of gasoline gel. This can be aimed like any other 500 lb bomb and, if dropped from 22,000 ft, will penetrate 30" of unreinforced concrete but from lower heights and against reinforced concrete it is disappointing. It can be successfully used against buildings such as factories or houses which it will penetrate before bursting. The bomb penetrates the ground somewhat before bursting and so the mixture is not splashed very far; 30 yds by 20 yds is quoted as the area of burst. The burning time is from 5 to 7 minutes.

4. The M-47 is an ordinary 100 lb bomb with gasoline gel filling. This is used by American Bomber Command aircraft against industrial targets.

5. The Droppable Gasoline Tank weighs 1132 lb, of which 990 lb is gasoline gel mixture. It is dropped usually from low heights (approx 1,000 ft) and tumbles over and over in the air, depending on hitting the ground for its burst. When dropped from such low altitudes there is still a large forward component of velocity which causes the mixture to be thrown forward. The resultant splash is said to be as much as 100 yds long by 30 yds wide. Burning time is quoted as from 3 to 10 minutes. The droppable gasoline tank has poor ballistic qualities and is thus inaccurate but if it were improved in this respect the forward splash effect would be lost.

6. The Droppable Gasoline Tank is not used against pin-point targets because of inaccuracy (see para 5 above) but is used in quantity, say 30 a/c each with 2 tanks, against an area target.

7. It is considered that, with any of these incendiary devices using No. Palm mixture, anything inflammable covered by the splash will be burnt. Thus an M-76 going through the roof of a building will set fire to the inflammable contents though a Droppable Tank bursting on the outside of the building would do little harm.

8. Troops in open trenches and emplacements would probably be burnt by the splash but very little of the mixture can be expected to penetrate the embrasures of a pill-box.

9. No. Palm incendiary mixture is not in itself affected by moisture and will burn on the surface of water, but its fire-rising properties are much reduced by dampness and, if dropped on a wet forest, probably only the light timber in the area covered by the splash would catch fire.

10. Although American bombers have used M-47 and IX USTAF have dropped the gasoline tanks no information could be obtained as to its results except that it made the enemy take cover and discouraged the ground troops who enjoyed seeing this "Airborne Flame Thrower" used against the enemy. It will be possible in the near future to examine targets which have recently been attacked with the jettisonable gasoline tank.

11. No definite statements were made as to the possibility of dropping the tank from heights in excess of 1,000 ft but it is believed that still greater inaccuracy would follow and much of the valuable forward splash would be lost.

12. Typical loads for tactical Air Force planes are: P-47 - 3 x M-76s (total weight of incendiary mixture 540 lbs) or 2 x Droppable Gas Tanks (total weight of incendiary mixture 1980 lbs). P-38 - 2 x M-76s (only 360 lbs incendiary mixture) or 2 droppable tanks. Thus the droppable tanks allow a much greater quantity of incendiary mixture to be carried.

13. Other developments of interest include the M-17 which is a cluster of 68 x 4 lb magnesium incendiary bombs. These are intended for starting numerous small fires in congested areas. There is also said to be a cluster of 33 x 10 lb White Phosphorus bombs being developed in U.S.A. The anti-personnel effects of this are hoped to be better than other W.P. bombs and shells, but the usual limitations of W.P. should be remembered; i.e. small particles are not very effective, thick clothing reduces W.P. effects and wet weather has a similar result.

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MEMORANDUM NO. 8

UNLOADING OF GLIDERS IN OPERATION "OVERLORD".

1. 353 gliders set out on operations "Battery", "Coup de Main", "Tonga" and "Waller", and de-briefing reports are available in 306 cases. These reports have been subjected to extensive analysis and, in addition, a number of glider pilots have been individually questioned on this subject.
2. Information was obtained from four sections of the de-briefing questionnaire; namely: "Time taken to unload", "Any difficulties in unloading", "Did the glider crash on landing?", and "Pilot's remarks".
3. Answers were given to the question about time taken to unload in 263 cases out of 306. These varied from 11 seconds to 6 hours and the average time was almost exactly 30 minutes. When varying between such distant maxima and minima the average is of little significance and the histogram attached is of greater interest. It will be seen that whilst 94 gliders required up to 10 minutes to unload, there were 75 cases where more than half an hour was needed.
4. The pilots of 107 gliders reported no difficulty in unloading yet in 15 such cases times in excess of 20 minutes are recorded. Many of the really quick and easy unloadings occurred where only live loads were carried.
5. There were 19 instances where damage to the undercarriage was responsible for delay. In most of these cases the nose wheel was broken and the tail was in the air. The delays were not excessive; in fact, the average unloading time for these 19 gliders was 29 minutes, slightly less than the average for the whole 263.
6. Nothing could have been done to prevent the above-mentioned accidents. Similarly, the 13 cases of crash landings, collisions on the L.Z., etc., which caused rather longer delays were unpreventable except possibly for the one outbreak of fire which the crew were unable to put out as their extinguishers were inoperable.
7. In 21 cases the glider pilots attributed the delay in unloading to the inexperience of the passengers, some of whom even confessed to complete ignorance of the fact that the Norman tail was detachable. There was also 8 cases where part of the load became entangled with the structure of the glider during unloading; these can probably also be attributed to insufficient training.
8. Although all the bolts retaining the tail units were greased on D-1, there were 41 reports which definitely mentioned stiffness of bolts. It would appear that the strain of landing on uneven ground had caused these bolts to become bent. 6 reports mention the failure of the cutters provided to cope with the control wires.
9. There were 14 instances recorded of difficulty being experienced in moving the tail unit after the bolts were undone and the control wires cut. One report says that a Jeep was used to tow the tail away and another that 12 men were needed. Lixing, chopping, or sawing of the tail unit was reported in 23 cases and, according to 3 other pilots, the tail was blown off; this must have been done in a very haphazard fashion as it is understood that the Cordtex Surcingle designed at A.F.D.C. was not issued. Indeed, one man mentioned the use of 308 for this purpose!
10. It is unfortunate that in so many cases where times of between half-an-hour and an hour were needed for unloading the only explanations given are such vague terms as "Tail Ass. w/s" or "Tail difficult to remove".
11. As a result of a careful scrutiny of the 306 reports it seems that great improvements could be effected. If the following provisions had been made, the number of gliders needing only 10 minutes for unloading could have been increased from 94 to 265:

- (a) Better training of Airlanding troops in tail unloading.
- (b) Better wire cutters.
- (c) Differential brakes to allow the pilots to avoid obstructions.
- (d) Cordtex Surcingles for cutting the tail.

This would also reduce the average unloading time from 30 minutes to 11.3 minutes.

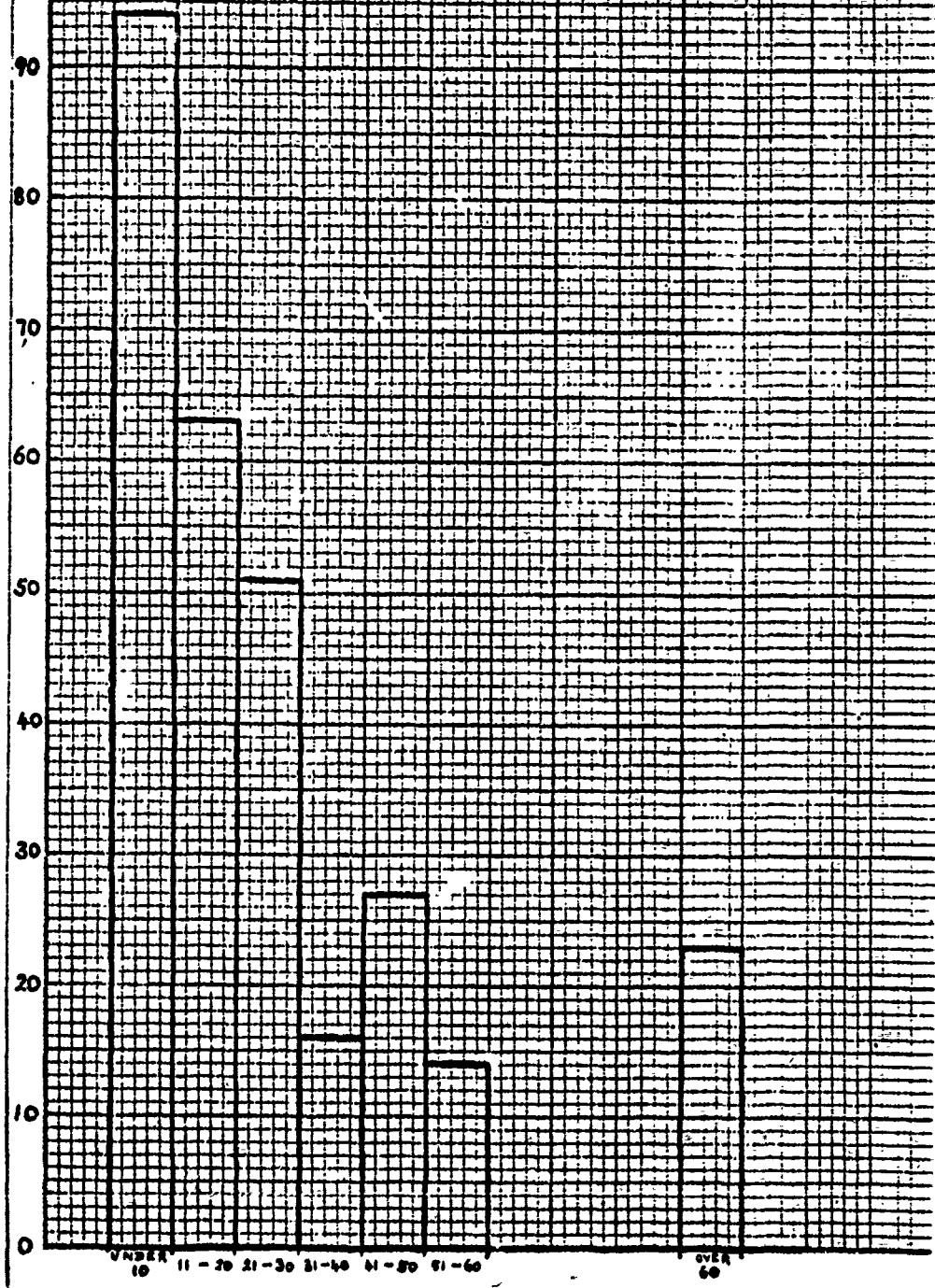
STATISTICAL ANALYSIS OF DIFFICULTIES ENCOUNTERED IN UNLOADING CARS.

Unloaded in less than 20 minutes Unloaded in more than 20 minutes	92 15 107	Reported no difficulty in unloading	107	94
Undercarriage damaged; coil in air More serious errors	19 13 32	Accidents	32	10
Passengers' interference Delay in unloading load	21 8 29	Due to insufficient training	29	9
Boils retaining coil stiff Vibr. causes bleed Difficulties after removing bolts	41 6 14 61	Specified trouble with coil unit Unspecified trouble with coil unit	61 54	20 18
Especially simple cases More serious cases	10 13 23	No time stated for unloading	23	74
			306	100

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HISTOGRAM TO SHOW THE DISTRIBUTION OF GLIDERS BY UNLOADING TIME

NUMBER
OF
GLIDERS



TIME TAKEN TO UNLOAD
(IN MINUTES)

PART II**ARTILLERY****CONTENTS**

- Chapter 6. Accuracy of Predicted Fire.
- Chapter 7. Counter Battery.
- Chapter 8. Morale Effects.
- Chapter 9. Artillery in the Assault on the Beaches.

CHAPTER 6.
ACCURACY OF PREDICTED FIRE.

CONTENTS

- Accuracy of Predicted Fire - Operation VERTABLE (Report No. 31)
Accuracy of Predicted Shooting - Operation SWITCHBACK (Report No. 24)
Use of G.L. III in Forecasting Wind for Artillery Meteor (Report No. 21)

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REPORT NO. 31.

THE ACCURACY OF PREDICTED FIRE: OPERATION 'VERITABLE'

SUMMARY.

The factors contributing to the accuracy of the artillery support in 'VERITABLE' (7/6 Feb 45) have been considered. The survey of certain gun positions and hostile batteries was conducted by a team of Is.O. visited command posts, and a number of calculations have been examined. An attempt is made to assess the meteor errors. The investigation shows that in this operation the survey and command post errors were in fact not so considerable as the meteor errors.

An attempt to measure the overall accuracy of the fire by counting shell errors at the targets and along the opening line of a barrage has been made. The results of the barrage counts are presented graphically: those for a number of hostile batteries indicate that of the predicted fire fired at a target not more than about 5 fell in a 100 yards square target area.

INTRODUCTION.

1. The 3 Is.O. Reports Nos. 26 and 29 dealt with the effectiveness of the artillery fire during the opening stage of Operation 'VERITABLE'. The present report deals as far as possible with the accuracy of predicted fire in the same stage.

METHOD.

2. A team of 3 Is.O. (Instructors in Gunnery) and 4 A.Is.O. (Assistant Is.O.) were available on 6th February, 1945, to visit a sample of the batteries that were firing the initial fire plans. They were provided with proformas and recorded where operationally possible as much relevant information as they could.

3. After the ground had been cleared, visits were made in particular to hostile battery sites, and the density of shell errors in target areas was measured.

4. The Survey Regiment R.C.M. resurveyed in some of the gun platforms used in the operation and some of the targets whose locations had been fixed from air photos.

5. A special air photo at 1:4000 scale was taken of the opening barrage line after the operation, and sample areas interpreted by APIS 21 Army Group.

RESULTS.

6. Survey. The results of the survey after the operation are given in Appendix A. In four cases out of five, the locations were within 15 yards of the position used by the G.P.O. in his calculations: in the remaining case confusion appears to have arisen as to which gun was pivot gun.

7. The average error in locating the remaining guns in relation to the pivot gun was 9 yards in 4 positions out of 5. There were discrepancies up to 100 yards in the data for the fifth troop.

8. Is.O. Visits. The information from the visits of the Is.O. to our gun positions are summarised in Appendix B.

Important sources of inaccuracy appear to be latent in command post work. In rechecking command post work at leisure, it has seldom been possible to find, as results of calculations, the exact figures that were used in operations.

The resulting discrepancies are composed of:-

(a) Errors. These represent sources of inaccuracy possibly inherent in the methods of calculation adopted; e.g. rounding off to whole numbers, graphical interpolations, etc.

(b) Mistakes. These represent inaccuracies due to incorrect methods, faulty arithmetic etc. Mistakes are also referred to as 'human errors'.

Wherever possible definite 'mistakes' have been indicated as such, but with the remaining discrepancies it was not possible to distinguish between 'errors' and 'mistakes'. In this remaining class there are indications that the magnitude of 'errors' may be up to 75 yds and 5 minutes.

9. The principal

Pivot gun

(of these 6, 5

Corrective

10. In addition, 6
Examples of such "a

(1) In 3 cases
used.

(2) In the case
100 yds
parallel

(3) In several
gun positions

11. In the case of
some in operations,
evidenced that the
mistakes did not

12. In rechecking,
where discrepancies
classified as "mistakes"
correction used has
were caused by the

13. Meteorological

Figures of the
operation: the
These are not of course
in the absence of
of the telegram is
differences are set
Equivalent Constant

Time of flight

Actual wind speed

Forecast used

84 group forward
Wind made

Ballistic Temp

Forecast used

Note: In para. 14
weather at 1
to any parti-
comparison
smaller.

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139

9. The principal "mistakes" found here as follows:

Pivot gun map data: line, 5 mistakes in 36 cases.
range, 1 mistake in 36 cases.

(of these 6, telephoning and copying may account for 5.

Correction of the moment:

In 61 calculations 2 definite "mistakes" were
found. Discrepancies up to 150 yds and 20°
were found here.

10. In addition, discrepancies were sometimes due to "mistakes" affecting many targets.
Examples of such "mistakes" are:-

- (1) In 3 cases out of 5, not all the times of flight given in the meteor telegrams were used.
- (2) In the counter battery shoot, troops were supposed to distribute over a frontage of 100 yds, with No. 3 laid on the target. In three cases out of four they fired parallel from frontages of 96 yds, 133 yds and 290 yds.
- (3) In several cases the discrepancies were systematic, as if slightly different pivot gun coordinates or meteor data had been used.

11. In the case of "copying" mistakes it is only fair to add that in addition to the copying done in operations, an additional copy was made by the observer. In two such cases there is evidence that the incorrect figures were not in fact used by the regiment. In other cases the mistakes did not exceed 200 yards or 1 degree.

12. In checking, particularly correction of the moment, it has proved impossible to find where discrepancies arose, because of the use of graphs and interpolations. Discrepancies were classed as "mistakes" when after making a graph similar to that used in the Command Post the correction used has corresponded to an obvious mistake in interpolation. Large discrepancies were caused by the "mistake" of using two few times of flight in preparing the graph.

13. Meteorological Conditions.

Figures of the actual upper air winds and temperatures were measured at the time of the operation: the winds were measured at 0500 hrs and 0900 hrs; the temperature at 0700 hrs. These are not of course the same as the conditions at the exact time and place of firing, but in the absence of better information they serve as a basis from which to estimate the accuracy of the telegrams issued. The telegram concerned was for the period 0500 - 1000 hrs. The differences are set out in Table 1 below. (Winds and temperatures have been converted to Equivalent Constant Winds and Ballistic Temperatures in accordance with M.O. 317 (2nd edition)).

TABLE 1.

Time of flight - secs:	30	40	50	60	70
Actual wind speed and direction. 0500 hrs	(26 269	33 277	44 272	54 289	65 234
	(31 265	36 270	45 271	55 291	69 295
0700 hrs	22 250	30 253	43 267	50 275	49 282
1000 hrs	(29 236	36 246	37 254	43 256	43 257
	(29 235	36 244	37 251	44 254	45 257
Forecast used 0500 - 1000 hrs	43 281	47 285	54 277	64 275	71 257
64 group forecast of wind made after 0200 hrs	44 280	48 286	54 277	64 275	73 276
Ballistic temperature 0300 hrs	41	41	44	44	43
Forecast used 0500 - 1000 hrs	45	44	42	43	42

Note: In para. 14 and Appendix C the comparison of the (500 - 1000 hrs forecast with actual weather at 1000 hrs has been made in 3 of the 4 cases considered. This does not correspond to any particular shelling, and hence no estimate of conditions at 0900 hrs been made, or a comparison made with the following meteor-telegram, the discrepancies would have been smaller.

140.

14. The targets were engaged by concentrations from many guns and the effect of the meteor conditions varying differed according to the line of fire and range of the gun. The estimate of variation applies over the whole area of the operation, and as it is possible to find the estimated displacement, due to weather, of the mean point of impact of shells aimed at a target by any gun. In Appendix C these displacements have been worked out for different times of flight and zero 15°, zero line and zero 30° for different equipments. The zero lines are those of equipments visited and vary from 45° to 110°; times of flight 30 up to 70 secs have been taken.

It will be seen that the displacement varies considerably. At 0900 hrs the direction was between east and north of the target, and displacements up to 700 yards were possible. The meteor conditions concentration from many guns would have been displaced into the NW quadrant, and those for individual guns would have been scattered so that the shells would in fact have been distributed over a much larger area. It is estimated that an effect similar to screeching and sweeping about the displaced people was produced.

15. From shells. It was originally hoped to give figures of the displacements of the mean point of impact of concentrations from their targets. It was impossible to distinguish the shells aimed at a target from that aimed at another for two chief reasons. First, the whole area was subject to heavy shelling both before and during the operation, and second, the Divisional artillery targets, Corps concentrations, and Hostile Battery positions were usually so close together that their targets were overlapped. Moreover, the number of rounds aimed at each target was too great for any attempt to be made to trace them all in any single case.

16. All the hostile batteries engaged in the preliminary C.B. programme within the area originally over-run were visited. Those not visited were either inaccessible owing to floods or too many. Center densities were measured at points as near as possible to the map spot of the target, where this was practicable; the results are set out in Appendix D where some previous measurements in a different operation are plotted on the same graph. The mean proportion of rounds aimed at a target falling in a "target area" of 100 yds x 100 yds was at most 5%.

17. These figures are deduced from counts of craters representing only a small proportion of the total rounds aimed at a target. The impression formed was that the distribution of craters was roughly uniform, with occasional patches of heavier shelling; there was no possibility of estimating the position of the mean point of impact.

18. Barrage. In Appendix E details are given of the number of shells ordered in the different lines of the barrage. At the points on the opening line counts of craters were made. In these ground checks, obviously all craters were disregarded. From special large scale air photos, three traces were made of the craters in a 100 yards strip at right angles to the opening barrage line. In these traces it was not possible to distinguish old craters from new.

The graphs of the ground checks in Appendix E suggest that some rounds fell short of the opening line by over two hundred yards and that the density of craters tended to increase at the opening line. In trace 3 it is thought that there was some considerable amount of firing in the area concerned in the weeks before the operation. Further investigation is being carried out in the aerial photographs but the procedure is laborious.

CONCLUSIONS.

19. The regimental survey of the pivot gun positions involved errors very small in comparison with other inaccuracies in predicted fire.

20. The fixation of targets by Aerial Photographic methods was very accurate.

21. There are collections that inaccuracies may arise in the application of position corrections and concentrations but in this operation these inaccuracies were not serious except in one case.

22. Although only a small sample has been examined, the number of mistakes and errors involved in the trigonometrical calculations and correction of the moment calculations is not a negligible factor.

23. The contributions made by meteor errors to the displacement of the mean point of impact of a shot were calculated for a sample of times of flight and switches for various equipments. The maximum contribution found was about 700 yds but in the main the contributions were between 200 yds and 250 yds.

24. It is considered that the meteor errors in the individual troop mean points of impact involved in a shoot have produced a screeching and sweeping effect about the displaced mean point of impact of the whole shoot.

25. As a result of ground checks it was found that on the average not more than 5% of the rounds aimed at a target fell in an area 100 yds x 100 yds at that target position. This conclusion is supported by the figures obtained in an operation of a similar nature.

1. Five

Serial

1

2

3

4

5

Average

The

from No.

the operation

2. Position

Serial

1

2

3

4

5

(a)

3. Location

Position

surveyed

APPENDIX A.

Survey Data, from information supplied by 2 Cdn Survey Regt, R.C.M.

1. Pivot Gun locations.

- DIFFERENCES -

Serial	Eastings metres	Northings metres	Total metres	yards
1	3.8	11.3	11.9	13.0
2	1.7	0.7	1.8	2.0
3	2.7	3.0	4.0	4.4
4	52.6	35.1	63.1	69.0
5	6.3	6.4	9.0	9.8
(see remarks below)				
Average (less 4)	3.8	5.3	6.7	7.3

The pivot gun coordinates used by the regiment in serial 4 were of a point only 15.4 m from No. 2 gun. It is possible that the wrong platform was surveyed as "pivot gun" before the operation. Position corrections have been computed using this assumption.

2. Position correction data (bearings and distances of other guns from Pivot Gun)

Serial	Gun	Surveyed		Used by Regt		Difference		Displacement expressed in yards
		Bearing grid	Distance yards	Bearing grid	Distance yards	Bearing degrees	Distance yards	
1	2	328°	196	328°	195	0°	1	1
	3	244°	425	242°	450	2°	25	31
	4	282°	608	282°	600	0°	8	8
2	2	279°	120	280°	110	1°	10	10
	3	340°	152	340°	150	0°	2	2
	4	307°	188	305°	200	2°	12	14
3	2	54°	182	60°	240	6°	58	63
	3	321°	135	355°	160	34°	25	59
	4	309°	330	325°	296	16°	34	93
4	2	70°	69	70°	54	0°	5	5
	3	346°	91	345°	83	1°	8	9
	4	19°	146	13°(n)	146(n)	6°	0	15
5	2	47°	36	50°	36	3°	0	2
	3	353°	51	355°	50	2°	1	2
	4	358°	96	2°	100	4°	4	8

Average excluding serial 3 1.7° 6.3 9.0

(n) Nos. 4 and 1 guns were not intervisible.

In serial 3, the observer noted that bearings and distances in use were incorrect.

3. Location of Targets.

Four hostile batteries whose locations had been given from air photos were subsequently surveyed on the ground.

H.B. No.	Nature	Location Errors			
		E metres	N metres	Total metres	Height metres
8853 AB	4 M.L. Pits	13	0	13	3.6
8696 AM	4 M.L. Pits	1	11	11	1.0
8644 LE	5 dunnies	15	14	21	0.5
8251 MI	4 M.L. pits	10	2	10	4.0
Average				13.7	2.3

APPENDIX B.

Reports on Command Post Work. Note: In what follows, "troop" includes heavy batteries.

1. Sight testing.

Last occasion tested by regiment:

Afternoon or Evening before Operation started (D-1)

First light on D-day

No. of troops

5
1
6

Discrepancies found at time of visit (all cases regimental check was on D-1)

20' in elevation (5.5-in) (new sight bracket)

15' in elevation (4.5-in)

5' in elevation (5.5-in)

Less than 5'

No. of guns

1
1
1
13
16

Total (8 x 4.5-in & 8 x 5.5-in)

2. Zero lines.No. of troops

Last checked. Before H-hour

Checked at first light

Checked at least four times during fire orders

3
2
1
6

Discrepancies found -

40' left due to slipping of platform (4.5-in)

None over 5 mins

Total (8 x 4.5-in, 4 x 5.5-in, 4 x 155 mm)

No. of guns

1
13
16

3. Charge temperature measurements.

of 9 troops, 6 had thermometers.

Procedures used:-

25 pr. Thermometer inside cartridge case.

4.5 in. Thermometer inside charge.

5.5-in. Thermometer attached to outside cardboard container in box.

155 mm. Charge bag broken and thermometer inserted, charge replaced in carton.

4. Propellants.

Sorting:

- Batteries -

	Sorted	Not sorted	Total
Propellant natures	3 (25 pr, 5.5-in)	1 (4.5-in)	4
Propellant lots	2 (5.5 in, 155 mm)	3 (25 pr, 4.5 in, 5.5 in)	5
Conditions	No. of troops	Charges found damp	Total examined
25 pr	1	3	9
4.5-in	1	0	10
5.5-in	2	1	16
155 mm	1	0	10

5. Ammunition condition.

	No. of Troops	Rusty rounds	Damaged driving bands	Total examined
25-pr	1	0	0	10
4.5-in	1	0	0	10
5.5-in	2	3	1	16
155 mm	1	6	1	10

6. Calculations.

These have been checked using Range Tables Part II, which includes four-figure tables.

7. Map E
No. 3 on E

Troop C

25-pr

4.5-in

5.5-in

5.5-in

155 mm

8. Appl

Troop

25 pr

4.5-in

5.5-in

5.5-in

155 mm

9. Appl

Troop

25-pr

4.5-in

5.5-in

5.5-in

155 mm

(c)

10. Cn

Orv

Orv

Orv

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145.

Batteries.

of troops

5
 1
 6

of guns

1
 1
 1
 13
 16

of troops

3
 2
 1
 6

of guns

1
 15
 16

In action.

Total

5.5 in 4
 5

Total examined

9
 10
 16
 10

1
 mod

gun tables.

7. Map Data for Pivot Guns only. (In most cases guns had to distribute over 100 yards, with No. 3 on target).

Troop	No. of Calculations checked	Line	Range	Angle of sight
25-pr	13	One 50' mistake, possibly due to distributing to the left	12 cases systematically too great (mean = 59 yds)	Within 4'.
4.5-in	10	O.K.	One copying mistake (over 1000 yds)	O.K.
5.5-in	4	3 mistakes (about 30') possibly due to copying.	O.K.	O.K.
5.5-in	1	10' mistake due to telephoning	O.K.	O.K.
155 mm	8	4 discrepancies 8' - 10'	One 55 yd discrepancy	O.K.

8. Application of position correction.

Troop	No. of Calculations Checked	Ranges to guns 2, 3 and 4.
25 pr	-	Guns used same data. (They were close together)
4.5-in	30	1 175 yard mistake (9 misread as 7 ?) 1 set of three ranges copied wrong (as was range for pivot gun)
5.5-in	3	O.K.
5.5-in	3	O.K.
155 mm	24	Includes discrepancies 70, 55, 50, 50 yards (remainder within 50 yards).

9. Application of concentration and distribution.

Troop	No. of calculations checked	Lines given to guns 2, 3 and 4
25-pr	-	Guns fired parallel (c)
4.5-in	-	Guns fired parallel (c)
5.5-in	3	(Concentration) Discrepancies of 7', 7', 8'.
5.5-in	3	One 9' discrepancy (c)
155 mm	-	Guns fired parallel (c)

(c) No. 3 gun was to be laid on target, and troops distributed 100 yds.

10. Calculation of Correction of Moment.

Methods used	Batteries
Graphs prepared based on calculations for zero line and 30° on either side	4
-do- 45° on either side	1 5
Graphs prepared based on calculations for: every 10 sec time of flight (5.5-in) 25, 35 and 50 secs (155 mm ch. super) 30, 40, 60, 80 secs.	2 1 1 4

144.

11. Accuracy of calculations of correction of moment.

Battery	No. of calculations checked	
25 pr	17	Range discrepancies included 151, 83 and 77 yds, and four others over 50 yds. 6 line discrepancies of 10' order.
4.5-in	24	In calculating the information on which the correction of the moment graph was based, the range correction averaged about +23 yds over the correct one. In addition one mistake was made, probably misreading -142 as +42.
	8	In applying the regimental graph to individual targets, 1 mistake in range correction was made (140 yds). Comparison of the regimental figures with individually calculated ones revealed, in addition, range discrepancies up to 87 yds and 3 line discrepancies (13', 9' and 7').
5.5-in	3	1 50 yd range discrepancy due to incompleteness of basic calculations.
5.5-in	1	72 yard discrepancy
155 mm	8	Discrepancies include 20', 12', 11' for line. The omission of the 50 and 70 sec times of flight in the basic calculations for the graph caused discrepancies from 58 to 130 yds in six of the eight calculations of range correction of the moment. Note: For each target only one correction of the moment was used for all guns of a battery. Separate calculations for individual guns revealed differences in range correction up to 100 yds.

12. Calibration.

Last adjustment of M.V. (Muzzle Velocity).

Guns Type	No.	No. since last adjustment of M.V.	
		Days	E.F.C. (Effective Full Charges)
25 pr	8	47	246 (average)
4.5-in	8	4	nil
5.5-in	4	11	19 (average)
5.5-in	4	14	28, 29, 131, 137
155 mm	4	14	14 (average)

13. Condition of guns.

The following is the information on the carriages obtained from proformas completed by E.M.E.

Guns Type	No.	Backlash in sighting and elevating gear	Condition of cradle slides	Remarks
4.5-in	8	No	good	One gun had 4° play in elevating gear when brand new. Adjusted by R.E.M.E.
5.5-in	8	No	Fairly good. Slight play in recoil blocks.	

DISPL

WIT

GN.
↑

8.5 in. Charge 4.

Fig. 4.

4.5 in. Charge

APPENDIX C

DISPLACEMENT OF MEAN POINT OF IMPACT

WITH VARIATION IN WIND AND TEMPERATURE

Fig. 1.

G.M.

155 mm. Charge 1 super

0900 hrs

TARGET

G.M.

Fig. 2.

55 in. Charge 4. 0900 hrs

TARGET

Fig. 4.

G.M.

TARGET

4.5 in. Charge 0900 hrs.

Fig. 3.

G.M.

TARGET

75 pr. Charge 3. 0900 hrs

0 100 200 300 400
SCALE (YARDS)

LEGEND

Circle denotes displaced position of M.P.I. which would have been on the target had meteor telegram been correct.

LINE OF FIRE AND TIME OF FLIGHT ARE SHOWN BY DIRECTION OF TAIL AND NUMBER OF FEATHERS, THUS:-

30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300 310 320 330 340 350 360 370 380 390 400 410 420 430 440 450 460 470 480 490 500 510 520 530 540 550 560 570 580 590 600 610 620 630 640 650 660 670 680 690 700 710 720 730 740 750 760 770 780 790 800 810 820 830 840 850 860 870 880 890 900 910 920 930 940 950 960 970 980 990 1000

and four others

rection of the
verged about
mistake was

targets,
1). Comparison
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up to 87

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30 yds in six
f the moment.
e moment
calculations
to correction

plotted by E.M.Es.

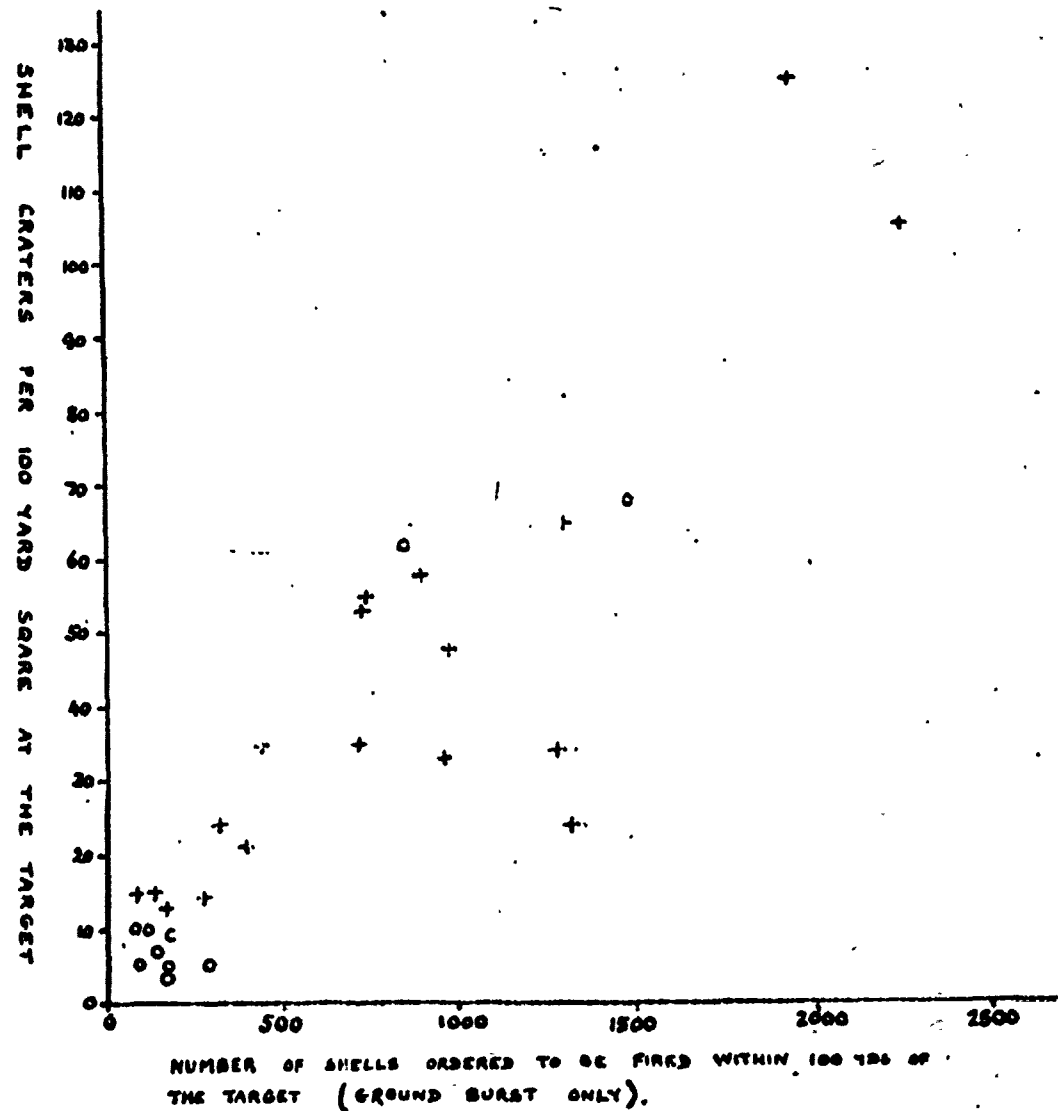
try in elevating
now.
E.

APPENDIX D Fig.5.

RELATION BETWEEN DENSITY OF CRATERS IN TARGET, AREA AND NUMBERS OF SHELLS ORDERED

PREDICTED FIRE
COUNTER BATTERY FIREPLANS

- + OPERATION "VERITABLE"
- o OPERATION "SWITCHBACK"



NUMBER OF SHELLS ORDERED TO BE FIRED WITHIN 100 YDS OF
THE TARGET (GROUND BURST ONLY).

APPENDIX D.

Hostile Batteries : 'VERITABLE' : 7-8 Feb 45.

TARGET	OTHER TARGETS WITHIN 100 YDS	HE SHELLS ORDERED TO BE FIRED AT TARGET	AT TARGETS WITHIN 100 YARDS	TOTAL	CRATERS FOUND ON GROUND IN TARGET AREA: PER 100 yds x 100 yds.	% OF TOTAL SHELLS ORDERED
7748 AT	-	328	-	328	24	7.3
7948 HE	-	184	-	184	13	7.1
7949 HB	-	728	-	728	53	7.3
7949 HD	-	736	-	736	35	4.7
8153 LK	1070	1500	416	1916	125	6.5
8153 LZ	-	1292	-	1292	65	5.0
8154 LY	1090	1180	1048	2228	105	4.7
8251 BH	-	720	-	720	35	4.9
8253 BV	1069	900	416	1316	24	1.8
8254 BO	1568, 8029	624	440	1064	34	3.2
8353 BN	-	950	-	950	33	3.5
8353 BT	-	96	-	96	16	16.7
8453 BU	-	890	-	890	58	6.5
8454 BV	-	970	-	970	48	4.9
8656 LK	-	442	-	442	35	7.9
8853 LD	-	404	-	404	21	5.2
0953 LB	-	280	-	280	14	5.0
TOTALS:				14644	730	
AVERAGE:						5.1

THIS LIST INCLUDES ALL FIRING OF WHICH A RECORD WAS AVAILABLE.

APPENDIX E.

THE OPENING LINE OF A BARRAGE.

Table 2 - Number of HE shells per line and per lane:

Line	Line - AB AC	CD, DE, EF, FG	GH	HI	IJ
1	572	504	232	232	232
2	596	264	264	264	264

Line	Lane - AB BC each	CD, DE, EF, FG each	GH	HI	IJ
a	792	198	264	264	264
d	816	496	320	239	257
e	576	336	336	255	273
f	576				

Table 3 - Dimensions of barrage : metres.

Lane:	AB	BC	CD	DE	EF	FG	GH	HI	IJ
Interval between lines:	75.5	77.7	80.3	83.3	86.4	89.5	93.0	97.4	101.8
Width of lanes:									
line a	817	817	340	340	340	340	426	545	426
b	820	820	343	343	343	343	427	546	427
c	823	823	346	346	346	346	428	547	428
d	827	827	350	350	350	350	429	548	429
e	830	830	353	353	353	353	430	550	430
f	833	833							

Table 4 - Number of shells per 100 yds width x 100 yds interval.

Lane:	AB	BC	CD	DE	EF	FG	GH	HI	IJ
line a	418	115	178	172	166	160	62	46	56
b	53	52	80	77	75	72	55	42	51
c	107	104	60	57	55	53	55	41	51
d	109	106	148	142	137	133	67	37	48
e	77	75	100	96	92	89	70	40	52
f	76	74							

Table 5 - Densities of craters found on ground. Craters per 100 yds x 100 yds.

Distance from opening line (yds)	Trace 1	Trace 2	Trace 3	Ground checks 1	Ground checks 2
-500 to -450	-	24	74	4	-
-450 to -400	-	32	64	13	-
-400 to -350	-	-	52	4	5
-350 to -300	-	-	42	-	40
-300 to -250	10	-	40	-	40
-250 to -200	34	-	62	-	0
-200 to -150	51	-	80	58	0
-150 to -100	82	56	112	48	0
-100 to -50	70	54	107	86	15
-50 to -0	60	54	50	138	30
(opening line)					
0 to 50	-	124	66	101	55
50 to 100	183	-	77	-	60
100 to 150	181	-	65	-	70
150 to 200	183	198	65	-	70
200 to 250	143	96	75	-	80
250 to 300	107	152	91	-	75
300 to 350	142	148	97	-	30
350 to 400	136	-	115	-	-

NOTES:

Distances from opening line are measured in the direction of advance.

Trace 1: Interpretations of craters on prints 3004, 4004, 3050 of 1 Can A.P.I.S. Sortie R4/2015, in a strip 100 yds wide, along 539 northing approximately.

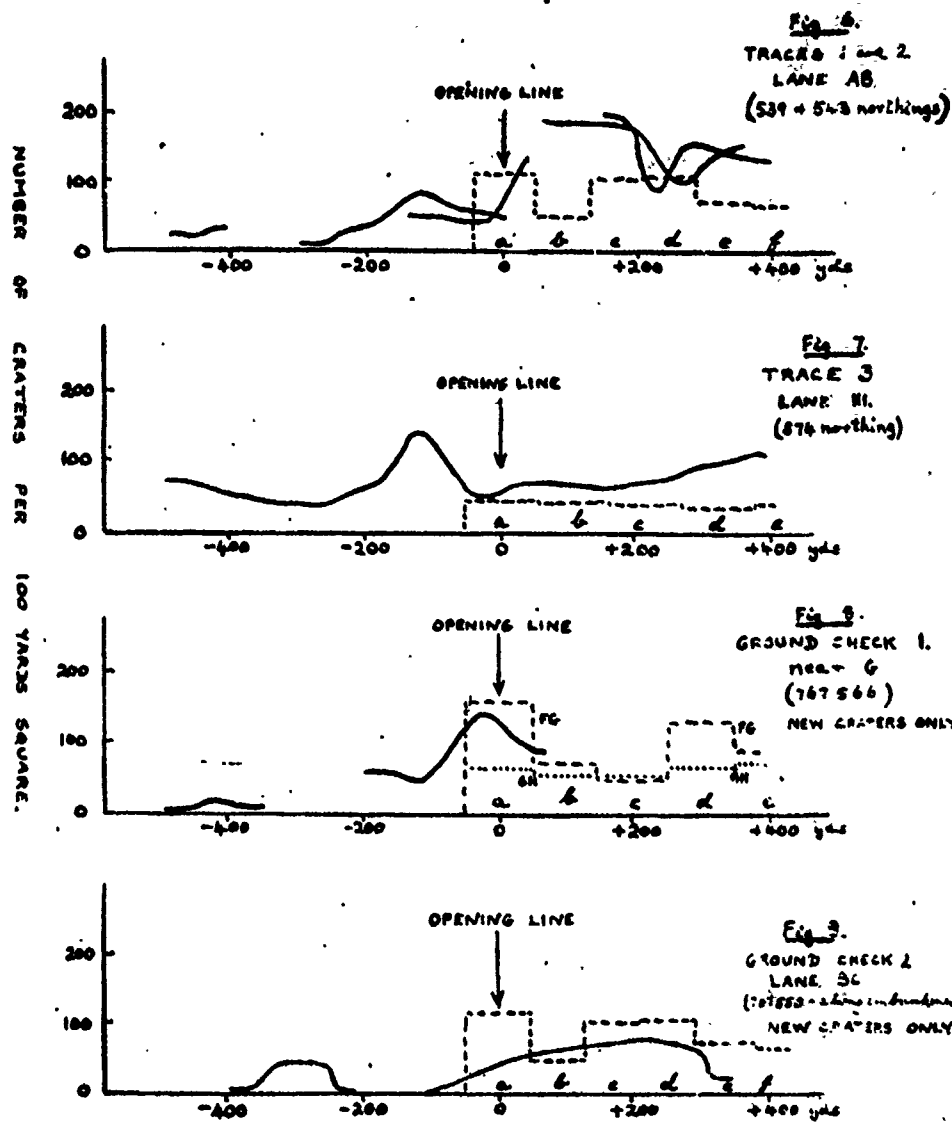
Trace 2: From prints 3006, 4006, and 3052: along 543 northing approximately.

NUMBER OF CRATERS PER 100 YARDS SQUARE.

200
100
0200
100
0200
100
0200
100
0

APPENDIX E

CRATER DENSITIES NEAR OPENING BARRAGE LINE



LEGEND — DENSITY OF CRATERS ON GROUND

--- NUMBER OF SHELLS ORDERED ON EACH LINE
(per 100 yds of lane and 100 yds interval
between lines)

NOTE This does not represent the expected density;
it would do so only if shells aimed at a
line were uniformly distributed over the
line interval, and did not interfere with
other lines.

13

264
257
273

13

101.8

426
427
428
429
430

13

56
51
51
49
52

ound checks

1	2
4	-
13	-
4	5
-	40
-	40
-	0
56	0
46	0
85	15
136	30

101	55
-	60
-	70
-	70
-	30
-	75
-	30
-	-

3. Sort 10

Trace 3: From prints 3014, 4014, and 3061; along 574 northing approximately.

Ground check 1: New centers were counted in squares 25 yds x 25 yds in the neighbourhood 767556; where the road GROESBECK - MYLER crossed the barren opening line.

Ground check 2: New centers were counted in strips either side of a railway embankment near 767550. The width of the strips were the mean of three estimates of 20 yds, and 25 yard lengths were posed along the tracks.

REPORT NO. 24.

ACCURACY OF PREDICTED SHOOTING.

INTRODUCTION.

1. An attempt was made, during operation "SWITCHBLANK" in October 1944, by No. 2 Operational Research Section to study the accuracy of predicted fire, and to assign causes of inaccuracy.

METHOD.

2. The Counter Battery fire in the Operation was all predicted and it was decided to study this alone. Certain Hostile Batteries which were included in the Counter Battery programme on D-day were selected. Aerial photographs of the fall of shot were taken immediately after the bombardments of these batteries. Hostile Battery History Sheets were examined to check that these were the first bombardments carried out against the particular batteries and also to check that no bombardment was carried out between H-hour and the time at which the photographs were taken. In one battery there was a possibility that a further bombardment - also predicted fire - may have been fired between H-hour and the time of the photograph. Only 5 Hostile Battery engagements were found to be unaffected by engagements of other targets, and otherwise suitable for investigation. These five were examined and the Counter Battery Programme ordered for them is given in Appendix 1. On conclusion of the Operation a ground check was carried out.

RESULTS.

3. The craters identified on the aerial photographs provided a minimum figure for the 100' zone of the predicted fire. The figures are minimum because the number of craters found was less than the number of rounds ordered (except in the one case referred to above, where a further bombardment may have been fired), and consequently there may have been rounds falling outside the 100' zone for which craters were not identified. These minimum 100' zones are tabulated in Table 1 below.

4. Expected 100' zones have been calculated as follows: given in the range tables are 50' experimental zones. It is stated that these (except for 25 pr) should be multiplied by 1.5 to allow for firing mixed lots. In all cases a further multiplication by 2 should be carried out to allow for worn guns. Finally, to convert the adjusted 50' zone to a 100' zone, a multiplication by 4 is required. Thus a total multiplication 12 times the range table 50' zone is carried out to obtain the 100' zone to be expected (8 times in the case of 25 pr). Allowance has also been made for the different lines of fire of the various regiments and the expected 100' length and breadth zones have been resolved along a mean line of fire to give the adjusted 100' expected length and breadth zones. The frontage of the Hostile Battery perpendicular to the mean line of fire has been included in the expected breadth zone. No allowance has been made for the fact that the positions of the worn points of impact of the regiments involved may differ; i.e., these expected zones have assumed that the mean point of impact is correct for all regiments. These expected zones are also shown in Table 1. In these engagements, neither searching nor sweeping was used.

TABLE 1
100' ACTUAL AND EXPECTED ZONES.

Hostile Battery		9606 BT	9713 RT	0314 RM	0506 VC	0715 RJ
100' LENGTH ZONES (yards)	Expected	540	1470	1680	960	1800
	Actual	900	800	1700	1000	1200
100' BREADTH ZONES (yards)	Expected	170	400	940	480	910
	Actual	1400	900	1200	1000	900

Note:- The calculation for 9713 RT is that of Table 6 below, and includes calibration and other errors.

5. In Table 2 details are given of the number of rounds ordered to be fired against each Hostile Battery, together with the number of craters identified.

Hostile
No. of
rounds

The
Table 3
form a
which the
ground the
are not
battery.

Hostile
No.
Line

6. A sample of
the number
this the
calculated
should be
position
it is so
was found

Hostile
Battery
9606 BT
0206
9407
9508
9405
0715
9715
9913
0114
0114
9706

(9606
(9706

(9706
(9706

TOTAL
1722

TABLE 2.

NUMBER OF ROUNDS FIRED AND NUMBER OF CRATERS FOUND.

Hostile Battery	9606 ST	9713 RT	0314 RN	0506 VC	0715 RJ
No. of (Ordered rounds (Found	144 58	112 33	104 113	168 93	144 69

The mean points of impact of the identified craters have been calculated and are given in Table 3 below. These figures cannot be considered reliable as the craters identified do not form a random sample. Identification of a crater is dependent partly on the type of ground on which the round has burst. There is a tendency for gun positions to be picked on more firm ground than the surrounding and craters are less easily identifiable here. Thus the samples are not random. In Appendix 2 plans of the identified craters are shown for each hostile battery.

TABLE 3.

MEAN POINTS OF IMPACTS OF IDENTIFIED CRATERS ONLY.

Hostile Battery	9606 ST	9713 RT	0314 RN	0506 VC	0715 RJ
Range Error - yds	- 95	+ 102	- 57	+ 170	- 143
Line Error - yds	Right 3	Right 78	Left 163	Left 13	Left 59

6. A ground check was carried out after the operation, in which the number of craters on a sample area at various Hostile Battery Positions was counted. This density was compared with the number of rounds ordered to be fired as recorded on Hostile Battery History Sheets. From this the percentage of rounds ordered which fell in a square 100 yds x 100 yds has been calculated. It is considered that the resulting figures are over-estimates of the percentage of shells actually fired, since it is likely that more rounds were fired near to Hostile Battery positions than are recorded in Hostile Battery History Sheets. Details are given in Table 4 and it is seen that the average percentage of rounds ordered which fell in a square 100 yds x 100 yds was found to be 4.8%.

TABLE 4.

PERCENTAGE OF ROUNDS ORDERED FALLING IN 100 YARDS BY 100 YARDS.

Hostile Battery	No. of rounds ordered	Equipments	Craters near target	PER 100 YDS SQUARE Percentage of rds. ordered	Type of Fire
9606 ST	144	Field	7	5	Predicted
0206 VC	168	Field, Medium	7	4	Predicted
9407 SS	168	Field, Medium	5	3	Predicted
9508 YE	296	Medium, Heavy	5	2	Predicted
9405 VK	168	Field	5	3	Predicted
0715 RJ	144	Medium	22	15	Predicted
9713 RT	112	Medium, Heavy	11	10	Predicted
9913 FV	96	Medium	5	6	Predicted
0114 RO	188	Medium, Heavy	9	5	Predicted
0114 RP	96	Medium, Heavy	10	10	Predicted
9706 VU	844	FC, Medium, Heavy	62	7	788 rds Predicted. 96 rds Comparator.
(9606 XO) (9706 ZO)	1471	Medium, Heavy	68	5	872 rds Predicted. 407 rds Air Gun. 192 rds J.R. Comparator.
(9706 VI) (9706 ZT)	1655	Medium, Heavy	49	3	1265 rds Predicted. 390 rds J.R.
TOTAL	5550	-	265	4.8	-

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permit fully legible reproduction

ADDITIONAL FACTORS.

SURVEY. 7. Owing to operational commitments it was impossible to carry out an accurate measurement of the survey errors involved. An extract from a letter received from 2 Canadian Survey Regiment dealing with the accuracy of the 1 : 25000 maps in the area is attached in Appendix 3.

All guns were surveyed on the "theatre" grid for the operation. It appears from the Survey Regt's letter that there is not likely to have been any large error due to a discrepancy between the theatre grid used for the guns and the 1 : 25000 grid used for the targets.

WIND. 6. In Table 5 below details of the meteor error calculated for each Hostile Battery are given. These have been calculated from the differences between forecast and actual barometric, temperature and wind conditions.

TABLE 5.
METEOR. ERRORS.

Hostile Battery	9506 BT	9713 RT	0314 RN	0506 VC	0715 RJ
Range Errors - yds	- 13	+ 62	+ 20	- 20	+ 24
Line Errors - yds	Left 10	Left 48	Left 41	Left 9	Left 65

CALIBRATION. 5. It was not possible to obtain the actual calibration errors in existence at the time of the fire plan. A sample of calibration errors was obtained, however, when the guns were calibrated at the conclusion of the operation.

The difference between the muzzle velocities set on certain guns and those muzzle velocities found after the operation by the calibration troop are taken as sample errors. These are shown in Appendix 4. The guns were those of the regiments which fired on 9713 RT. A more detailed analysis of this argument gives the results in Table 6.

6. In this detailed analysis separate ranges and lines of fire for each troop firing were used. Also the error in correction of moment has been estimated by comparison of actual correction of moment applied with that subsequently calculated as the true correction of the moment.

TABLE 6.

	5.5" 100 lb Shell	5.5" 80 lb Shell	
No. of rounds ordered:	48	48	
No. of rounds fired:	12 - Charge IV	6 - Charge IV	24 - Charge Super
Errors in Mean Point of Impact (yards)	(yards)	(yards)	(yards)
Errors in choice of point of aim	+ 74	not known	not known
Estimate of Error in calibration (from Appendix 4)	-210	+ 93	+ 101
Estimate of error in correction of the moment	+113 Left 18	+ 58 Left 36	+ 84 Left 48
Total:	- 11 Left 18	+151 Left 36	+ 209 Left 48

No. of rounds
No. of rounds

Zones of Dispersion
(1)

50% Zone due to cooperative (from Appendix 3)

50% Range table for mixed line for worn guns were in half of that

Combination 50 100

(11)

100% Range table for mixed

Max. Frontage aim

Total 100

NOTE: The

DISCUSSION.

11. Breadth Zones

The width of five - see Table perpendicular to firing on different the breadth zones individual guns.

12. Length Zones

The centre (see Table 1) and mean points of impact realised. Indeed 100% zones from 5

13. Magnitude of

From To 1000 yds. Using centre of a 100 y comprises statistics

	5.5" 100 lb Shell	5.5" 80 lb Shell	
No. of rounds ordered:	48	48	
No. of rounds fired:	12 - Charge IV	6 - Charge IV	24 Charge Super
<u>Zones of Dispersion</u>	(yards)	(yards)	(yards)
(i) <u>Range zone</u>			
50% Zone due to errors in comparative calibration (from Appendix 4)	212	200	224
50% Range table zone allowing for mixed lots but not for worn guns (since most guns were in the first half of their life)	240	150	210
Combination 50% Range Zone 100% Range Zone	300 1200	250 1000	306 1224
(ii) <u>Line Zone</u>	(yards)	(yards)	(yards)
100% Range table zone allowing for mixed lots only	132	140	144
Max. Frontage of points of aim	119	244	244
Total 100% Zone:	251	304	308

NOTE: The 2 rounds fired by the 7.2" howitzers have been disregarded. The dimensions of the "100% zone" expected extend to + 821 yards and - 651 yards for length, and approximately Left 242 yards to Right 156 yards for breadth.

DISCUSSION.

11. Breadth Zones.

The salient point in the results is that the actual 100% breadth zone is in 4 cases out of five - see Table 1 and Table 5 - very much larger than is to be expected. The dispersion perpendicular to the mean line of fire is caused by two factors. One is the length zones of guns firing on different lines, and would be reduced if these zones were reduced. The other factor is the breadth zones perpendicular to true lines of fire. This is made up of the breadth zones of individual guns, errors in laying and sight testing, and the use of incorrect data.

12. Length Zones.

The actual length zones are all either less or of the same magnitude as the expected (see Table 1) and it must be remembered that the expected zones make no allowance for errors in mean points of impact. The expected zones can therefore be said to cover only the actual zones realized. Indeed, it would appear that the use of a factor of 12 (or 6 for 25 pr fire) to obtain 100% zones from 50% range table zones is excessive.

13. Magnitude of Dispersion.

From Table 1 it can be seen that the 100% length and breadth zones are each approximately 1000 yds. Using this figure and assuming a normal distribution with mean point of impact at the centre of a 100 yd x 100 yd area, the percentage of rounds falling in the area is 4.4%. This compares satisfactorily with the ground check where the corresponding average percentage taken

158.

over 13 hostile batteries and 5550 rounds ordered was 4.2. The implication of this is that to cause 100 rounds to fall in a field 100 yds square would require some 2000 rounds, whereas for 25 pr or 5.5" gun at 10,000 yds - the corresponding number of rounds, using the basic range table zones, is 170.

CONCLUSIONS.

14. In the conditions of this operation the dispersion for line was unduly high and gave a 100% zone about 1000 yards. Only part of this dispersion could be associated with meteor, survey, and calibration; and other sources of error such as command post work, sight testing, and gun laying, are suspected.

15. The dispersion for range, which also gave a 100% zone of the order of 1000 yds lay within the limits given in the range tables, when allowance was made for errors due to calibration.

16. Calibration, both absolute and comparative, was a greater source of error than meteor; survey was a smaller source than either.

17. With the dispersions found in these engagements, searching and sweeping were unnecessary.

18. The vertical photograph method of recording fall of shot needs a larger scale than was used. One not less than 1 : 5000 should be satisfactory.

ACKNOWLEDGMENTS.

19. Acknowledgments are gratefully expressed to the Senior Meteorological Officer and his staff at 81 Group R.A.F., ...P.L.S. staffs at First Canadian Army and at 21 Army Group, to C.S.O. 2nd Canadian Corps, and to R.A. and R.C.A. Regimental and formation staffs in 2 Canadian Corps.

APPENDIX 1.

TABLE 7.

COUNTER BATTERY NEUTRALISATION PROGRAMME.

Extracted from 2 Canadian Corps Counter Battery Task Tables dated 5 Oct 44.

Hostile Battery No.	Number of Troops, or Heavy Batteries, to engage:					From To	Serial and Task Table
	Field	5.5 100 lb shell	5.5 80 lb shell	7.2" 155 mm			
0506 VC	6	8	-	-	-	H-55 H-52	1 (91/C)
9713 RT	-	4	4	2	-	-40 -37	4 (9 B)
0314 RM	-	6	-	-	4	-40 -37	4 (91/C)
9606 BT	12	-	-	-	-	-45 -42	3 (9 A)
0715 RJ	-	-	12	-	-	-50 -47	2 (9 C)

SCALE:-

Field and Medium
Heavy

- 3
- 2

Ammunition : H.E.

H-hour was 0530 6 Oct 44.

96
07

96

97

14

97

APPENDIX 2

Fig 1.

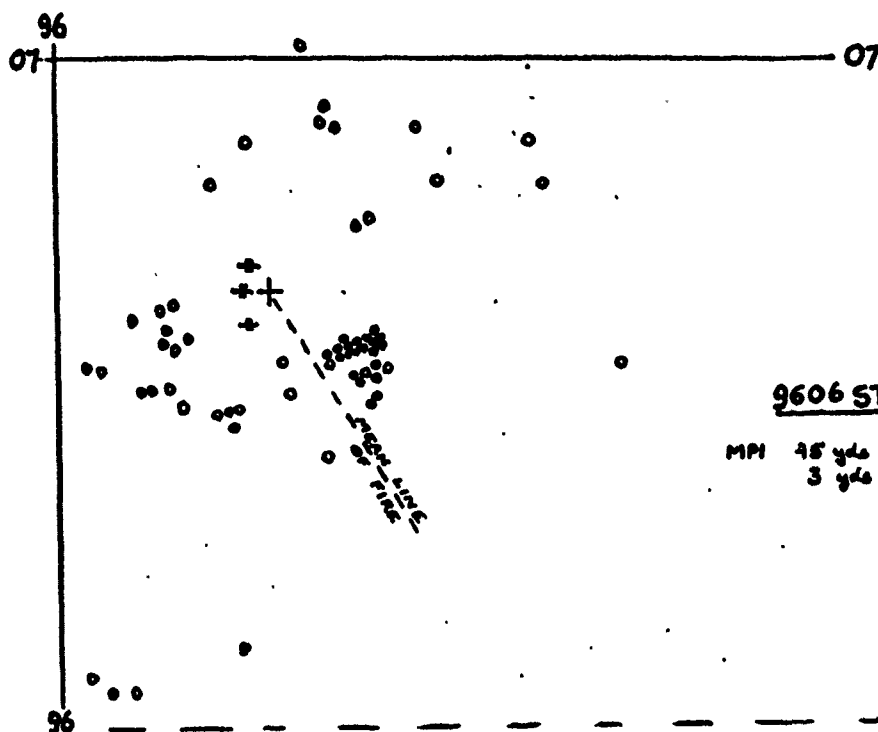
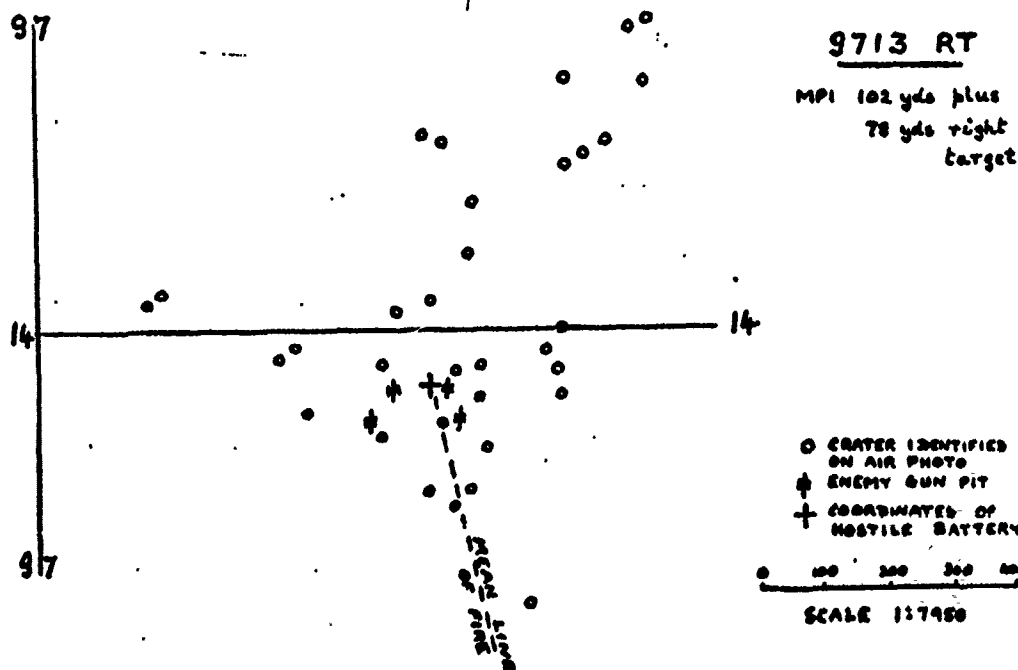


Fig 2.



on of this is that to
rounds, whereas for
the basic range table

high end gave a 100%
th meteor, survey,
ht testing, and gun

1000 yds lry within
a to calibration.

for than meteor;

g were unnecessary.

r scale than was

Officer and his staff
P-up, to C-3-0.
in 2 Canadian Corps.

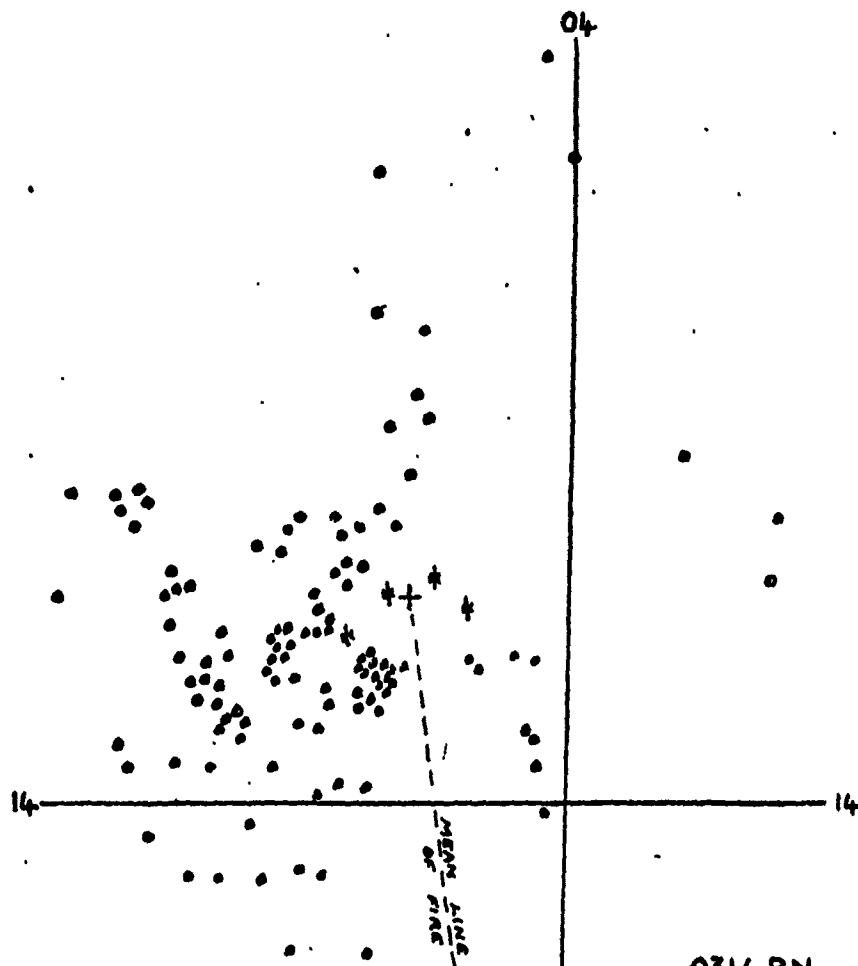
Dated 5 Oct 44.

TO	Serial and Task Table
5 M-52	1 (9 J/C)
C -37	4 (9 3)
-37	4 (9 J/C)
-42	3 (9 A)
-47	2 (9 C)

3
2

N.E.

F₃.



Q314 RN

● GRATER IDENTIFIED ON
AIR PHOTO

⊕ ENEMY GUN PIT

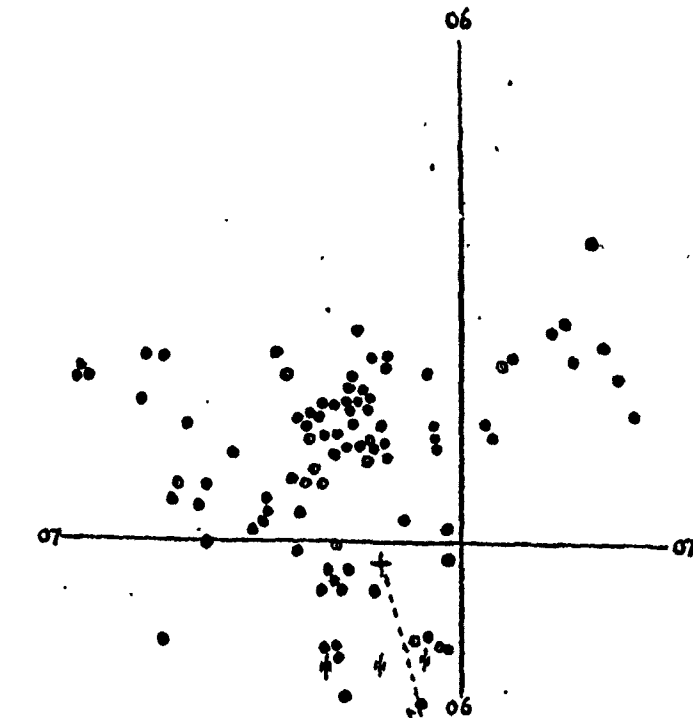
+ COORDINATES OF HOSTILE
BATTERY

0 100 200 300 400

SCALE 1:7450

M.P.I. 5740 short
163 yds left of target

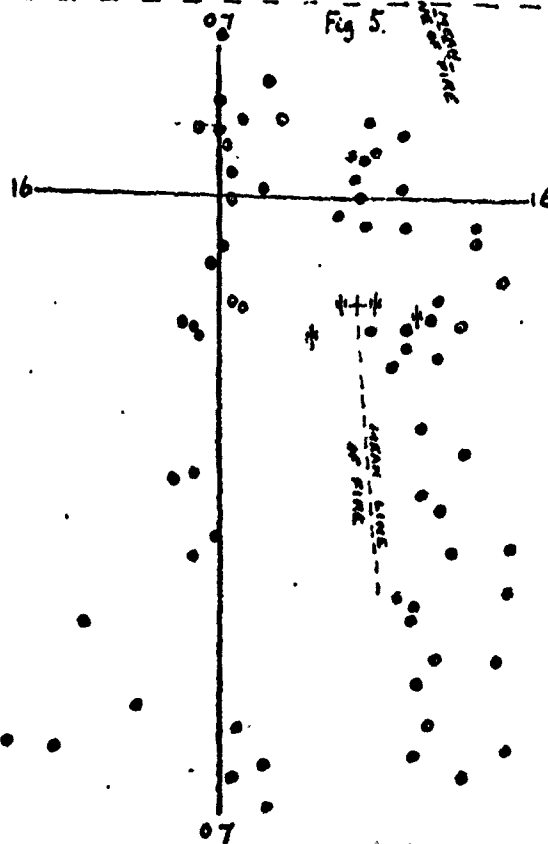
Fig 4



0506VC

M.R.I. 170 yds plus
13 yds left
target.

Fig 5



0715 RJ

M.R.I. 143 yds short
59 yds left of
target.

● CRATER IDENTIFIED
ON AIR PHOTO
+ ENEMY GUN PIT
+ COORDINATES OF
HOSTILE BATTERY

0 100 200 300

Scale 1:17450

APPENDIX 3.ACCURACY 1 : 25,000 MAP.

1. Extracts from a letter by 2 Canadian Survey Regiment, R.C.A., dated 20th October, 1944, follow in the next paragraph:

"The plotted accuracy of ground detail varies considerably from sheet to sheet. In general, however, the accuracy of detail is within the limits of accuracy of reading a 1 : 25,000 map; i.e. Trig Points, road and railway intersections, villages, and other artificial features on the maps agree reasonably with their surveyed co-ordinates, with a few exceptions. Omissions, however, were found on most sheets, and cases of incorrect colouration, i.e. minor features such as sections of third class roads, buildings, etc., not shown; woods shown where no woods exist. There were indications that all sheets are not uniformly up-to-date:

In these portions of 1 : 25,000 Sheets OSGS 4427 22 NW, 22 NE, 22 SW, and 22 SE lying WEST of the canal between NEUZEN D2711 and SLUISKIL D2805, to the SAVOJALLOS PLANT, ground detail checked well, average differences being 1 m EAST and 8 m NORTH.

On that portion of 22 NE lying SOUTH of the SCHELDE, while a number of points checked reasonably well, some were found to be in error from 30 to 36 m; the Trig List, Feb. 1940 system, revised June 1943, for Sheet 22 NEUZEN gives for No. 16 OSGINISSE R.C. Church

Steeple:-	338757.7 E	506595.3 N
the church map spots at:-	338740. E	516660. N
a difference of:-	7.7 E	65.3 N

There is also a major omission in squares 3613 and 3614 - a dyked and reclaimed area and road not shown.

N 1 Sheet 22 SE no major discrepancies were found."

2. The 1 : 25,000 Sheets involved in this report were OSGS 4427 21 W and 21 SE which are adjoining to those referred to in the above extracts.

APPENDIX 4.CALIBRATION.

It was known before "SWITCHBACK" that many of the guns required calibration, which had been impossible earlier for operational reasons. Shortly after the operation some regiments that took part were calibrated by 1 Canadian Calibration Troop R.C.A., and the results are set out in Tables 8 and 9 below. The 5.5" guns were used to engage 9713 RT (see Table 6).

TABLE 8.Tabulation of Muzzle Velocities : 155 mm Guns

The column headed "error" gives the difference between the muzzle velocity obtained by Calibration and that adopted for the gun before calibration.

Liner No.	Charge normal		Charge Super	
	M.V.	error	M.V.	error
	f.s.	f.s.	f.s.	f.s.
1669	2104	- 25	2753	- 33
1255	2029	- 66	2665	-128
957	2026	- 63	2686	- 70
968	2007	- 47	2693	- 42
1742	2068	- 52	2745	- 65
1506	2101	- 19	2751	- 39
969	2034	- 16	2701	- 59
1293	2010	- 9	2585	- 5

TABLE 9.

TABULATION OF MUZZLE VELOCITIES : 5.5" GUN.

The column headed "error" gives the difference between the muzzle velocity obtained by calibration and that set on the muzzle velocity scale of the gun before calibration.

Liner Number	CHARGE I		CHARGE II		CHARGE III		CHARGE IV	
	M.V. f.s.	Error f.s.	M.V. f.s.	Error f.s.	M.V. f.s.	Error f.s.	M.V. f.s.	Error f.s.
L 4304	884	- 6	1162	- 2	1402	- 8	1701	- 9
L 5528	882	- 8	1162	- 4	1400	- 10	1699	- 7
L 4134	867	- 23	1152	- 13	1381	- 29	1682	- 28
L 1596	839	- 33	1153	- 23	1343	- 42	1649	- 40
L 4225	861	- 19	1148	- 12	1373	- 23	1675	- 21
L 2463	836	- 19	1131	- 12	1339	- 26	1645	- 22
L 3958	855	- 15	1150	- 10	1378	- 19	1679	- 17
L 2054	864	- 7	1150	- 5	1377	- 9	1678	- 9
L 1371	820	- 72	1120	- 35	1317	- 94	1627	- 58
L 3347	832	- 48	1142	- 33	1360	- 64	1664	- 57
L 3589	852	- 43	1142	- 35	1360	- 76	1664	- 58
L 4023	840	- 60	1133	- 39	1343	- 80	1650	- 70
L 3350	861	- 39	1147	- 29	1372	- 51	1674	- 61
L 2969	833	- 41	1128	- 25	1334	- 52	1641	- 44
L 2130	833	- 41	1129	- 23	1335	- 51	1642	- 42
L 4001	861	+ 2	1146	+ 3	1371	- 2	1675	+ 3
L 1263	831	- 19	1125	- 12	1331	- 25	1640	- 23
L 5619	853	+ 6	1141	+ 5	1360	+ 6	1665	+ 6
L 5599	857	+ 12	1143	- 4	1366	+ 14	1670	+ 12
L 5960	862	+ 11	1146	- 2	1372	+ 14	1676	+ 10
L 4332	861	+ 11	1146	+ 7	1371	+ 13	1674	+ 11
L 3007	859	+ 6	1145	+ 3	1369	+ 7	1673	+ 8
L 1413	836	+ 12	1124	+ 9	1330	+ 17	1630	+ 11
L 1340	820	+ 22	1117	+ 14	1316	+ 30	1626	+ 24
L 3769	853	+ 2	1141	+ 4	1361	+ 4	1666	+ 12
L 2590	831	- 12	1150	+ 42	1390	- 14	1697	- 14
L 1275	812	+ 10	1111	+ 13	1305	+ 25	1617	+ 23
L 1835	834	+ 22	1127	+ 14	1335	+ 28	1643	+ 27

NOTE: These figures were supplied 13th November, 1943, by R.C.A., First Canadian Army.

OBJECT: 1.
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REPORT NO. 21.

USE OF G.L.III IN FORECASTING WIND FOR ARTILLERY METEOR.

OBJECT: 1. To assess the value of G.L.III in forecasting wind strengths and directions for artillery meteor telegrams for surface targets.

2. A subsidiary object was to find the effect on accuracy of shooting of actual errors in the forecasts made.

METHOD: 3. Before Operation "SWITCHBACK" on 6th October, 1944, two G.L.III sets were deployed, and were available for 2 Canadian Corps Meteorological Section. It was intended that they should measure wind strengths and directions at two hourly intervals, but this was not always found possible for administrative reasons.

At the same time the Senior Meteorological Officer, 84 Group R.A.F., arranged for two forecasts of wind to be made independently of one another; one using information normally available, the other using the same information supplemented by G.L.III observations.

4. A comparison of these two forecasts has been made, with the G.L.III observations made at a time to which these forecasts applied. The assumption is made that these G.L.III observations are as nearly correct "winds" as it is possible to obtain. G.L.III readings were available from 1000 ft to 38,000 ft. As these heights are of most importance with times of flight of 30 secs and over, the basis of comparison has been the correction of the moment, for wind only, at 30 secs and 40 secs time of flight: the gun chosen was the 5.5". For these times of flight the measurements at 1000, 3000, and 5000 ft only were required.

5. Only seven such sets of data have been available, and these represent an extremely small sample of weather conditions; the results are, however, an indication of the difference that would be made by using G.L.III on a Corps front.

6. A comparison has also been made of the forecast wind with the wind actually recorded by G.L.III in 17 cases. The differences are expressed in terms of the corresponding correction of the moment for wind for a 5.5" gun.

RESULTS: 7. In Table I are set out the Equivalent Constant Winds for times of flight 30 secs and 40 secs, calculated, in accordance with "Instructions for the Preparation of Artillery Meteor Reports" (Meteorological Office), from the figures supplied.

In Table II the range and line corrections for these winds are given for the 5.5" gun firing on lines 90° and 180° from true north, ranges 10,000 and 13,800, with charges 3 and 4 respectively. The times of flight for these ranges are almost exactly 30 and 40 seconds.

In Table III shows the portion of the correction of the moment corresponding to the measured wind and the errors in the forecasts made by both methods.

8. The arithmetical averages - over the seven cases - of the figures given in Table III are:

		Range	Line
		10,000 yds	13,800 yds
Correction due to wind	-	range 50 yds line 30 yds	range 80 yds line 110 yds
Error in forecast ignoring G.L.III:		range 100 yds line 30 yds	range 150 yds line 60 yds
Error in forecast using G.L.III:		range 45 yds line 15 yds	range 70 yds line 30 yds

9. The effect of these line errors can be illustrated by the following example. The 50% probability breadth zones for the 5.5" gun (now) at these ranges are 8 and 12 yards respectively. For mixed lots these figures are multiplied by 1.5.

Considering targets as wide as these 50% zones, the proportion of rounds that fall in target for line will be as follows:

	Range	Line
	10,000 yds	13,800 yds
(i) no line error in m.p.l.	50%	50%
(ii) line error due to forecast ignoring G.L.III (averages from table III)	0	0
(iii) line error due to forecast using G.L.III (averages from table III)	15%	8%

10. Table IV shows in the columns headed G.L. the total correction due to measured winds. In the columns headed A the error in that correction due to the forecasting of these winds is tabulated. This forecast made use of the G.L.III measurements. The same ranges are used. The arithmetical averages of these figures, which are based on 17 forecasts made on 6 days using G.L.III measurements, are as follows:-

		Range. 10,000 yds	Range 13,800 yds
Correction due to actual wind:	range line	190 yds 60 yds	290 yds 130 yds
Error in forecast correction:	range line	50 yds 15 yds	10 yds 30 yds

CONCLUSION: 11. The actual figures cannot be regarded as more than a guide, as they are based on only seven forecasts. These do not represent a full range of weather conditions. Nevertheless the results show that use of the G.L.III enables a forecast to be made which will give an appreciable reduction in the error of correction of moment for surface targets at times of flight over 30 seconds.

The example given above shows the importance of this in terms of shells in a target area.

ACKNOWLEDGMENT: 12. The meteorological information provided for this investigation was obtained through the Senior Meteorologist Officer and his staff at 84 Group R.A.F., whose help and advice are gratefully acknowledged.

TABLE I

EQUIVALENT CONSTANT WINDS.

- CL = calculated from G.L.III measurements of wind.
 A = calculated from forecast made ignoring G.L. measurements.
 B = calculated from forecast made using G.L. measurements.

DATE	TIME	TIME OF FLIGHT 30 SECONDS						TIME OF FLIGHT 40 SECONDS					
		CL		A		B		CL		A		B	
		deg.	f.s.	deg.	f.s.	deg.	f.s.	deg.	f.s.	deg.	f.s.	deg.	f.s.
OCT 6	0200	060	36	-	-	060	44	063	45	-	-	060	48
	1400	070	43	040	37	070	37	071	54	040	40	070	44
	1800	053	54	-	-	046	55	062	58	-	-	048	61
8	2200	081	70	040	37	090	59	077	73	046	45	090	63
	1400	020	14	330	15	014	11	054	7	325	15	083	8
	13 1400	214	36	196	33	216	33	219	41	199	39	218	39
15	0600	223	25	-	-	233	29	231	32	-	-	243	33
	1400	183	26	230	22	222	25	195	29	230	30	233	31
	1800	127	9	-	-	227	29	152	12	-	-	229	37
18	0600	241	55	-	-	245	59	250	61	-	-	248	59
	1800	242	53	-	-	240	48	259	57	-	-	253	61
	19 0200	254	56	-	-	235	59	258	61	-	-	250	61
19	0600	271	75	-	-	286	59	279	76	-	-	288	71
	1000	284	99	-	-	282	50	291	64	-	-	287	66
	1400	303	38	340	58	306	59	306	44	337	59	308	63
18.0	303	46	-	-	-	305	55	310	49	-	-	314	57
	2200	301	26	230	22	300	29	303	31	286	26	300	33

TIME

OCT 6 0200 CL

1400 CL

1000 CL

2200 CL

8 1400 CL

13 1400 CL

15 0600 CL

1400 CL

1800 CL

16 0600 CL

1800 CL

19 0200 CL

0600 CL

1000 CL

1400 CL

1800 CL

2200 CL

TABLE II.

RANGE AND LINE CORRECTIONS DUE TO WIND.

- Q = calculated from G.L.III measurements of wind.
 A = calculated from forecast made ignoring Q measurements.
 B = calculated from forecast made using Q measurements.

TIME		5.5" gun: range 10,000 Charge III				5.5" gun: range 13,000 Charge IV			
		Line of fire 90°		Line of fire 180°		Line of fire 90°		Line of fire 180°	
		range yds	line mins	range yds	line mins	range yds	line mins	range yds	line mins
OCT 6	0800	Q +223	L14	-129	L23	+391	L21	-195	L41
		B +273	L16	-156	L29	+402	L24	-246	L42
	1400	Q +284	L11	-107	L31	+406	L17	-170	L52
		A +170	L21	-200	L18	+253	L31	-300	L27
		B +248	L10	-93	L26	+405	L15	-146	L42
	1800	Q +308	L24	-228	L32	+500	L29	-260	L53
		B +281	L28	-272	L29	+446	L43	-400	L46
	2200	Q +483	L 8	-77	L52	+685	L17	-160	L73
		A +170	L21	-200	L18	+315	L32	-305	L33
		B +423	0	0	L44	+610	0	0	L65
3	1400	Q +35	L10	-93	L 4	+55	L 4	-41	L 6
		A -54	L10	-93	H 6	+84	L13	-120	H 9
		B +20	L 8	-76	L 2	+78	L 1	-10	L 8
13	1400	Q -144	H22	+219	H15	-250	H33	+310	H26
		A -63	H23	+225	H 7	-121	H39	+360	H13
		B -139	H20	+192	H14	-237	H31	+305	H26
15	0600	Q -120	H14	+130	H13	-240	H20	+195	H25
		B -165	H13	+122	H17	-290	H15	+150	H30
	1400	Q - 8	H19	+180	H 1	-75	H30	+270	H 8
		A -120	H11	+101	H13	-225	H20	+190	H23
		B -120	H14	+132	H13	-240	H19	+180	H25
	1800	Q +50	H 4	+39	L 5	+55	H11	+105	L 6
		B -148	H15	+139	H16	-280	H25	+245	H28
16	0600	Q -342	H20	+182	H36	-560	H20	+200	H60
		B -370	H19	+177	H40	-530	H23	+220	H55
	1800	Q -328	H19	+180	H35	-540	H11	+110	H57
		B -293	H18	+168	H31	-570	H18	+180	H60
13	0200	Q -380	H12	+106	H40	-500	H13	+120	H61
		B -342	H25	+242	H36	-560	H20	+200	H59
	0600	Q -522	L 1	- 8	H36	-740	L11	-120	H77
		B -401	L12	-112	H43	-660	L23	-215	H70
	1000	Q -402	L11	-100	H43	-580	L24	-220	H60
		B -400	L10	-81	H43	-610	L20	-190	H65
	1400	Q -224	L16	-144	H24	-350	L26	-255	H36
		A -146	L41	-369	H15	-225	L55	-340	H24
		B -330	L25	-247	H35	-485	L40	-375	H30
	1800	Q -270	L19	-184	H29	-360	L32	-310	H38
		B -388	L24	-226	H34	-400	L40	-395	H41
	2200	Q -158	L10	-96	H17	-255	L18	-165	H26
		A -152	L 3	-26	H16	-240	L 7	-75	H25
		B -177	L11	-105	H19	-280	L17	-160	H29

TABLE III

COMPARISON OF CORRECTIONS OF THE MOMENT.

- Q = Correction due to actual wind as measured by G.L. III
 (magnitude only).
 A = Error due to forecast made ignoring Q measurements.
 B = Error due to forecast made using Q measurements.

Time and Dir. of Wind	5.5" gun: range 10,000 Charge III						5.5" gun: range 13,000 Charge IV					
	Q		A		B		Q		A		B	
	range yds	line yds	range yds	line yds	range yds	line yds	range yds	line yds	range yds	line yds	range yds	line yds
000												
0100 hrs.												
90°	234	32	114	29	36	3	496	68	243	57	91	8
180°	107	90	93	38	14	14	170	209	130	501	25	40
0200 hrs.												
90°	183	25	213	38	60	23	685	68	270	61	75	68
180°	77	151	123	99	77	23	160	294	145	161	160	32
0300 hrs.												
90°	35	29	89	0	15	6	55	16	139	36	23	12
180°	93	12	0	29	17	6	41	24	79	60	31	8
0400 hrs.												
90°	144	64	81	3	5	6	250	133	129	24	13	8
180°	219	44	6	24	27	3	310	104	50	52	5	0
0500 hrs.												
90°	8	55	112	23	112	14	75	121	150	41	165	45
180°	180	3	79	35	48	35	270	32	80	60	90	68
0600 hrs.												
90°	224	46	79	73	106	27	350	105	125	116	135	56
180°	144	70	245	26	103	32	255	145	285	48	120	56
0700 hrs.												
90°	158	29	6	20	19	3	255	72	15	44	25	4
180°	96	48	70	3	9	6	165	104	90	4	5	13

Time	Dir. of Wind
OCT. 6 0200	90°
1400	90°
1000	90°
2200	90°
1400	90°
3 1400	90°
5 3600	90°
1400	90°
1000	90°
0600	90°
1800	90°
3 0200	90°
0600	90°
1000	90°
1400	90°
1800	90°
2200	90°

TABLE IV
ERRORS IN FORECASTED WINDS

Q. = correction to wind as measured by G.L.III.
D. = error in forecast.

Charge IV	
range	line
yds	yds
91	8
25	40
75	68
160	32
23	12
31	8
13	8
5	0
165	45
90	68
135	56
120	56
25	4
5	13

Time	Line of Fire	5.5" gun; range 10,000 Charge III.				5.5" gun; range 13,800 Charge IV.			
		range yds	line yds	range yds	line yds	range yds	line yds	range yds	line yds
OCT. 6 0200	90°	223	41	50	5	391	84	11	12
	180°	129	67	27	17	195	165	51	4
1400	90°	284	32	36	3	496	68	31	8
	180°	107	90	14	14	170	209	25	40
1000	90°	300	70	27	12	500	116	55	57
	180°	228	93	44	9	260	213	140	28
2800	90°	403	23	60	23	685	68	75	60
	180°	77	151	77	23	160	294	160	32
8 1400	90°	35	29	15	6	55	16	23	12
	100°	93	12	17	6	41	24	31	8
3 1400	90°	144	64	5	6	250	133	13	8
	100°	219	44	27	3	310	104	5	0
5 0600	90°	120	41	45	3	240	00	50	20
	180°	130	36	8	11	195	101	45	19
1400	90°	0	55	112	14	75	121	165	45
	180°	180	3	48	35	270	32	90	60
1000	90°	50	12	190	32	55	44	335	56
	100°	39	15	100	61	105	24	140	00
3 0600	90°	342	58	20	3	560	00	30	12
	100°	102	105	5	11	200	241	20	20
1400	90°	320	55	35	3	540	44	30	20
	100°	100	102	12	12	110	229	70	12
9 0200	90°	300	35	30	30	530	52	20	20
	100°	106	116	136	11	120	245	00	0
0600	90°	522	3	121	32	740	44	80	48
	180°	8	163	104	38	120	309	95	27
1000	90°	402	32	2	3	580	36	30	15
	180°	100	125	19	0	220	241	30	20
1400	90°	224	46	106	27	350	105	135	35
	180°	144	70	103	32	255	145	120	56
1800	90°	270	55	48	15	360	129	40	32
	180°	184	84	42	15	310	153	85	12
2200	90°	158	29	19	3	255	72	25	4
	180°	36	48	9	6	165	104	5	13

CHAPTER 7. COUNTER BATTERY.

CONTENTS

- Ground Support in Assault on Boulogne (extract from Report No. 25)
- Effect of Counter Battery fire in Operation VERTURE (Report No. 29)
- Artillery in the Counter Flak Programme in
Operation PLUNDER (extract from Joint Report No. 4)

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PART OF REPORT NO. 16.

161.

THE ASSAULT ON BOULOGNE.

IV. ARTILLERY.

1. General.

1. Taking part in the Operation were the artillery of 3 Cdn and 51 (Highland) Divisions, 2 (Cdn) AGRA and 9 AGRA, and 2 HAA Regiments, making a total of -

Field Regiments	5	-	120 guns
Medium Regiments	8	-	120 guns
Heavy Regiments	3	-	48 guns
H.A.A. Regiments	2	-	48 guns
			<u>336 guns.</u>

2. After a timed programme on enemy F.D.Ls, lasting for about 1½ hours, and expending some 20,000 rounds, regiments were sub-allotted to Artillery Group Commanders at each Brigade, except that the Heavy and HAA Regiments, and from time to time others, were at the disposal of the C.B.O.

3. It became clear at an early stage that the most important aspect of the battle was the destruction and neutralisation of hostile batteries, and we have studied this in as much detail as circumstances permitted. There was, however, much firing at hostile batteries by the Artillery allotted to Brigades, of which no records were kept, as well as by the C.B.O., so that an exact analysis of what fell where has not been attempted.

2. C.B. Programme.

1. The details of the C.B. programme, which were modified several times both before and during the attack are of no special concern. There was a pre-arranged programme up till half an hour after the end of bombing on Target Area 1, when harassing fire was started, controlled by Air O.Ps. There were five of these, each allotted to a Regiment, and covering a zone of the defences. On the first day of the attack, which was fine, they were very effective in locating enemy batteries and bringing fire to bear on them.

2. It had been hoped that the Heavy Bombing of Targets 2, 3, 4 and 5, west of the river, would render hostile batteries in this area inactive. In fact, however, Air O.Ps. spotted batteries active even during the bombing (although presumably not in the actual target areas) and C.B. was therefore carried out in this area actually during the bombing.

3. The Hostile battery list contained 48 fixed positions: 19 of these were not examined. Of the remaining 29:-

Genuine battery positions	9
Odd guns	6
Dummy positions	3
No guns present	11
	<u>29</u>

In addition to this, 4 further battery positions were discovered on the ground, and 8 further positions were indicated by the Infantry as causing trouble as the attack progressed, or were mentioned by PI but were not examined. Details of all the battery positions, located and unlocated, false and genuine, are given in Map 2. It is thought that altogether there were about 90 enemy guns of 75 mm calibre or greater in BOULOGNE.

4. There were certain discrepancies between the Hostile Battery List and the Intelligence Overprint. Neither appear to have incorporated certain battery lists issued by 1st S.W.A.F. although these may have been issued in some other form. The best possible collection of the information then available would have given 15 batteries completely correct, and substantially fewer false positions. The lesson to be drawn is that Intelligence, AFIS, and G.I. information must be closely coordinated to produce the best possible Hostile Battery List.

5. The incompleteness of the Hostile Battery List depended as well on the normal limitations of air photography in detecting genuine battery positions, which in the case of BOULOGNE were enhanced by the careful preparation and emoullage of the photographs. Good quality 1/8000 scale verticals supplemented where possible with 1/4000 compassed verticals of pinpoints will show all there is to be seen from verticals. Low obliques are the only means of detecting positions screened by overhead cover such as camouflaged guns, or batteries on the edges of woods. Photographs of all these three types are desirable but their availability must depend on the operational conditions existing during the planning period.

6. There is no doubt also that the enemy pursued a careful and comprehensive policy of sound ranging deception. In such a case as BOLLONGNE, sound ranging before the assault cannot be regarded as giving more than an indication of where to search for guns on air photographs.

7. The great importance of coordination of all sorts of information about hostile batteries needs no emphasis. Without a substantially correct R.B. list, much air and artillery effort is inevitably wasted.

8. Enemy activity, and effects of our C.B.

(c) P.W. Information.

1. A Captain, commander of the Army artillery of the garrison, captured on the second day, claimed that he had not lost any of his guns through C.B. (3 Btys 4 x 10.5 cm gun hows, 1 Bty 4 x 10.5 cm guns), and that we appeared not to have pinpointed his positions accurately. His return fire was limited by lack of ammunition and lack of working O.Ps. His line communications, though not his wireless, had been put out by bombing, and the large amount of artillery fire made his O.Ps. disinclined to get out in the open.

2. 3 O.R. P.W. from the 88 mm Flak battery at NONVILLE, captured at the end of the third day, claimed that they were frequently shelled heavily for periods of about 15 minutes. Personnel took cover only on the order of the Battery Commander, and then only during the actual shelling, and each gun fired many hundred rounds. Our counter fire did not appear to follow activity on their part. Line communication within the battery was working all the time, as the cables were buried two metres deep.

3. 4 O.R. P.W. from a 155 mm Bty south of NOCQUET, captured on the 5th day, said that bombing had destroyed one gun and cut telephone communication with the O.P. Artillery fire caused no damage or casualties, and mostly fell a considerable distance short of the battery (the position had not been located before the battle). They had fired all their available ammunition (30 rds per gun).

(b) Information of own troops.

1. The whole attack was heavily influenced by enemy shelling, which caused the greater part of the 600 casualties. From Appendix A, the narrative of the battle, it will be seen how frequently forward movement and the mopping up of defences was delayed by shelling.

2. In spite of the concentrations and 'stomks' at the immediate disposal of the Infantry, no less than 17 batteries were reported back to Division as being particularly troublesome, with requests for air or other action.

3. Discussion with Infantry and Artillery personnel served to confirm once more two well known difficulties; firstly that while an accurate concentration on a well located battery invariably silenced it for the duration of the concentration, the effect seldom lasted for any length of time afterwards; secondly, that in many cases, the battery doing the shelling could only be located approximately, if at all, so that although concentrations were laid on the most likely positions, they were by no means always effective.

(c) Examination of enemy battery positions.

1. An examination of a number of batteries was made, and the results are summarised in the table below. Details of the examination are shown in Appendix C (which is to be found in Part I Chapter I where this report is reprinted in toto). All guns were in open concrete pits, except where specifically stated.

Map Ref.	No. & Type (incl light flck) of Guns	No. & Type put out of action by Art.	Rds fired by Bty	Estimated rds put on enemy bty (in 300 yd diam circle)
682554	5 88 mm	1 88 mm	1200	3600
677566	2 210 mm	Nil	-	-
	4 105 mm	1 105 mm	300	?
	2 76.2 mm	Nil	-	-
663532	6 88 mm	2 88 mm	2000	5700
654524	4 138 mm	1 138 mm	1500	?
	1 76.2 mm	Nil	-	-
660515	6 88 mm	1 88 mm	2000	?
700518	5 88 mm	1 88 mm	200	?

In some cases that could be considerable.

9. Discussion

1. Then might have been expended.

2. Infantry who were in view of the guns. All O.Ps., and information about

3. thought and the operation were

4. reactions of the out with more

In most cases shell craters were obscured by spoil from bomb craters, but if the two cases that could be counted are typical, the number of rounds put on the batteries was very considerable. In spite of this they were far from silenced.

9. Discussion.

1. The Artillery assembled for the Operation (about 350 guns) was less successful than might have been expected in neutralising Hostile batteries, on which some 80,000 shells were expended.

2. The location of enemy guns during a battle has always presented a problem. The Infantry who are being shelled cannot easily make careful observations, and are usually out of view of the guns firing on them. Artillery O.P.s., F.O.O.s., and Counter Mortar Personnel, and Air O.P.s., are the only ones in a position to deal with the problem, and greater interchange of information between them should be attempted.

3. The neutralisation of a Hostile battery once it is located also needs proper thought and ingenuity. The sudden and very heavy concentrations of 10-15 minutes used in this Operation were not entirely satisfactory.

4. It is urgently recommended that opportunities be made to study in detail the reactions of some hostile batteries to Counter Battery fire of different types so as to find out with more certainty what methods show most promise.

REPORT NO. 29.

EFFECT OF COUNTER-BATTERY FIRE IN OPERATION 'VERITABLE'.

OBJECT.

1. An attempt is made to assess the effect of our counter battery fire on the German artillery formations between the RHINE and the MALS which were supporting 84 Div and 180 Div.

METHOD.

2. Full details of the initial counter battery tasks were obtained from C.B.O. X Corps. Information about the enemy order of battle was obtained from intelligence reports, and artillery P.O.s were interrogated. A ground check was made of a number of battery positions. Considerable use has been made of 2 Canadian Corps Counter Battery Intelligence Report No. 7 dated 22nd February, 1945, which gives details of further ground checks.

ENEMY ORDER OF BATTLE.

3. The enemy artillery in the area examined consisted of the following:

1st Artillery Regiment	6 Troops
1st 2nd Heavy Fortress Battalion	5 Troops
1st 2nd Army Artillery Battalion	3 Troops
1307 Fortress Artillery Battalion	up to 27 guns.

As a result of the ground examination 20 troop positions were found, which either had been, or must probably had been, occupied at the opening of the operations. These 20 accounted for all 16 troops of the first three of the above formations, but the remaining 6 positions accounted for 11 out of a possible 27 guns of 1307 Fortress Artillery Battalion. In addition a further five positions were discovered consisting of infantry guns etc. In our endeavour to cover all H.B.s. which might have been active, it is possible that some positions of 1307 Battalion and some infantry guns may have been overlooked.

4. The relationship between the enemy order of battle and hostile battery positions in the area is shown in Appendix B.

DESCRIPTION OF COUNTER BATTERY FIRE.

5. 45 Hostile Battery positions were engaged in the initial fire plan. 27 were in an area overrun sufficiently quickly to be available for examination with little risk of confusion. As a result of this examination and interrogation of P.W. it appears that 14 of them had been occupied and 13 unoccupied. Also in the same area a further 11 positions, which were not engaged, were found to have been occupied.

6. Details of the 11 Hostile Batteries that were not engaged are given in Table 1.

TABLE 1.

Hostile Battery	Whether included in 2 Cdn Corps or Veritable H.B. Lists	State of occupation deduced before Veritable
7951 DR	Correctly located	Known to be occupied but found out too late for inclusion in fire plan.
8052 DL	Correctly located	Considered unoccupied.
8353 DH	Correctly located	No information - presumably considered unoccupied.
8556	Not listed	Defence overprint shows a weapon pit.
3'50 FV) 6250 NH) 5'51 ID)	Correctly located. -do- -do-	Positions were considered unoccupied. Guns moved in on night 7/8 Feb.
8555 VS	Correctly located	Considered unoccupied.

Hostile
Battery
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8243
8448 13

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MATERIAL EFFECTS

8. D
Appendix C.
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CONCLUSIONS

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Hostile Battery	Whether included in 2 Cdn Corps or Veritable M.B. Lists	State of occupation deduced before Veritable
8352	Not listed	Defence Overprint shows a dugout.
8243	Not listed	Several unoccupied gunpits shown in this area on Defence Overprint.
8449 IJ	Correctly located	No information but presumably considered unoccupied. This was actual occupied by Airborne recoilless guns. It is possible that these guns occupied the position only about 8/9 Feb. 45.

It may be seen that only three of the batteries had not been listed and that a further three were not occupied until the eve of the operation.

7. It seems clear that the difficulty in Operation 'VERITABLE' did not lie in locating the battery positions but in deciding which were most likely to be occupied.

MATERIAL EFFECTS.

8. Details of the physical effects of the bombardment on H.B. positions are given in Appendix C. This shows that out of a total of 28 guns that were in positions engaged by C.B., 5 were probably hit and 7 withdrawn. Out of 27 guns in positions that were not engaged 15 were withdrawn. It would appear that the results of the counter battery fire in respect of actual material damage was satisfactory. There is also prima facie evidence that guns are less likely to be withdrawn from positions that are engaged than from those that are not. However too much reliance cannot be placed on this as the availability of transport is not known and may well have been an overriding factor.

9. In addition four infantry gun positions were engaged by C.B. fire and two guns knocked out. These positions are not included in Appendix C owing to uncertainty of the fate of other possible infantry guns.

NEUTRALISATION.

10. At Appendix D is summarised the available evidence of the degree of neutralisation that was achieved. Results of P.W. interrogation are summarised at Appendix E. It would appear that the most important factor was the condition of the enemy troops. Thus 1307 Bn showed very little fight while 184 Regt and 1152 Bn both fought quite hard. The different effects of the various weights of fire put down were masked by the inherent differences in morale of the opposing artillery regiments.

11. Where there was positive evidence that batteries did or did not fire it was found that out of 10 engaged in the initial C.B. programme only 3 fired, but out of 9 not so engaged 6 fired. However the 9 not engaged by C.B. were not left entirely untested, as 8 of them had cones or stonks fired into their neighbourhood. There is therefore an indication that the weights of C.B. fire were about adequate, whereas that produced incidentally through other bombardments was insufficient.

12. The Corps Operations Log showed only five reports of enemy shelling for 8th February over the whole Corps front. This together with very favourable opinions expressed by our own troops suggests that enemy artillery fire was not a source of trouble on that day.

13. At Appendix A is a series of illustrations showing the number of shells fired at an enemy battery with the times of the day at which they were fired. There were indications that neutralisation was achieved but that there was firing during lulls. It would seem therefore that an improvement in neutralisation could be achieved by spreading the counter battery fire over as long a period of time as possible. Examination of the illustrations in Appendix A suggests that it might be practicable to provide for a counter battery programme more evenly spread over a period of time. Provided the numbers of shells fired was kept unaltered there would not be any material alteration in the chance of destruction.

COMMUNICATIONS.

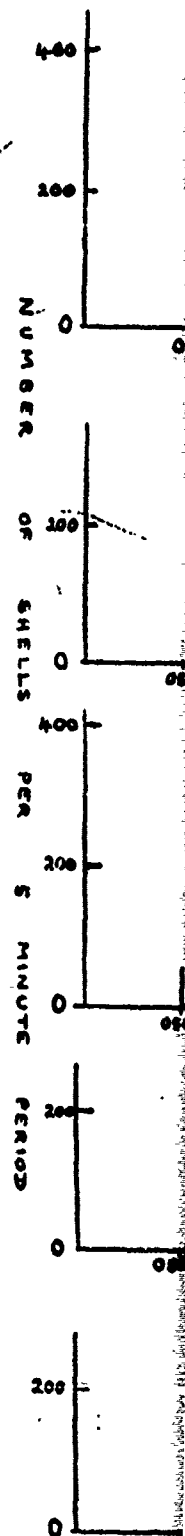
14. Cutting of communications was also a factor in restricting the amount of enemy artillery fire. It is probable that it caused the enemy to resort to predicted fire (although only one such case has been recorded) where normally his O.P. could have conducted an observed shoot. Table II below summarises the available evidence obtained by questioning P.W.

TABLE II - COMMUNICATIONS.

Unit	Communication From	To	Hostile By reference	Line Communication	Estimated length of line	Radio Communication
1152 Bn	O.P.	Own	One of 101, FV or 1D	Failed after 0900 hours	5000 yds	Failed
	Unit H.Q.	Own	One of 101, FV or 1D	Functioned	Unknown	-
1/184 ----- no record -----						
IV/184	Unit H.Q.	Own	VS	Failed at 0800 hrs	1500 yds	Functioned
	Unit H.Q.	Own	DM	Failed at 0830 hrs	1500 yds	Functioned
	Unit H.Q.	Own		Failed at 0930 hrs	1500 yds	Functioned
	Unit H.Q.	Superior H.Q.	-	Probably failed at times	Unknown	Functioned
1307 Bn ----- no record -----						
1512 Bn	O.P.	Unit H.Q.	-	Failed after 0900 hrs.	5000 yds	No record
	Unit H.Q.	Own	DM	Failed but restored	1000 yds	No record
	Unit H.Q.	Own	BB	Failed but restored	1200 yds	No record
	Unit H.Q.	Own	BV	Failed	4000 yds	Failed
	Local O.P.	Own	BV	Functioned in afternoon	500 yds	No record

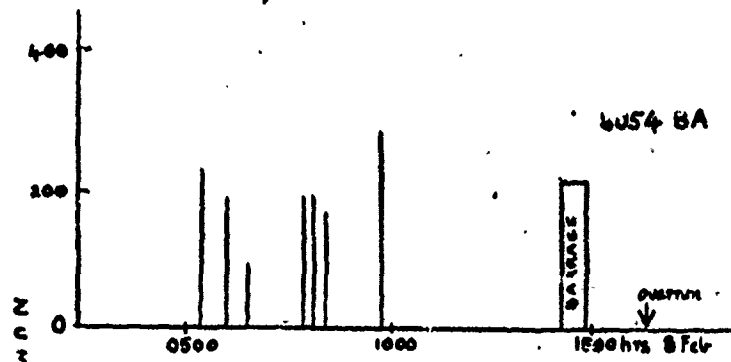
APPENDIX B

Relationship between Enemy Artillery Order of Battle and the Hostile Battery Positions considered to have been occupied on 8th February 1945.					
134 Artillery Regiment			1512 Heavy Fortress Battalion		
I	1	8254 BO	1	8454 BV	
	2	8154 AZ	2	8251 DM	
	3	8453 BU	3	8252 BJ	
IV	10	8353 DM	4	8253 AV	
	11	8352 -	5	8243	
	12	8555 VS			
1152 Army Artillery Bn			1307 Fortress Battalion		
1	8150 FV		8153 AZ		
	2	8151 ID	8353 DT		
	3	8250 KM	7949 MD		
			7951 DR		
			8052 DL		
			8256 -		

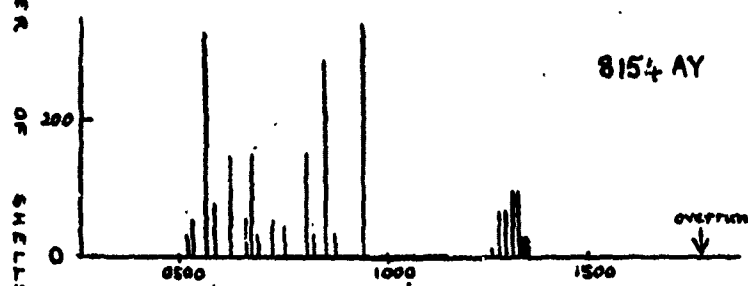


APPENDIX A Page 1

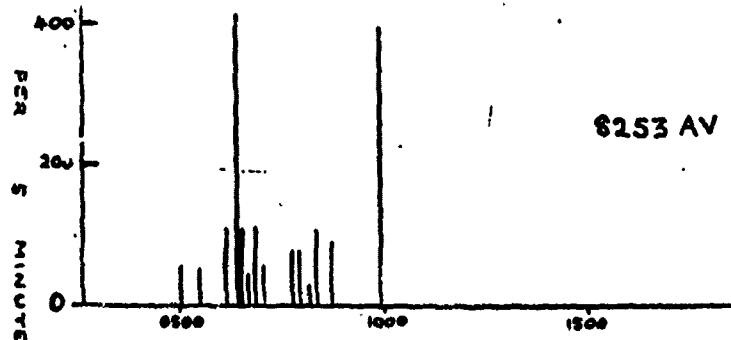
Radio
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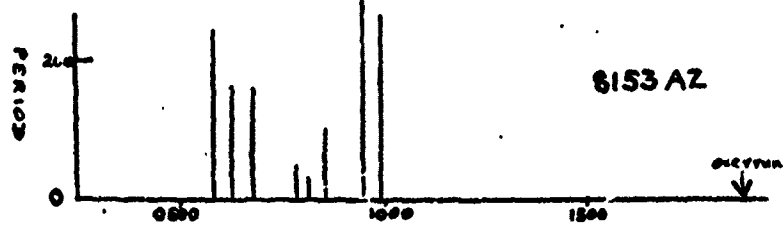
Both guns destroyed



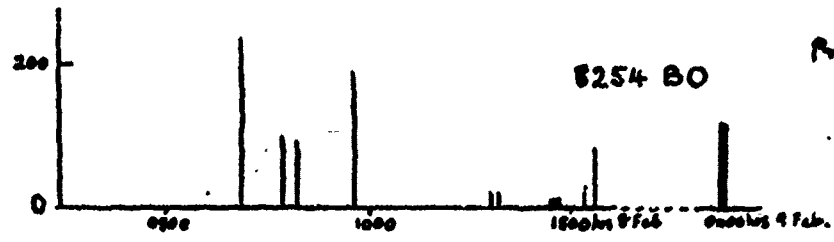
Continued firing
One gun damaged



Withdraw?

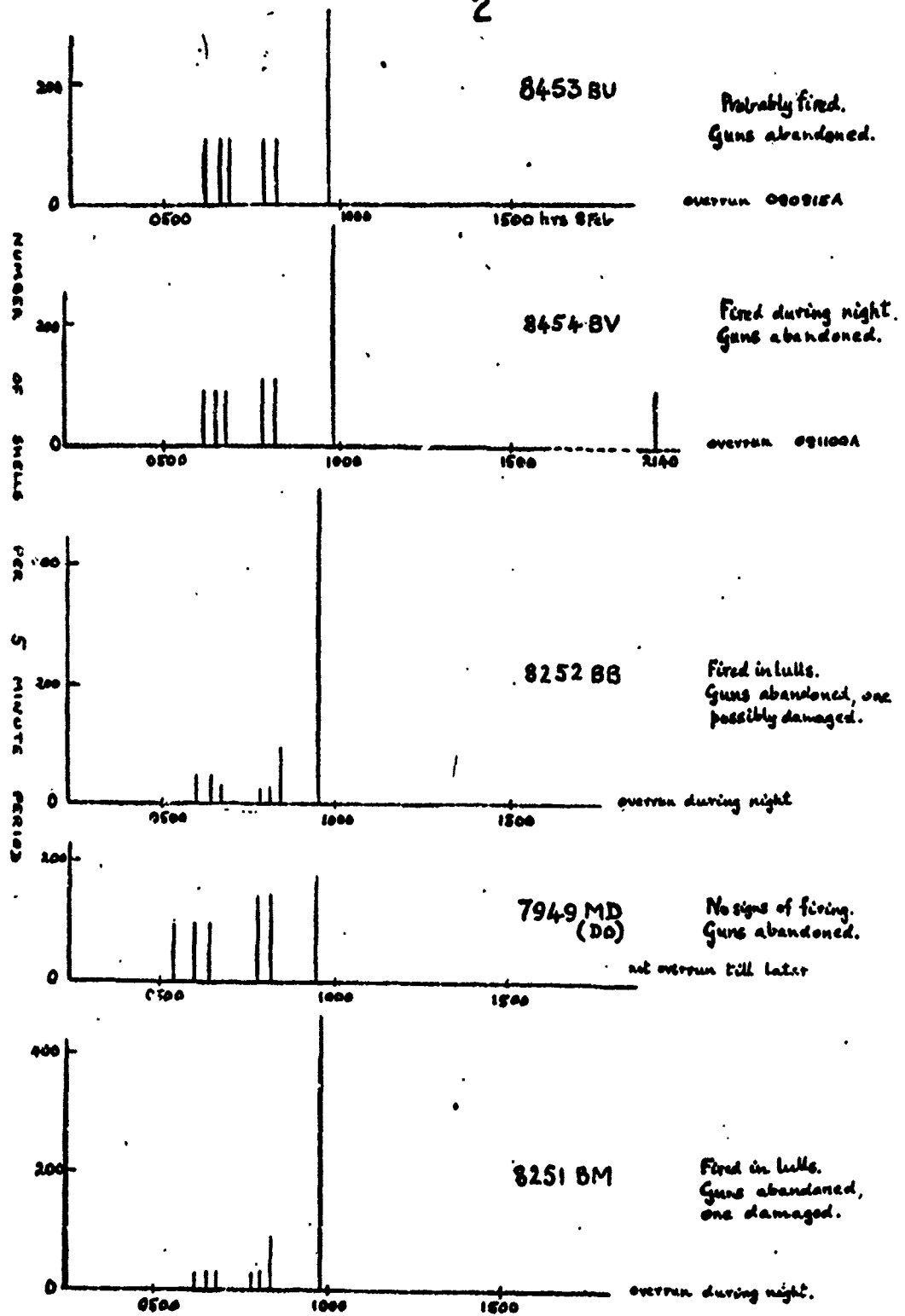


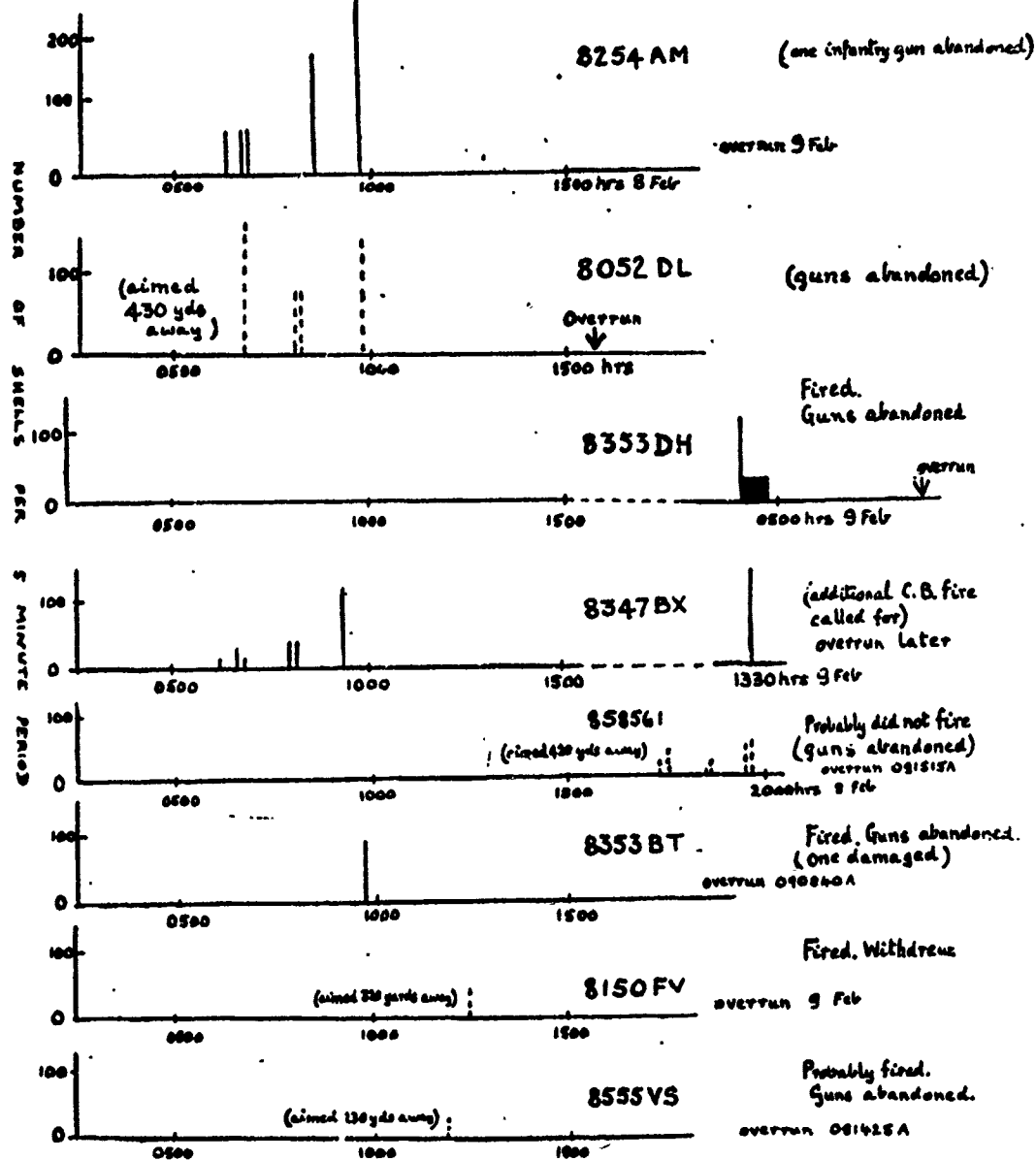
2 guns abandoned,
of them damaged



Probably fired
Withdraw.

2





NOT ILLUSTRATED

7951 DR (360 shells aimed 260 yds away) withdrew ?
 8151 ID no shelling recorded within 500 yards withdrew ?
 83895290 " " " " " " guns abandoned.
 8243 area " " " " " " never fired.

Note. In these figures no attempt has been made to make the thickness of the vertical line correspond to the duration of the shelling except when this lasted over 5 mins. Fractions of 5 mins have been taken as going throughout.

Relationship between Enemy Artillery Order of Battle and the Hostile
Battery Positions considered to have been occupied on 8th February 1945.

Five other hostile battery positions were found as follows:

8054 JA - Infantry gun position. 2 x 15 cms found.
(1051 Infantry Regt)

8254 JH - Infantry position. 1 x 7.62 cm found.

7948 HE - This may or may not have been occupied.
Perhaps a roving gun.

8347 DX - Possibly an infantry position in this locality -
7.62 cm found in neighbourhood.

8949 IJ - Airborne recoilless gun positions.

Equipments:

1/184 Artillery Regiment	10.5 cm howitzers.
1V/184	15 cm howitzers.
1512 Battalion	Three tps 12.2 cm howitzers. One tp 15.2 cm howitzer. One tp 10.5 cm howitzer.
1152 Battalion	15 cm howitzers.
1307 Battalion	Krupp 75 mm made early this century.

APPENDIX C

Battery	Guns found by ground check	Guns thought to have been there from PW reports etc.	Guns probably hit by counter battery fire	Guns destroyed by other means	Guns withdrawn	
6154 AY	3	3	1	2	-	2 Tps, 152 Bn
8253 AV	0	3	-	0	3	4 Tps, 152 Bn
6153 AZ	2	2	1	1	-	1307 Bn
8254 AO	0	3	-	-	3	1 Tps, 152 Bn
7951 ER	0	1	-	-	1	1307 Bn
6453 BU	2	3	-	2	1	3 Tps, 152 Bn
8454 BV	3	3	-	3	-	1 Tps, 152 Bn
8252 BE	4	4	1	3	-	3 Tps, 152 Bn
7949 HD	2	2	-	2	-	1307 Bn
8251 JH	3	3	1	2	-	2 Tps, 152 Bn
8052 DL	2	2	-	2	-	1307 Bn
8250 NH	0	3	-	-	3	1 Tps, 152 Bn
8353 DH	1	3	-	3	-	10 Tps, 152 Bn

Hostile Battery	Guns found by ground check	Guns thought to have been there from PW reports etc	Guns probably hit by counter battery fire	Guns destroyed by other means	Guns With-drawn	Unit
8556 -	2	2	-	2	-	1307 Bn
8353 BT	2	2	1	1	-	1307 Bn
8555 VS	2	3	-	2	1	12 Tp, IV/184
8190 FY	0	3	-	-	3	Tp of 1152 Bn
8151 ID	0	3	-	-	3	Tp of 1152 Bn
8352 -	3	3	-	3	-	11 Tp, IV/184
8243 -	0	4	-	-	4	5 Tp, 1512 Bn
Total figures	33	55	5	28	22	-
Engaged in opening fire plan	21	28	5	16	7	-
Not engaged in opening fire plan	12	27	0	12	15	-

APPENDIX D

Whether directly engaged in intelligence work or not

Hostile Battery

Prisoner of War Statements

Evidence from Ground Check

Unit

Weight in tons

No. of hits

Guns

APPENDIX E.

INFORMATION OBTAINED BY QUESTIONING PRISONERS OF WAR.

Hostile Battery	Unit	P.W. Statement
8154 L	2. 1/184 A.R.	From accounts by P.W. from this Unit it appears that No. 3 gun was damaged by our shelling. The HQ 1/c No. 1 gun was secured and they did little firing. No. 2 gun however fired extensively from 0800 hrs when it first was ordered to fire, in spite of our shelling which was aimed accurately at them and included airbursts. After midday, possibly 1500 hrs, our shelling stopped, and they later engaged our infantry over open sights. Tanks came on to the position from a flank while they were held down by mortar fire. After this they observed that Nos. 1 and 2 guns had been knocked out.
8454 M	1. 1512 Dn.	From accounts by PW of this Unit it appears that they fired up to 50-60 r.p.g. during the night 8/9 Feb. They fired little, if at all, by day after the C.B. programme started. No guns were damaged, but there was about one casualty. They realised the position had been spotted and disliked tree bursts particularly. Their communications with Abteiling (5000 yards away) whose fire orders usually came, had been cut; if they did shoot it was observed from an O.P. about 800 yards away on the hill in front of the position. When the position was overrun they ran off through the woods: the guns were to be blown up.
8252 D	3. 1512 Dn	PW said there were 3 guns here and a fourth gun per troop in reserve. One of their guns had been pulled out because of damage. They fired in the woods in our shelling, alternating with 8251 Dn. They were overrun by tanks, abandoned their guns and were used as infantry. They had no transport. PW from Dn No. 1 said lines to troops were cut in the morning but restored in the afternoon. They fired on information from neighbouring units as their O.Ps. were not functioning.
8250 M) 8150 M) 8151 D)	1152 Dn	A PW from 1 troop said they came into position night 7/8 Feb and did quite a lot of firing, and were not counter-battered though they had a certain amount of shelling. They lost 1 killed, 1 wounded, and withdrew during the night. From accounts of PW from 3 troop it appears that they also came into position the night before the attack and were not specifically engaged but odd shots came into the position. After about 0300 hrs line and wireless to the O.P. failed. The guns did some firing. PW could not specify positions but any of the three 8250 M, 8150 M, 8151 D would be consistent with their stories.
8353 M	10. IV/184	A PW from 10 tp said they were fired at from 5 a.m. to 5 p.m. It was destructive fire but generally fell short and was heaviest in the evening. They did fire. PW from Stab/IV/184 said the line to 10 troop lasted about three hours after our fire plan started; it was then cut and had to be repaired twice - they were in touch by Rf.
858961	1. 1307 Dn	PW said that the position they occupied may have been here; or it was described by one as 1000 yds SE. Their story may be typical of the battalion. Our shelling was very heavy on the position though not actually directed at them. They were secured. Nearly all stated they did not fire a round.
6353 M	1. 1307 Dn	PW said one gun was damaged by shelling, the other did some shooting during the morning and early afternoon of 8 Feb.
8555 M	12. IV/184	PW from Stab/IV/184 said the line to 12 troop failed about 4 1/2 hrs after our fireplan started. They were in touch by Rf.
6309) 5290)	11. IV/184	PW from 11 troop IV/184 A.R., who may have been here, said shelling was so strong they did little firing. The gun, for which he was an ammunition number, fired four rounds. PW from Stab/IV/184 A.R. said line failed 3 1/2 hrs after our fireplan started, but they were in touch by Rf.

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EXTRACT FROM JOINT REPORT NO. 4.

ARTILLERY IN THE COUNTER-FLAK PROGRAMME IN OPERATION VARSITY.

The number of enemy L.A.A. guns of all calibres deployed throughout the "Varsity" area was considerable. The Second Army Hostile Battery List, extended up to 2359 hrs. 23rd March, 1945, contained 357 positions in two lists. List A, consisting of targets in the Artillery Zone (roughly between the Autobahn and the Rhine, see Map at Appendix A), gave 106 positions which were shown as having 231 L.A.A. and 103 H.A.I. guns in all. List B, batteries beyond the Artillery Zone, had 251 flak positions containing possibly 668 L.A.A. and 78 H.A.I. guns. Subsequent examination of the ground and interrogation of local civilians showed that about half of these positions were unoccupied on the day of the operation.

Over 150 prisoners from these flak positions were interrogated and documents found on the sites were scrutinised; as a result it has been possible to form a clear picture of the Order of Battle of Flak formations in the "Varsity" area (see Appendix B). This shows that, had all units been at full strength, there would have been 562 L.A.A. guns in the area, 78 heavy and 484 light. As many of the L.A.A. guns were tripling or vierling and as it is known that a number of mobile 2 cm vierlings were also operating in the area at the time, it appears that the number of barrels that could be fired at the airborne armada was not far short of a thousand.

Some of the flak units had been brought into the area as late as D-1 and prisoners stated that the airborne landing was expected at the time and place at which it did occur. The discovery of a marked German map suggests that some leakage of information had taken place. In spite of the re-inforcements which were probably brought in as a result of such leakage, the number of guns in the area was still very much less than that shown on the Hostile Battery lists. There were very few real gun positions which did not figure in these lists, although the counter-battery intelligence work was very difficult owing to bad weather and to the fact that the Germans refused to disclose their positions by firing before D Day.

Artillery.

The counter-battery fire of the night D-1/D was not specifically directed against flak positions as such, but several of them were engaged and where damage was done this has been included in the part played by the Artillery in reducing the fire power available to the enemy during the airborne operation. Full details will be found at Appendix D.

Between 0930 and 0952 hrs. on 24th March, 1945 some 24,000 rounds (44. tons) were fired at flak positions in the "Varsity" area. 12 Corps fireplan "Carpet" was the engagement of 79 points, each by a single battery for 25 minutes, and the 30 Corps programme "Napier" was the engagement, scale 2 or 3, time on target, of 22 points. Where the points were very close together or coincident they have been grouped together and the total number of targets thus arrived at is 95. The amount of fire with which the targets were to be engaged varied from 10 to 1,000 rounds with an average of 242 rounds per target. (Corresponding average figures in other operations were "Switchback" 427 and "Veritable" 1117 rounds per target).

All but three of the 95 positions engaged by 12 and 30 Corps were visited a few days after the operation and those cases where signs of damage were discovered are fully described in Appendix D. 39 of the positions were probably unoccupied on the day in question and 24 of these had been engaged in the fire plan. A further 23 with no evidence whatsoever of any occupation were also engaged.

As was the case with the medium bombing the physical damage inflicted by the artillery was very small but it is considered that there was some temporary lowering of morale. Prisoners from flak positions in the Artillery Zone stated that several 2 cm guns were jammed by the dust which the shelling raised. The Map at Appendix E shows that the effectiveness of the opposition met by the first squadrons of troop-carrying planes was very much less than that encountered by later arrivals; this would seem to suggest that gunners, who had gone to ground during the artillery programme and the medium bombing, did not return to their guns immediately the airborne armada was sighted.

Note: Joint Report No. 4 appears in Part I Chapter 4.

*Tripling are triple and Vierling quadruple L.A.A. guns.

APPENDIX D.

ARTILLERY TARGETS.

95 targets were engaged in the Counter-flak programme.

92 of them were visited by the ground investigators.

11 of these showed signs of damage or casualties that might be attributed to Artillery, though not necessarily to the Counter-flak programme.

C.J. Number	Map Reference	Weight of Bombardment	Findings of Investigators
191	16655217	133 rds Hed (4.8 tons)	One of three 2 cm Vierlinge still in position but destroyed by Germans. Position heavily shelled probably mostly by observed fire.
258	25654467	133 rds Hed (4.8 tons)	Three 2 cm guns. No damage. One dead German. PW said that communications were cut but this did not prevent them from firing.
228	21184521	600 rds 25 lb Airburst and 400 rds 25 lb HE shells	Four pits with dummy guns but signs of recent occupation. One German grave dated 24th March. No craters found but airburst splinters in all 4 pits.
205	26374486	133 rds Hed (4.5 tons)	Several craters near gun pits. Guns moved 500 yds on 24th March because of shelling, said PW. Burnt out 3/4 truck arm carrier found on situ. Arty out comms but did not stop firing.
230	242480	100 rds Hed (4.3 tons)	8 German graves dated 24th March 1945. PW said both cluster bombs and Arty killed men but guns continued to fire.
338	240483	100 rds Hed (4.3 tons)	One German grave dated 24th March.
256	28704303	133 rds Hed (4.8 tons)	Undated German graves. No signs of recent occupation.
1031	232474	400 rds 25 lb HE shells (4.5 tons)	One German grave dated 24th March. No signs of damage.
1016	25603911	1200 rds 25 lb airburst	Many craters found, including craters in 2 gun pits.
221	21824955	200 rds Hed (8.5 tons)	One gun pit probably hit by Arty, 1 dead German on site.
MM	21935007	100 rds Hed and 40 rds in CJ programme (5.8 tons)	Two gun pits received Arty hits. Guns destroyed by Germans. 2 dead Germans found on site.

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CHAPTER 8.

MORALE EFFECTS OF ARTILLERY.

CONTENTS

The Effect of Artillery Fire on Enemy Forward Defensive Positions in
the Attack on Gailenkirchen (Operation CLIPPER) (Report No. 22)

Fire Support in Operation VERITABLE - Effect on Forward
Defensive Positions (Report No. 24)

Morale Effects of Artillery (Ann. No. 7)

REPORT NO. 22.

THE EFFECT OF ARTILLERY FIRE ON ENEMY FORWARD DEFENSIVE POSITIONS
IN THE ATTACK ON GEILKIRCHEN (OPERATION CLIPPER)

INTRODUCTION.

1. We have tried to discover in this Operation how different weights and durations of fire affected the enemy's resistance, the ultimate aim of this and further investigations of the same sort being to give some definite figures on the amount of fire needed against enemy troops of different qualities in different types of defensive positions. Such information, if it can be produced, would usefully supplement the practical experience which must be the main factor in planning any bombardment.

THE ATTACK.

2. This operation was particularly favourable for our purpose, since it went almost entirely according to plan and the battle was not confused by subsequent events. A part only was studied, namely the attacks on 18th November, 1944, by 5 Dorsets, 7 Somerset L.I., 1 Worcester and 5 D.C.L.I. battalions of 43 Division, supported by the Divisional artillery and 5 M.C.R.A. The co-operation of 43 Division has made it possible to collect in detail all the relevant information, which, for the sake of conciseness, is presented on the attached map. This should not be regarded as a plan of the battle, however, since all the details not strictly relevant to the purpose of the investigation have been omitted. Since they exert an indirect effect, the results of C.B., C.M., harassing fire and air attack in rear and gun areas, have not been considered, nor has the assistance given by tanks. Roughly speaking, however, all these forms of support should have helped each battalion to an equal extent.

3. The most outstanding feature of the whole operation was the bombardment of LAUCHEN and subsequent attack by 5 Dorsets. The enemy, about 150 strong, were in open trenches round the village. The area was subjected first to 10 minutes artillery fire (49 tons), then to 3 hours mortar fire (44 tons) as well as some 30 mm, 40 mm, and 75 mm tank fire (18 tons), and finally to a little over half an hour of artillery fire (73½ tons), making in all 184½ tons spread over nearly 4 hours, giving a density of about 1.8 tons per 100 yds square. The enemy offered not the slightest resistance, and was described by the attacking troops as looking "absolutely yellow coloured." P.W. interrogated later were clearly very shaken physically and said they had felt quite overwhelmed with a sense of helplessness in the face of immense superiority. A few P.W. who had sheltered in cellars were not so shaken, but had still not offered any resistance. The disruptive effect on the enemy had also been considerable, in that line communications were cut at an early stage and subunit command was had not moved at all during the bombardment. Enemy casualties are not known exactly, but are thought to have been about 10 - 15%. In the whole attack our own casualties were only 7, of which 4 were due to our own shells falling short. It is worth noting that the weight of fire put down in this attack is of the same order as in other attacks where enemy resistance was paralysed (VALENCIENNES 1918 and TUNIS breakthrough).

4. The attacks of 7 Somerset L.I., 1 Worcester, and 5 D.C.L.I. battalions took a rather different form. In all three attacks successive areas were bombarded for only 20 - 40 minutes with weights ranging from ½ to 1 ton per 100 yd square. It is not possible to distinguish clearly between the effectiveness of the different weights, but even in the most lightly bombarded area (.23 tons) there was no serious resistance, and the heavier concentrations were not markedly more efficient. It was evident from P.W. and our own troops that these bombardments had not produced the same powerful effects as the prolonged bombardment of LAUCHEN, because of their lesser weight and lesser duration. On the other hand they did have a strong effect, in that the enemy surrendered with little opposition, and P.W. said once again that they felt helpless in the face of overwhelming superiority. The effect in some areas at least (12 and 15) was much more than a mere "keeping down of heads" since in the 7 Somerset L.I. attack, our troops were, towards the end, as much as 30 minutes behind the concentrations and, even so, no effective resistance was offered. The weight of the concentrations in these two areas was .45 and .67 tons per 100 yard square respectively. The disruptive effect on the enemy in all the areas in the path of these attacks appears to have been considerable - line communications were cut, the commander was cut off from his company throughout the action, a platoon was unable to take up a new position, and so on. Enemy casualties are not known exactly, but are thought to have been about 5%. Our own casualties, which were several times greater in each battalion than at LAUCHEN, are shown on the attached graph.

5. The quality of enemy troops was not high. 183 Volksgrenadier Division consisted of about 70% Austrians, many of whom were not fit and not enthusiastic for battle. Nevertheless, they could resist strongly as was shown when 5 Dorsets carried out a small attack on 19th November against enemy positions by-passed in the woods NW of RIESCHEN. This attack had to be put in hurriedly relying solely on the battalion's resources, and without artillery support. The forward troops were sharply engaged by the enemy with L.H.G.s. and mortars and suffered 11 casualties in a

2,500

MAP TO SHOW 43 DIVIS

18 NOV 4

ENLARGED FROM GSCS FRANCE & BELGIUM 1:50,000 SH

6 Coy 351 GR
(ABOUT 110)

5 Coy 351 GR
(ABOUT 110)

SOMERSET L.I.

OWN TROOPS

CASUALTIES. 25

TIMING. CLOSE UP TO CONCENTRATION
INITIALLY: JOMINS BEHIND TOWARDS
THE END

RESISTANCE. SLIGHT EVEN WHEN TROOPS
ARRIVED JOMINS AFTER CONCENTRATIONS
CASUALTIES PARTLY FROM S.P. GUNS
MANY PRISONERS TAKEN

NEMY

MORALE. MAJORITY INDUCED TO GIVE UP
FROM A SENSE OF OVERWHELMING
SUPERIORITY OF OUR ARTILLERY & HELPLESS-
NESS IN FACE OF IT. NOT PHYSICALLY SHAKEN.

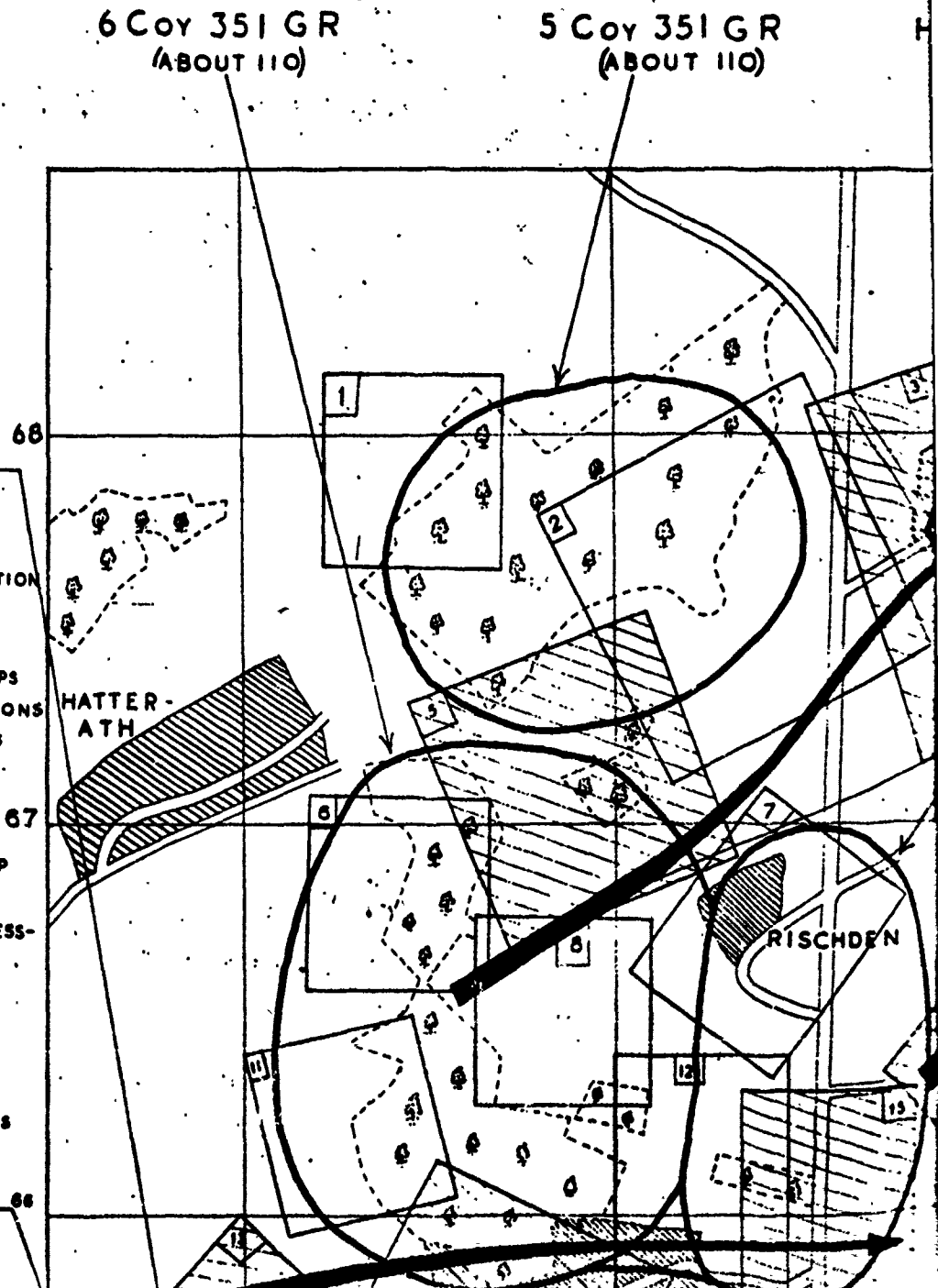
COHESION LINE COMMUNICATIONS OUT AT
AN EARLY STAGE. COY COMD HELD DOWN
BY FIRE AWAY FROM COY H.Q. THROUGHOUT
THE ENGAGEMENT.

CASUALTIES SLIGHT, NO EXACT FIGURES

ORSETS

OWN TROOPS

CASUALTIES. 7 (4 CAUSED BY OWN SHELL)

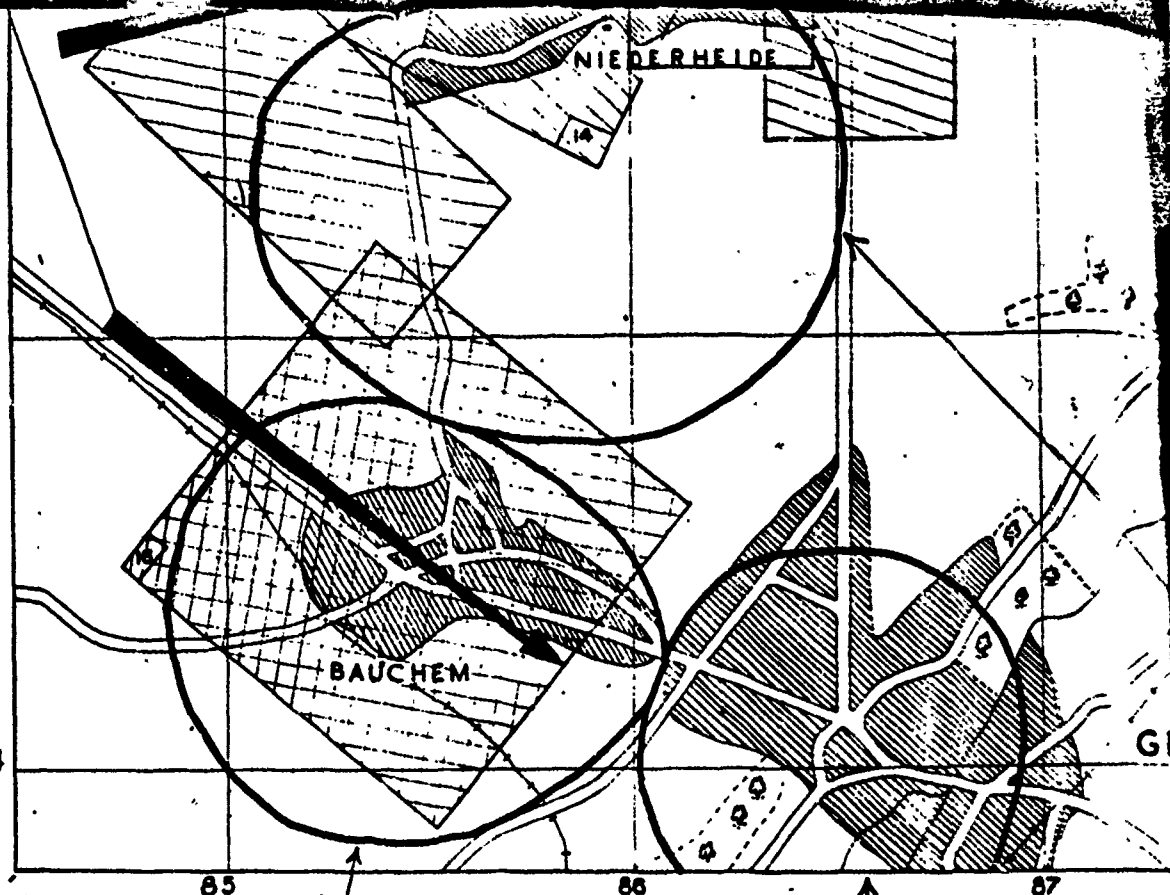


LOSE UP TO CONCENTRATIONS
PRACTICALLY NIL ENEMY
ALL TAKEN PRISONER

COMPLETELY BROKEN DOWN
MORALLY AFFECTED; LOOKED
LOW COLOURED

TY AND FLANKING 65
AT AN EARLY STAGE. COY
IT TO HAVE MOVED
MOUNT OF FIRE.

IT KNOWN ACCURATELY
IT BEEN 10-15%



5 Coy 343 GR WITH ELEMENTS
13 & 14 Coys (ABOUT 150)

8 Coy 343 GR

ND

3 TONS PER 100 YDS SQ

30

30

5 IN CORNERS REFER
ON SEPARATE SHEET

D

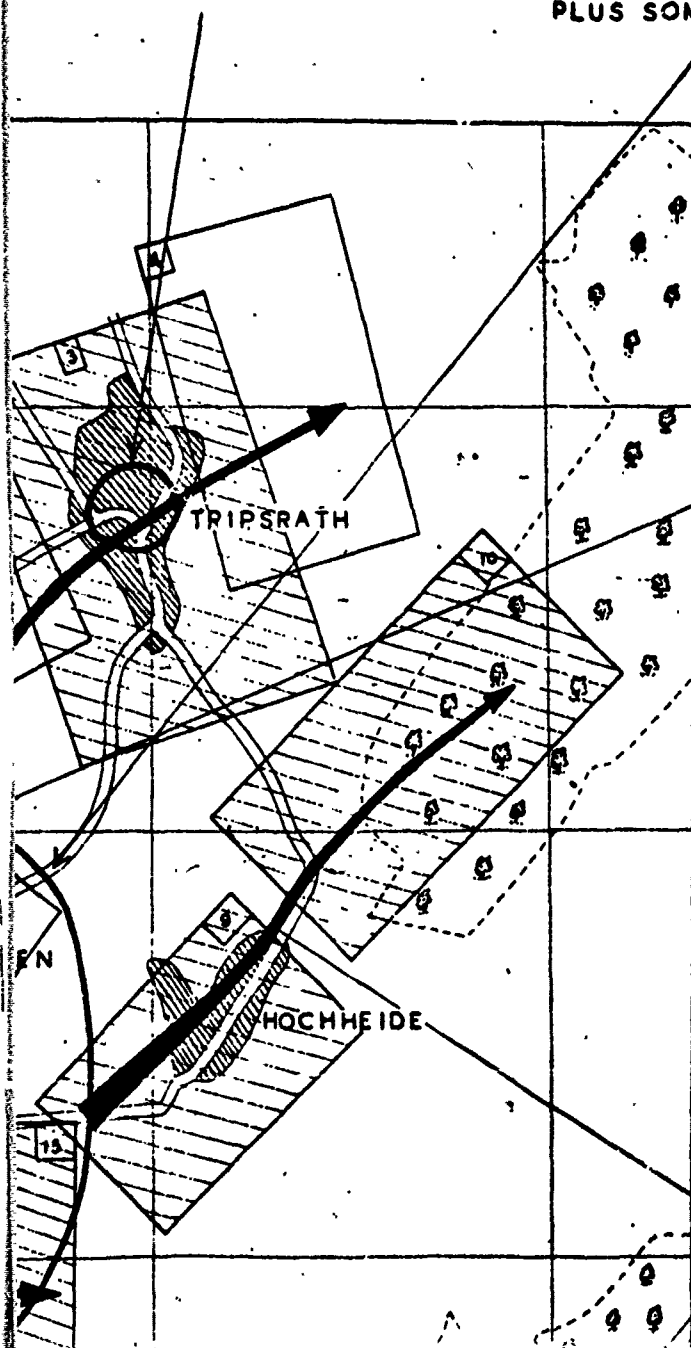
VISION ATTACK

44

TO SHEET 48 TO A SCALE OF 1:12,500

H.Q. 2 BN 351 GR

8 COY 351 GR (MORTARS ONLY)
PLUS SOME BN ADM PERSONNEL
(ABOUT 80)



1 WORCESTERS

OWN TROOPS

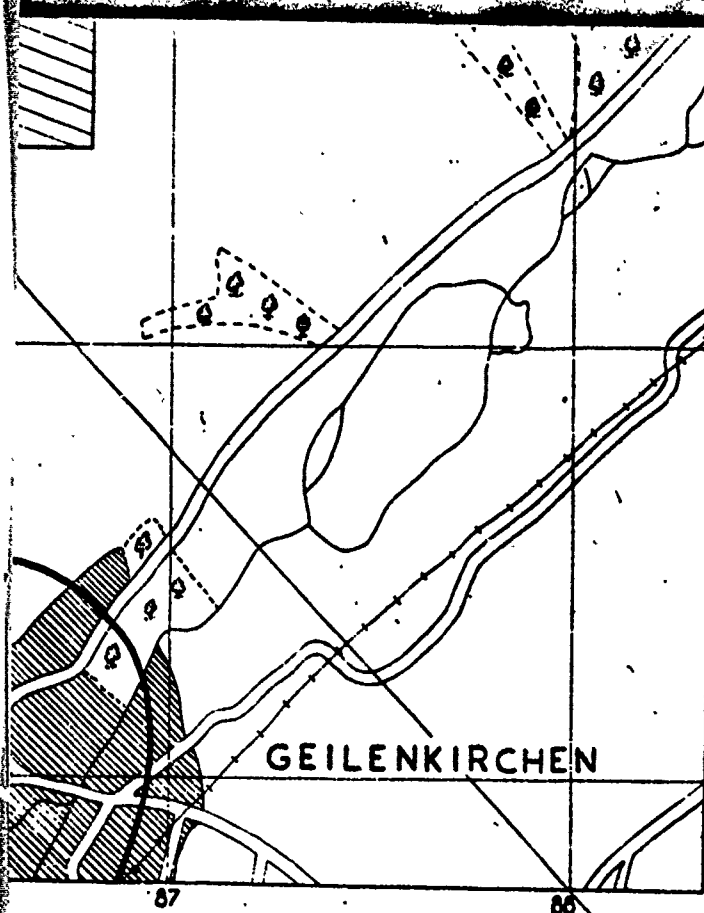
- | | |
|----------------------|-----------------------------|
| 1. <u>CASUALTIES</u> | 27 |
| 2. <u>TIMING</u> | CLOSE UP TO CONCENTRATIONS |
| 3. <u>RESISTANCE</u> | SLIGHT MANY PRISONERS TAKEN |

ENEMY

- | | |
|----------------------|--------------------------|
| 1. <u>MORALE</u> | AS FOR 750MEPSET L.I. |
| 2. <u>COHESION</u> | NO SPECIAL INFORMATION |
| 3. <u>CASUALTIES</u> | SLIGHT; NO EXACT FIGURES |

5 DUKE OF CORNWALL'S L.I.

OWN TROOPS



2. TIMING CLOSE UP TO CONCENTRATION
3. RESISTANCE SLIGHT MANY PRISONERS TAKEN

ENEMY

1. MORALE AS FOR 7 SOMERSET L.I.
2. COHESION NO SPECIAL INFORMATION
3. CASUALTIES SLIGHT NO EXACT FIGURES

43 GR

7 Coy 351 GR
(ABOUT 110)

short space of time. It was apparent that an assault without further support would be costly so they withdrew and attacked the following morning with artillery. A density of about .3 tons per 100 yds square was put down on the edge of the woods (855673) and on various points inside, and the battalion went in with very little opposition from enemy infantry. They were, however, met with a considerable amount of fire from artillery, and S.P. guns from outside the area, which caused some casualties. (Total 39, 6 caused by small arms). While there are many better enemy formations than 183 Volksgrenadier Division, the majority of infantry charged with holding the line are likely to be of similar quality.

6. The front of this attack had been static for about 6 weeks, and the enemy had therefore had ample time to prepare defences. In fact, possibly because they were only outposts of the Siegfried Line, the defences were not elaborately prepared and consisted almost entirely of open trenches. In the villages there were some cellar-shelters but, as far as could be determined, the great majority of troops were, in fact, in the open defences during the bombardments.

CONCLUSIONS.

7. This investigation is only a first attempt at producing definite figures for bombardments. We have no evidence yet on how these figures will vary for different circumstances and they must, at present, be treated with reserve. In particular it should be noted that they refer to troops in open field defences.

8. Against troops of the calibre of 183 Division (2nd grade infantry divisions) a bombardment of $1\frac{1}{2}$ tons per 100 yd square, carried on continuously for several hours, will have an overwhelming effect and paralyse all resistance. The effect will be less in built up areas or where other strong shelters are available. Concentrations of 1 ton per 100 yd square continued for only 20-40 minutes do not, however, produce at all the same mental and physical breakdown caused by the prolonged bombardment with a weight not very much greater.

9. Against the same troops, concentrations of $\frac{1}{2}$ ton per 100 yds square and upwards, lasting for 20 - 40 minutes, will have a strong demoralising and disruptive effect, which may last for a short time afterwards and is apparently more than mere neutralisation.

10. A weight of 1 ton per 100 yd square did not have a markedly greater effect than a weight of $\frac{1}{2}$ ton; both were very effective and the greater weight is therefore possibly uneconomic.

EXPLANATORY NOTES ON MAP TO SHOW 43 DIVISION ATTACK, 18TH NOVEMBER 1944.

1. Concentrations and 'stocks' of the actual fire plan are grouped to give the bombardment areas shown on this map. Single concentrations and 'stocks' are taken as being 900 x 900 yards.

2. The line of the 4 battalion attacks are shown by black arrows. The bombardment areas touching or immediately adjacent to these arrows are therefore the relevant ones for the respective battalions.

3. Areas of enemy companies are shown approximately. The exact areas of enemy troops within the companies are not shown - the majority were in trenches along the forward edges of the company areas. The bombardment areas were arranged to cover defensive positions further back, some of which were occupied all the time, others by troops as they retreated. There were very few enemy who were not in bombarded areas.

4. The weights and durations of the various bombardments are given below:

Concentration	Weight in tons per 100 yds square	Duration in minutes
1	.32	20
2	.43	35 + 12
3	.94	35 + 32
4	.34	35 + 20
5	.70	20
6	.32	10

Concentration	Weight in tons per 100 yds square	Duration in minutes
7	.46	30
8	.23	24
9	1.13	65 + 25
10	.63	35 + 25
11	.30	35
12	.15	20
13	.98	20
14	1.04	44
15	.67	40
16	1.84	231

GRAPH
BATTAL
THE

CASUALTIES PER BATTALION

30

20

10

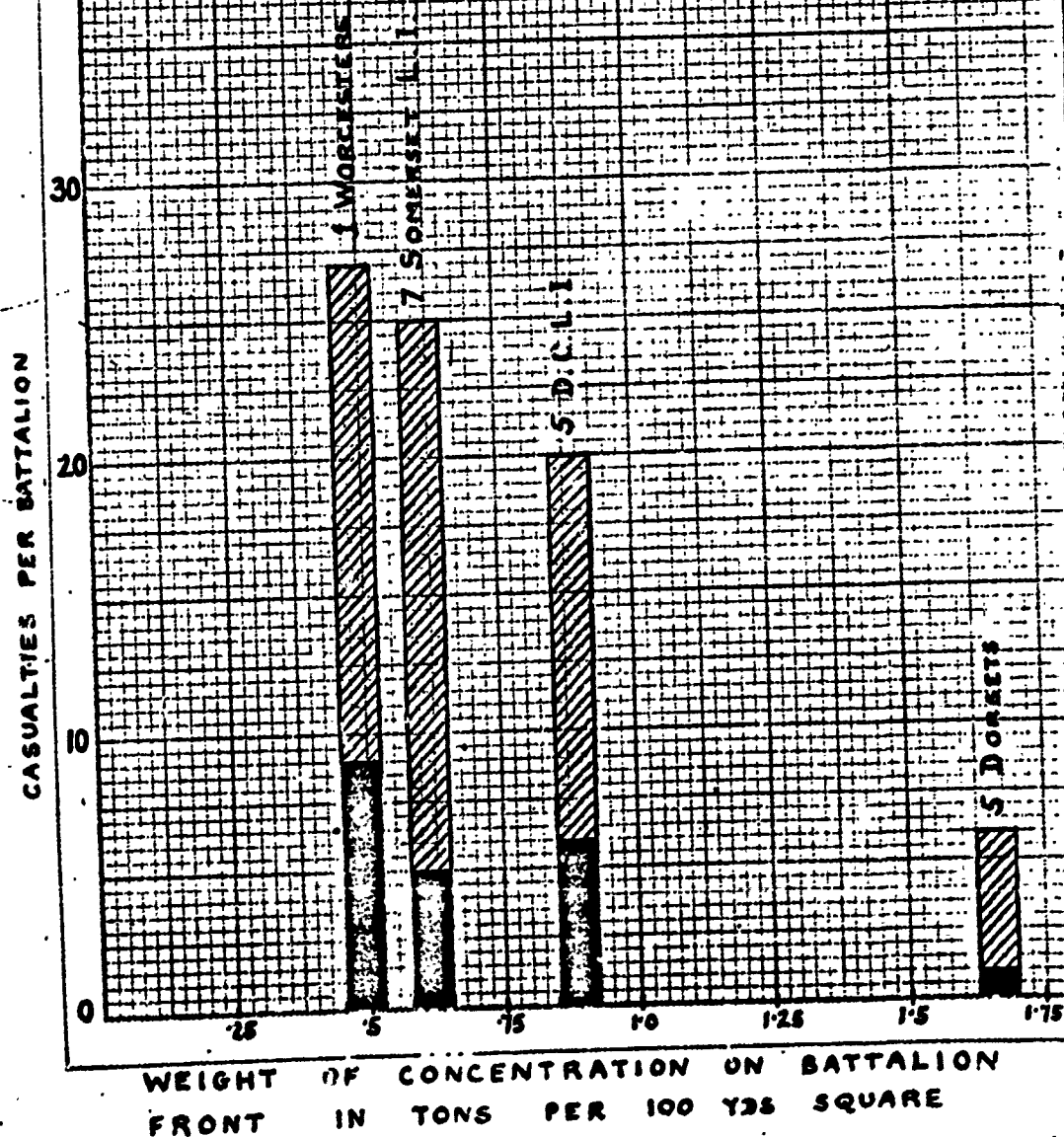
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WEIGH
FRONT

GRAPH TO SHOW THE CASUALTIES PER BATTALION AND THE WEIGHT OF FIRE ON THE BATTALION FRONTS.

CASUALTIES DUE TO BULLETS, DIRECTLY ATTRIBUTABLE TO FORWARD DEFENCES

CASUALTIES DUE TO H.E. (MORTARS AND ARTILLERY), ATTRIBUTABLE PARTLY TO FORWARD DEFENCES AND PARTLY TO GUNS OUTSIDE THESE AREAS.



EUROPE
Scale 1:1,000,000

5° W. (DEC. 1943)

52° 3' North

NORTH

SE

4°

H

0

5°

L

L

A 6°

N

D

7°

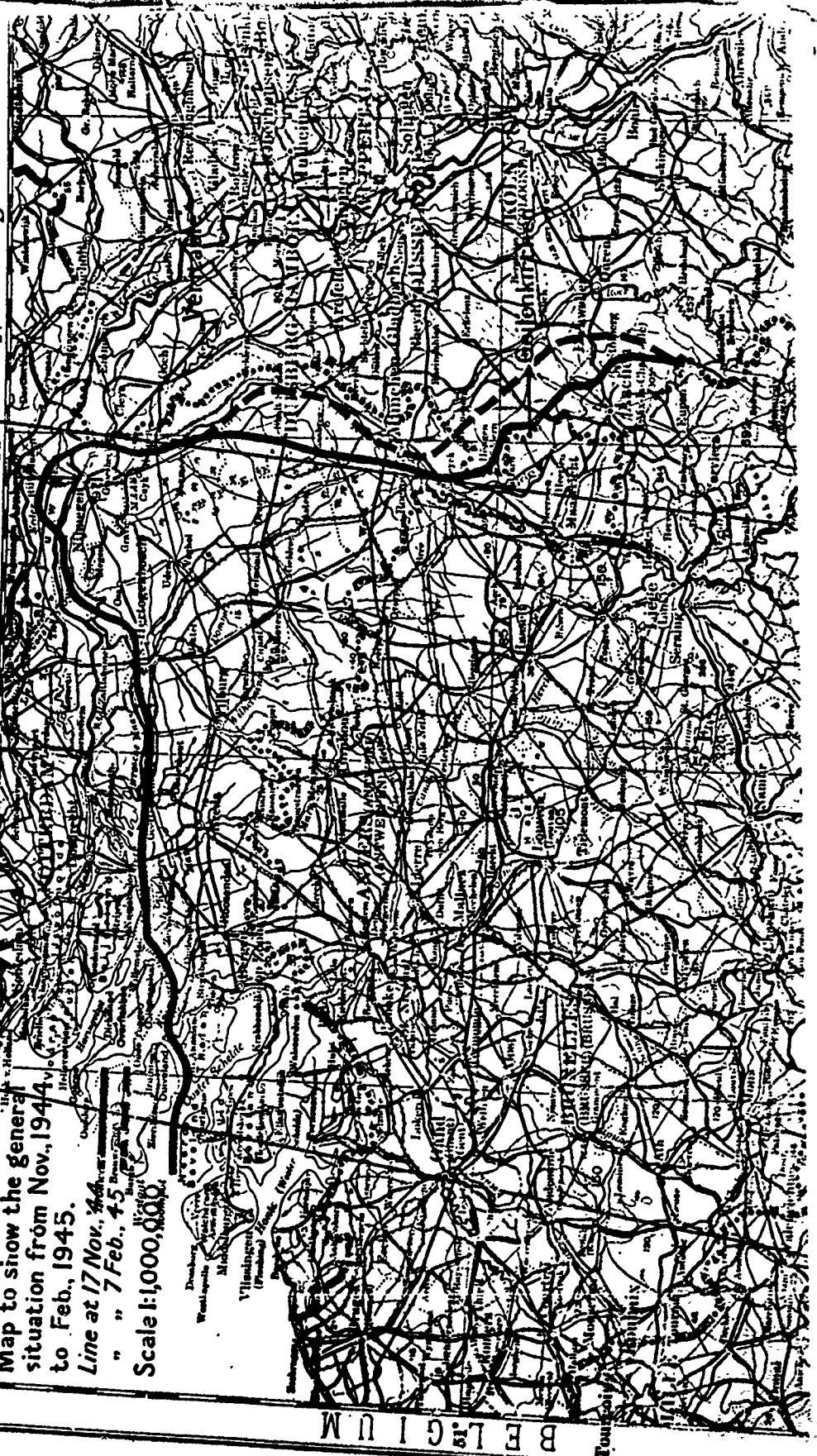
BRUXELLES - W. (BRUSSELS)

7° W. (DEC. 1943)

Map to show the general
situation from Nov., 1944,
to Feb., 1945.

Line at 17 Nov. 44.
" " 7 Feb. 45.

Scale 1:1,000,000.



BELGIUM

REPORT NO. 26.

FIRE SUPPORT IN OPERATION VERITABLE - EFFECT ON FORWARD DEFENSIVE POSITIONS.Summary of main conclusions.

1. A density of 650 - 1300 Field and Medium shells per kilometre square succeeded in cutting all the line communications in the forward defences. (para 15)
2. A density of about 650 Field and Medium shells an hour per map square, or 1 - 2 shells every minute within 200 yards seems to have been enough to keep officers and everyone else firmly in their shelters. (para 17)
3. A density of about 2600 shells an hour per map square or about 6 a minute within 200 yards seems to have been enough to neutralise the quality of troops in these defences. (para 18)
4. There is an indication that our own casualties do not fall much with weights of fire of over 100 tons per kilometre map square put on the enemy. (para 26)
5. There is an indication that numbers of shells are more important than sheer weight of shell, and that pepperpots are therefore a most valuable way of increasing fire effect without much increase in weight of ammunition. (paras 21 & 27)

INTRODUCTION.

1. In O.R.S. Report No. 22, "The Effect of Artillery fire on enemy forward defensive positions in the attack on GEILENKIRCHEN", we explained that the object of such investigations is to discover how different weights and durations of fire affected enemy resistance, the ultimate aim being to provide some definite figures on the amount of fire needed against enemy troops of different qualities in different types of defensive positions. Such information, if it could be obtained, would usefully supplement the practical experience which must be the main factor in planning any bombardment.
2. In the opening phase of Operation 'VERITABLE' we have considered both fire on forward defences and Counter-Battery. The latter is to be reported separately and it is enough to say here that it was conspicuously successful. Little enemy shellfire was experienced on the first day of VERITABLE and this incidentally has made it easier to assess the effect of fire on forward defences.
3. The investigation has involved computations from the fire plans, the interrogation of some 70 PW, discussion with units and formations and examination of the ground. All this has been made possible by the unstinted help and cooperation of 30 Corps.

OUTLINE OF THE ATTACK.

4. Before the attack the enemy held a slightly concave front from the RHINE to the MAAS. Between the RHINE and WYLER (7758), the ground was largely flooded and was only lightly held; this area was attacked separately by 3 Cdn Div. South of WYLER the front curved south and slightly west to the MAAS. On 8th February, 1945, 4 divisions attacked between WYLER and ORLÉANS (7652), with 51 (Highland) in the south, 53 (Welsh) and 15 (Scottish) in the centre, and 2 Cdn in the north. 10 battalions were involved in the first assault, and 2 more attacked later in the day. All were supported by tanks.
5. The area to be assaulted was bombarded by Field, Medium and Heavy artillery on a Corps plan from 0500 until 0920 hrs. At the same time the more forward defences were "peppered" with 4.2" mortar, 75 mm Sherman HE, 17 pr HE, 40 mm HE and HEAT. At 0920 a barrage of Field and Medium opened up and continued for about 6 hours, moving forward to cover the advances of 2 Cdn, 15 (Scottish) and 53 (Welsh) Divisions. In the case of 15 and 53 Divs, the divisional artilleries fired in addition a small amount after the barrage to cover the last stages of the advance. 51 (Highland) Div was not supported by a barrage but by a series of concentrations and strikes, which moved forward on a timed programme. The types and quantities of artillery employed are set out in Appendix B.
6. In the later stages of this first fire plan, areas further on were receiving preliminary bombardments, but the subsequent attacks we have not considered, since, as a result of the complete success of the first days battle, the enemy became so disorganised that it was impossible to determine what units were where, and therefore to estimate the potential strength of defences. In some instances our troops bumped large numbers of enemy, in others they went forward without firing a shot.

7. The battle as a whole has been studied by G (Ops) B 21 Army Group, and it is not proposed therefore to describe it in any further detail. The various parts of the first fire plan are shown on Map I and the general line of advance of the different battalions on Map II.

THE ENEMY: QUALITY, DISPOSITIONS AND DEFENCES.

8. The front was held entirely by 84 Division, a formation in every way typical of German second-class infantry. The division was well up to strength in men and material. If anything it was a little above average in the medical category of troops.

9. The disposition of units in the area of the attack is known fairly accurately, and is shown on Map II. It will be seen that in the first instance we attacked into 4 separate enemy battalions and met elements of 2 more battalions further back.

10. The defences encountered in the first drive were extensive, but not particularly strong; there was no concrete. Weapon pits and communication trenches were not usually covered in, but there were numerous roofed dugouts. There were many houses in the area, mostly isolated, the cellars of which had clearly been used as shelters, but had not been reinforced.

ENEMY CASUALTIES.

11. It has been possible to get details of 52 PW casualties passed through British divisional medical channels on the first day; of these 24 were attributed to shellfire. No figures are available for those passing through 2 Cdn Div and it is possible, though unlikely, that some enemy wounded were evacuated through their own channels during the bombardment, so that altogether there may perhaps have been double this number of PW casualties. Probably about one quarter as many as were wounded were killed, so that there may have been a total of 60 enemy casualties caused by shellfire. The number of enemy in the areas bombarded must have been at least equivalent to 5 or 6 battalions, that is 2250 - 2700 men, so that the casualties due to shellfire were about 2 - 3%.

12. PW evidence on casualties is often contradictory, but in this case almost all confirmed the above finding and said that their losses were slight. It is evident that the casualties, in themselves, were not very important.

DISORGANISATION BY LINE-CUTTING.

13. All PW, including a number of signallers, confirmed that line communications were cut throughout the preliminary bombardment area within 1 - 2 hours of the start of the shelling. This gives a figure of 650 - 1300 shells (25 pr and 5.5") per kilometre map square to effect complete line cutting in areas of fairly elaborate earthwork defenses. As far as could be seen, line was laid on the ground, or supported on trees and was not dug in.

MORALE EFFECTS.

14. Four degrees of severity of morale effect can be distinguished; they are:

- (i) to stop movement,
- (ii) to stop firing - neutralisation,
- (iii) to produce some sort of longer term neutralisation which persists for a time when firing has ceased,
- (iv) to produce a complete collapse.

From this operation there emerges a certain amount of information about each of these four.

STOPPING MOVEMENT.

17. Many PW said they received no orders from the moment the shelling started; officers said they were unable to get round to their troops. During the preliminary bombardment, in the areas further back, shells (again 25 pr and 5.5") were coming over on the average at the rate of about 650 per map square per hour, or 1-2 shells every minute within 200 yds; this seems to have been quite enough to keep officers and everyone else firmly in their dugouts. Further forward, in the pepperpot area, shells were coming over on the average at 4 times this rate.

Although in fact many different targets were engaged and re-engaged at different times, PW all seem to have been under the impression that they were shelled incessantly. For this reason we have taken, as a measure of the shelling, the weight or number of shells in a thousand metre map square. A smaller area would mean correspondingly fewer shells or smaller weights.

SHOOTING

OPERATION VERITABLE

FIXED FIRE PLAN OVERPRINT

ST DIV. TARGETS SHOWN IN RED (C)

H DIV. TARGETS SHOWN IN BLACK

W DIV. TARGETS SHOWN IN BLUE

SMoke SCREENS SHOWN IN GREEN

DESIGNATES CONCENTRATION OF PRELIMINARY

P

LEFT

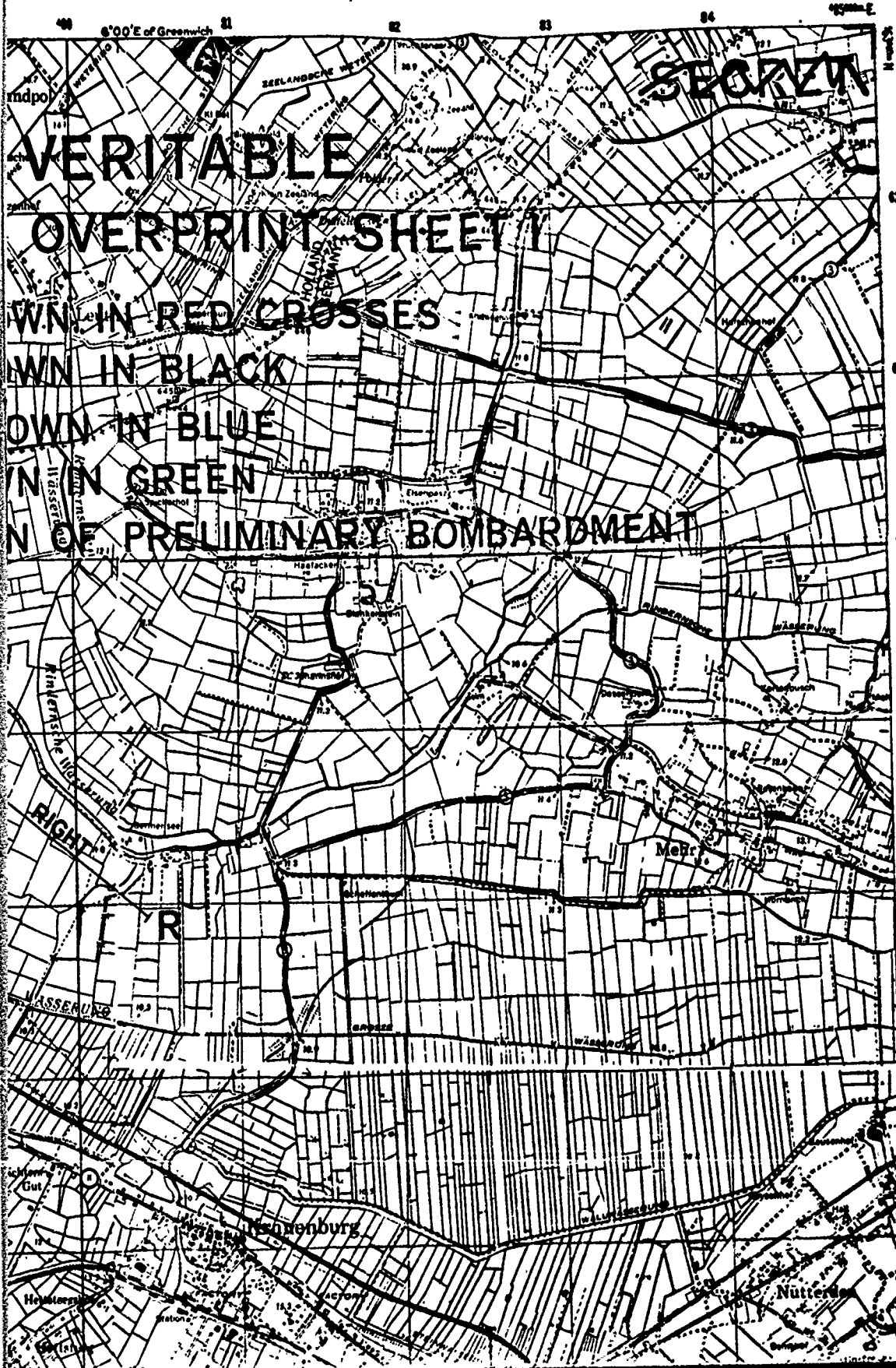
EDWARD

RIGHT

R

BELGIUM

HEIKANT



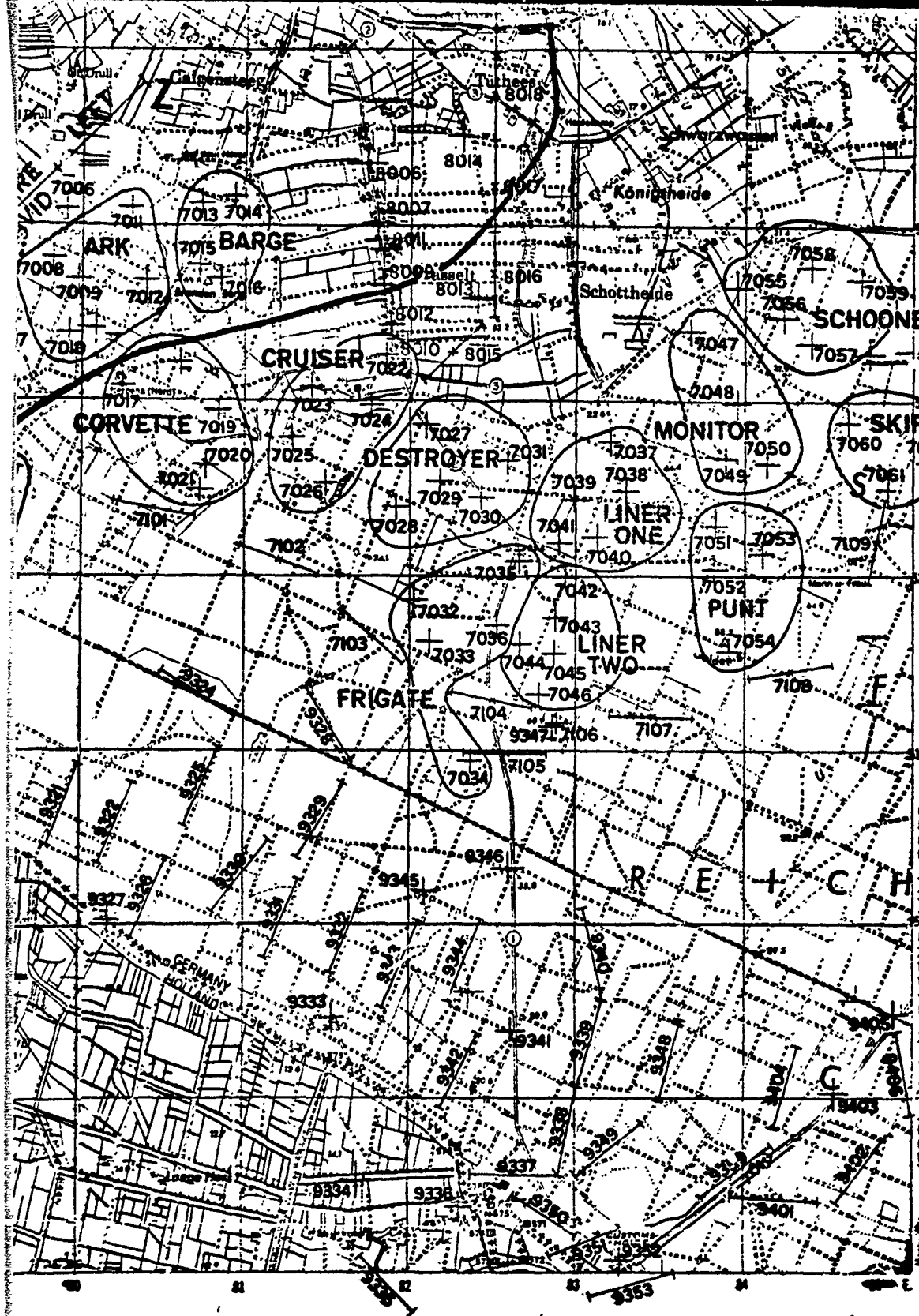
COMPOSIT



75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

E MAP

PARTS OF GSGS 4427 SHEETS 6SW, 12NW & 12SW.
GSGS 4414 SHEETS 4102 R, 4202



NEUTRALISATION.

18. On the evidence of PW and our own troops, there is little doubt that neutralisation was well effected at all times during the barrage (6500 shells an hour per map square) and at least in the most forward defences during the preliminary bombardment and pepperpot stage (2600 shells an hour per map square). A few enemy mortar crews however do claim to have fired a little during this latter period. Further back, out of range of the pepperpot, neutralisation may not have been effected, but there was little if anything which could in fact have reached far enough to fire back at this stage. It would seem that a rate of 2600 shells an hour per map square, or about 6-8 minute within 200 yards is enough to neutralise the quality of troops in these defences.

AFTER EFFECTS.

19. In this operation the after effect was certainly present and, when the fire support was followed up closely, the enemy surrendered at once. But the effect, as so often, was transitory. Three battalions got well behind the shelling for one reason or another and found the enemy recovering and beginning to resist.

COMPLETE COLLAPSE.

20. The complete collapse that occurred in the 43 Div attack at GELENKIRCHEN, in the village of BAUCHEN (O.N.S. Report 22) nowhere seems to have occurred in this operation. It is significant that PW did not speak of overwhelming casualties, which is often a psychological sign of breakdown.

21. BAUCHEN in fact received no greater weight of fire than several areas in this attack. It did however receive many more shells, the balance being made up by light stuff such as 3" mortar and 40 mm. It may be that number of shells is really the most important factor in this case. The defences at BAUCHEN were also considerably more open than in 'VERITABLE'.

REACTION TO SPECIAL WEAPONS.

22. Of all the 76 PW interrogated by us, none appear to have noticed either the Artillery Rockets or the Radio Proximity Airburst shells. Even an Artillery O.P., one L/Cpl. Hendig, who occupied a commanding position on the edge of the Reichswald and who was observing all the time, failed to notice anything unusual. It appeared that in the midst of the general unpleasantness caused by this bombardment, the particular properties of special weapons did not make any special impression. In the assessment in the next section we have not therefore differentiated rockets or airburst either in carrying at total weights or total numbers of shells.

THE SUCCESS OF THE FIRE SUPPORT.

23. The final test of the success of fire support is the extent to which it helped the Infantry; measuring this help however is difficult. We have taken casualties suffered by our own side as an indication of enemy resistance, although some at least must have been caused by guns outside the area of forward defences. In this operation however there was little shelling after the intense CB programme and it should not seriously affect the figures. Casualties due to mines have been excluded from the final figures.

24. The information we have obtained is given in the Appendix and the results are shown in two graphs, in one of which our casualties per enemy company attacked are shown for different weights of fire put on the enemy and in the other for different numbers of shells put on the enemy.

25. There are several points to notice in these two graphs:

(a) that the casualties, although showing a general trend to fall as the amount of supporting fire goes up, show a considerable variability. This is, of course, only to be expected in such a variable matter as war;

(b) that the casualties show a general agreement with those of the 43 Div attack at GELENKIRCHEN (ONS Report 22), although they tend to be somewhat higher. This again is to be expected in view of the better defences encountered in VERITABLE and the slightly higher quality of the defending troops;

(c) that battalions which got left well behind the barrage or concentrations had higher casualties, even though they had had very heavy weights of fire put down in front of them. This again is fully in keeping with normal experience.

Although in fact very different targets were engaged and re-engaged at different times, PW all seem to have been under the impression that they were shelled incessantly. For this reason we have taken, as a measure of the shelling, the weight or number of shells in a thousand metre map square. A smaller area would mean correspondingly fewer shells or smaller weights.

26. Further examination of the graphs show that although casualties drop as amounts of fire go up, they do not do so rapidly, and that for instance, 200 tons of fire per map square does not result in half the number of casualties that would have occurred with only 100 tons. There seems an indication in all the figures taken together that casualties fall fairly rapidly as weight of fire goes up to about 60 - 100 tons per kilometre square, but that there is no very noticeable decrease beyond 100 tons. This suggests that where ammunition is limited, shells that might be used to give greater weights than 60 - 100 tons per kilometre square would better be saved for another occasion.

27. The two graphs are based on two extremes, one by weight which takes no account of the number of 'bangs' and the other by number of shells which takes no account of weight of shell and, for instance, puts a Bofors and 5.5 shell equal. In spite of this, both graphs show the general tendency for casualties to fall with increasing amounts of fire; if anything Graph II, based on numbers of shells goes further to smoothing out the irregularities. In fact, the important feature in fire effect is clearly a combination of total weight and total numbers of shells, but the indication is that, at least up to a point, numbers of shells are more important than weight of shells. This suggests that the Peppercorns, which put down large numbers of light shells, were a most valuable means of increasing fire effect without a great increase in the weight of ammunition to be transported.

28. From the information collected it is not possible to draw any definite conclusions on the relative merits of the concentrations on the 51 (H) Div front, as opposed to the barrage on the other fronts. Although 2 of the 3 battalions in 51 Div did not fare as well as the majority elsewhere, this was probably because they were not as well up to the fire. It seems that the advantages of a quick follow up easily outweigh the advantages of one type of support as against another.

29. The initial assault must be reckoned as highly successful, in that elaborate defences were penetrated with small losses. This is without doubt to be attributed largely to the excellent fire support. In the first day of 'VERITABLE' we captured 1115 PW, for the loss of 459 of our own infantry or, excluding aines, 349. This gives a ratio of 2.4 : 1, or 3.2 : 1. The comparable figure for the first day at GEILENKIRCHEN was 3.9 : 1.

APPENDIX A APPENDIX SHOWING DETAILS OF BATTALION ATTACKS.

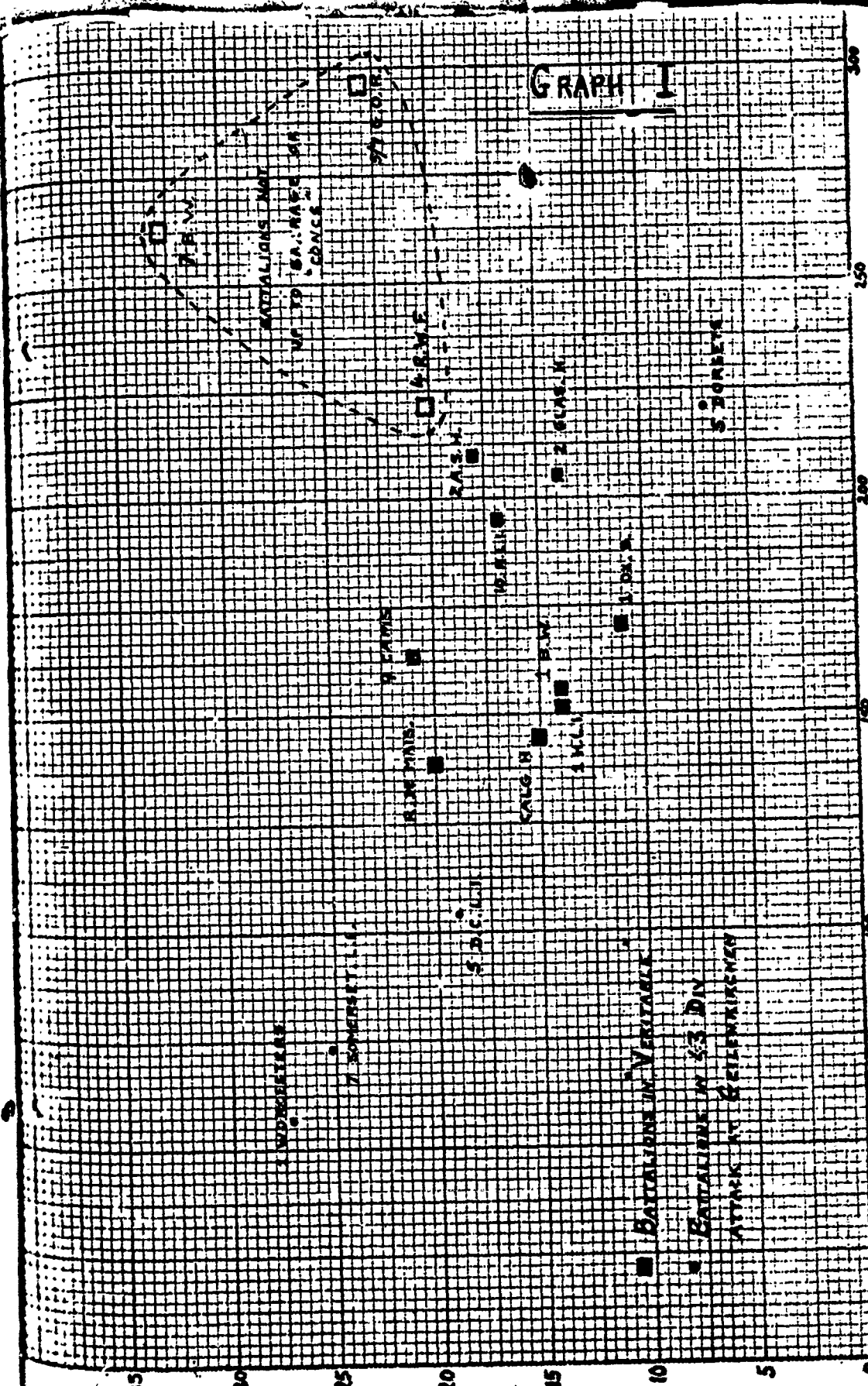
BATTALION	ENEMY	OWN TROOPS	AVERAGE HEIGHT OF FIRE IN FRONT OF BARRIERS PER 1000 H. SQ.	AVERAGE NO. OF SHEDS IN FRONT OF BARRIERS PER 1000 H. SQ.	TOTAL BN CAS (EXCL MINES)	NO. OF ENEMY COYS OR ENVI-LENT ATTACHED	CAS PER ENEMY COY ATTACHED
7 BLACK WATCH	Part of coy of 1/1222 lying forward, and part of a second coy lying back.	Difficult terrain, obstacles and some opposition slowed down advance, which got well behind artillery. As a result enemy recovered and resistance grew. As a result of 7 M attack being behind time, Bn started late and was not up to army. Considerable opposition encountered. Difficult terrain, but attack went as planned, without much opposition.	262	20,300	33	1	33
5/7 GORDONS	Part of coy 1/1222 lying back, and about one coy 1/1062. Latter had fought hard.		296	21,600	35	11	23
1 BLACK WATCH	Part of coy of 1/1222, and elements of 1/1062, probably a coy. 1/1222 had only moved in night before and still some tips of 1/1062 about. 1/1222 had not offered much opposition, 1/1062 however resisted rather more. Parts 2 & 3 coys 84 Fus Bn. P's strongly affected by arty and had fought very little. Parts 2 & 3 coys 84 Fus Bn. As for 1 H.L.I.		156	14,500	22	11	14
1 H.L.I.	Parts 1 & 3 coys 84 Fus Bn. P's strongly affected by arty and had fought very little. Parts 2 & 3 coys 84 Fus Bn. As for 1 H.L.I.	Attack went according to plan, and kept well up to barrage; very little opposition. Bn were popping up, and did not keep up to barrage. Encountered somewhat more opposition for this reason.	155	10,700	14	1	14
4 R.N.F.	Parts 1 & 3 coys 84 Fus Bn. P's strongly affected by arty and had fought very little. Parts 2 & 3 coys 84 Fus Bn. As for 1 H.L.I.	Attack went according to plan, and kept well up to barrage. Very little opposition.	202	17,000	30	1	20
1 OF 3 BUCKS L.I.	Parts 1 & 3 coys 84 Fus Bn. Otherwise as for 1 H.L.I.	Well up to barrage. Little opposition, but numerous 1/1000000 mines.	171	14,500	11	1	11
2 GILSON HIGHLANDERS	Part 2 coy 1/1051. Part 1 coy 84 Fus Bn and part 4 coy 84 Fus Bn. P's severely shaken and reported "green looking". Had remained in shelters till the last minute and fought very little.	Attack went according to plan, but with a certain amount of scattered opposition. Some 1/1000000 mines.	205	21,200	21	11	14
9 CAMEROUNS	Part 4 Coy 2 Bn 84 Fus Bn, elements of 4th and elements 1/1062. Some opposition from Bn latter.	Attack went according to plan and well up to barrage. Little opposition. Many 1/1000000 mines.	163	7,900	41	2	21
2 SOUTH 3 SURRELANDS	Parts 2 & 3 coys 1/1051, elements of 4th and elements 1/1062. P's severely shaken and "green looking".		211	15,700	16	24	18

BATTALION	ENEMY	OWN TROOPS	AVERAGE WEIGHT OF FIRE IN FRONT OF ENEMY PER 1000 M. S.	AVERAGE NO. OF SHELLS IN FRONT OF ENEMY PER 1000 M. S.	TOTAL IN CAS (EXCL. MINES)	NO. OF ENEMY COYS OR EQUIVALENT ATTACHED	CAS PER ENEMY COY ATTACHED
10 M.L.I.	Parts 1, 2 and 3 coys 1/1051, elements of artillery, and Regt H.Q., Def Pla, etc., of 1051.	Well up to barrage. Not much opposition. Many ./Personnel mines	196	11,600	42	24	17
Regiment de MINOISES	1 Coy 1/1051. Severely shaken and "green looking" then captured.	Attack went according to plan. Little opposition.	138	11,000	20	1	20
CALGARY HIGHlanders	11/1051. The very shaken and did not fight much.	Attack went according to plan in morning, but some opposition from south of WILKIN HILL. Attacked with further observed fire support in afternoon.	144	14,600	44	3	15

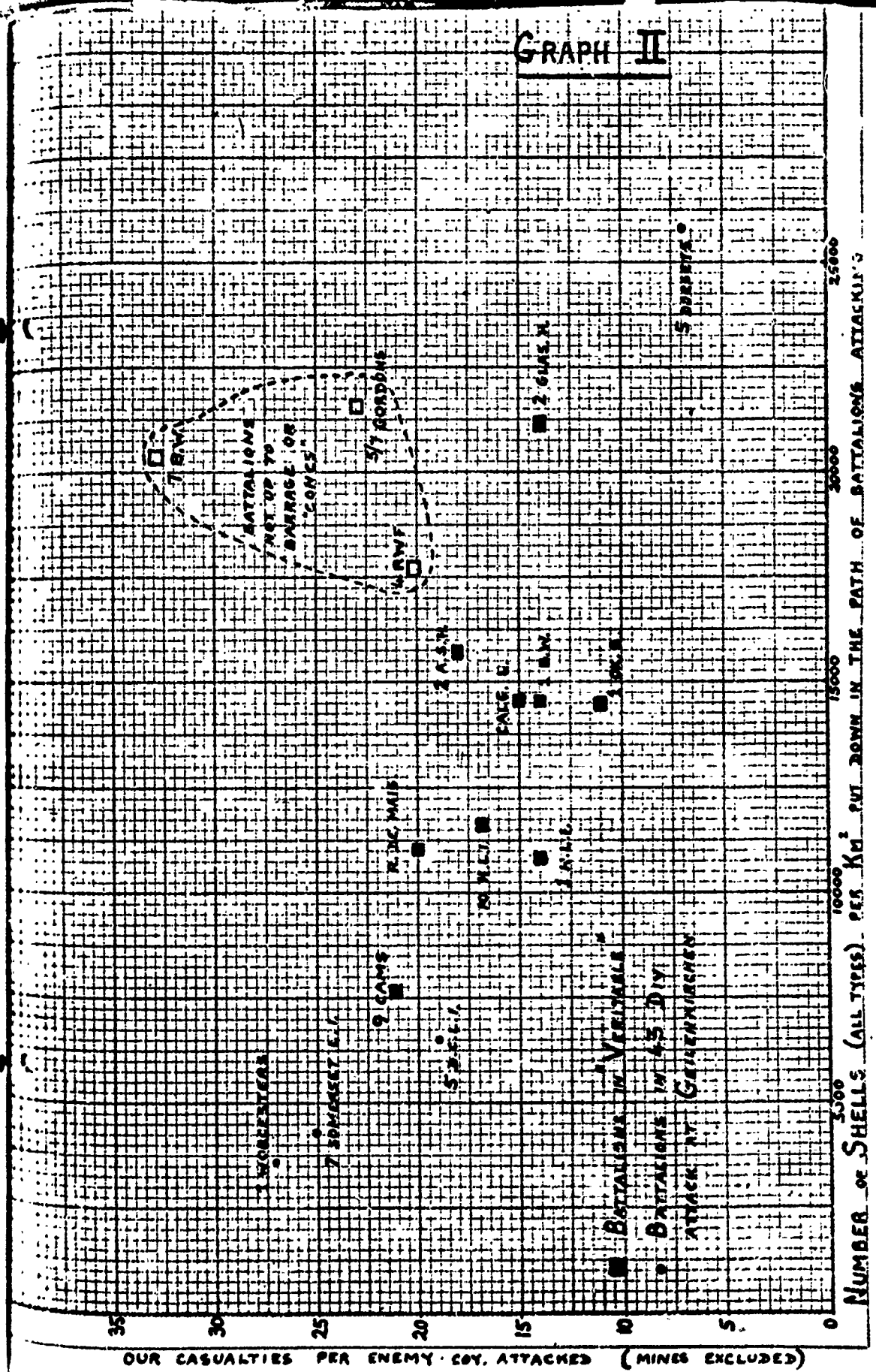
OUR CASUALTIES PER ENEMY COY. ATTACKED (MINES EXCLUDED)

GRAPH I

WEIGHT OF FIRE (ALL TYPES) IN TONS PER KM² PUT DOWN IN THE PATH OF BATTALIONS ATTACKING



GRAPH II



OUR CASUALTIES PER ENEMY COY. ATTACHED (MINES EXCLUDED)

NUMBER OF SHELLS (ALL TYPES) PER Kt² PUT DOWN IN THE PATH OF BATTALIONS' ATTACKING'

APPENDIX 3 - TYPES AND QUANTITIES OF ARTILLERY EMPLOYED.

1. (a) The operation was supported by a very great quantity of artillery, in all:-

	<u>Guns</u>
24 Fd Regts	576
20 Med Regts	320
3 H.A.A. Regts	72
19 Hvy Bys	76
1 Super Hvy Regt	6

Total: 1050

with 1 Rocket regt of 12 32-barrelled projectors.

- (b) In the preliminary "Pepperpot" these took part also:-

	<u>Guns</u>
40 mm Bofors	114
4.2 Mortars	80
75 mm Shermans	60
17 pr A/Tk guns	24
MMGs	188

2. The approximate totals of rounds fired in the phase under consideration were:-

- (a)
- Artillery.

	<u>Preliminary Corps Bombardment of whole area</u>	<u>Barrage 2 Cdn, 15(S) & 53 (W) Div Fronts</u>	<u>Concentration on 51(H) Div Front</u>
25 pr (Percussion)	58,680	129,406	33,672
25 pr (VT airburst)	1,200	-	-
3.7 in (Time fuse airburst)	8,760	-	7,776
3.7 in (VT airburst)	4,080	-	-
Rockets	5,730	-	-
5.5 in	10,016	30,382	12,648
7.2 in (Percussion)	2,360	-	233
7.2 in (Time fuse airburst)	432	-	-
8 in	24	-	-
240 mm	48	-	-
Total number of shells	91,330	160,388	54,329
Total weight (tons)	1,596	2,793	1,044

- (b)
- Pepperpot.

Type of ammunition:

40 mm HE	100,000
4.2 Mtr HE	24,000
75 mm HE	17,000
17 pr HE	4,000
MMG	2,000,000

Total number of shells (excluding
(MMG))

145,000

Total weight (tons)

520

MEMORANDUM NO. 7.

THE MORALE EFFECTS OF ARTILLERY.

1. We have now studied the morale effects of artillery in two operations: the attack at GEILENKIRCHEN and the assault between the RHINE and the MAAS. These reports, Nos. 22 and 26, are an attempt in a new direction, to get a scientific connection between the fire put down and the results achieved, and they go a little way, perhaps, towards settling matters which have been argued or suspected by gunners for a long time past. The following paragraphs by no means amount to solid proof: rather they contain the general indications of this study.

2. Because battles are complicated things, we simplified the issue as much as we could. We chose set piece attacks on well prepared field fortifications, held by second grade infantry and we reckoned, for battles dominated by artillery to the extent these were, that any differences in enemy resistance or our own troops' progress would be largely the result of differences in the type or amount of artillery support.

Weight of bombardment: our own casualties in the attack.

3. We have taken our own casualties in the attack as giving a rough indication of the strength of the enemy's resistance. The following table gives averages taken from all the battalions examined:

Weight of Bombardment in tons per km square	Average number of casualties per Bn for each enemy company attacked
50 - 100	26
100 - 150	18
150 - 200	15
Over 200	13

An interesting point arises here. What happens if this table is projected backwards towards nil fire support? Attacks on fixed defences without artillery support have succeeded by surprise, but are liable to be very expensive. Between weights of bombardment nil and 50-100 therefore casualties have dropped from some high figure down to 26, while between 50-100 up to over 200, they only drop a further 13.

There is evidently a law of diminishing returns in force.

4. Various reasons could be suggested for this: that the lesser weights produce very adequate neutralisation (the reports indicate that 50 tons per km square per hour is enough) which greater weights do not much increase, while they still do not reach the point at which the enemy collapses, or that the greater the weight the greater the scatter, with the result the infantry keep further from the main part of the bombardment or suffer occasional casualties from our own shells. Whatever may be the real reason, there seems little doubt that with the greater weights of fire, there is not the same return for the ammunition expended (with one proviso to be mentioned later).

Intensity of bombardment and duration: complete collapse.

5. Although the weights put down in the two separate battles were of much the same order, the way they were put down was very different. At GEILENKIRCHEN, with one exception, all the bombardments were put down at a very great intensity (100 - 200 tons per km square per hour), but lasting only about half an hour. In the RHINE - MAAS attack the same sort of weights were put down much more slowly over 8 or more hours. Nevertheless the results in both cases were comparable.

6. There was however one exception - the bombardment of the village of SAUCHEN in the attack at GEILENKIRCHEN, which lasted nearly 4 hours at a rate of 60 tons per km square per hour. This bombardment alone seems to have had a quite exceptional effect in paralysing the enemy and reducing resistance. It is significant that this bombardment was of comparable duration and intensity to the other bombardments which produced a shattering of morale - VILLERIEUX in the last war and the FINIS break-through in this war.

7. These points are not as clear as they might seem at first sight. It has been put forward by psychologists and is confirmed by gunners that small intensities of fire are liable not to have an accumulative effect. The enemy may get accustomed to it. On the other hand a complete collapse of morale takes some time to develop and cannot be achieved in say half an hour by even the most intense bombardment. In fact, there is an optimum

intensity and duration of fire and it seems that this optimum intensity is around 50 - 60 tons per km square per hour, and the optimum duration round 3-4 hours. Anything other than this, if it produces a collapse at all, can only do it with more total expenditure of ammunition.

Types of Fuse: Large and small shells: Pepperpots.

8. So far we have talked of bombardment only in terms of weight, which, though a useful simplification, is hardly the whole story. There is first of all the type of fuzing. For clearly not even the greatest weights of airburst on troops with adequate head cover, or of 25 pr D.A. on troops deeply dug in, will have much prolonged morale effect, although of course it may neutralise and impede movement and communications. In the two battles we have studied the right sort of fuzing was being used and in generalising about artillery we must suppose that this is always the case.

9. Secondly, there is the question of numbers of shells as opposed to sheer weight - the age old argument in another form of Field versus Medium artillery. There are a lot of jobs where the heavier shells are essential, either because of their greater range or greater penetrative and explosive powers. But where lighter stuff can reach, and is capable of hurting the enemy, the evidence of these two reports seems to be that the thing that counts most of all is the number of bangs. Clearly one 100 lb shell is better than one 25 pr one. It is on the other hand very questionable whether it is 4 times better. It is for this reason that Pepperpots as practised by several Corps are so successful. For a given weight of ammunition they put down a phenomenal number of bangs.

Closeness to the barrage.

10. The great importance of keeping close to barrage or concentrations has always been realised. There is an indication in these reports that falling half an hour or so behind is equivalent to cutting down the weight of the bombardment four or five times, and perhaps more.

11. How much it matters falling say 5 or 10 minutes behind cannot be told, but at least it can be said that keeping within a minute or two of the barrage instead of within 5 or 10 minutes must be worth quite a lot of extra fire power. Unfortunately with the huge predicted fire concentrations on a timed programme so often employed nowadays, it is our impression that the infantry are of necessity 5 or 10 minutes and often more behind and the value of such huge weights is therefore in considerable measure wasted.

Application on a small scale as well as on a large.

12. We have talked throughout of weights of fire in terms of tons per kilometre square, giving the impression that all these conclusions hold only for huge bombardments. There is no reason why this should be so. 50 tons per kilometre square represents for instance only about 200 25 pr shells per 200 metre square, which can be readily put down by a battery or a troop using observed fire. It should be remembered that if this sort of density is wanted at the centre of a predicted fire concentration, it will need perhaps 6 times as many rounds, for they cannot accurately be dropped within a 200 metre square.

CHAPTER 9.

- ARTILLERY IN THE ASSAULT ON THE BEACHES.

CONTENTS

Self Propelled Artillery in the Assault on the Beaches
(Report No. 1)

Employment of Royal Marine Artillery in Operation
NEPTUNE (Report No. 2)

REPORT NO. 1.SELF-PROPELLED ARTILLERY IN THE ASSAULT ON THE BEACHES.3 Cdn Inf Div Sector.OPERATION NEPTUNECONCLUSIONS.

1. The S.P. artillery on the 3 Cdn Inf Div sector followed the procedure laid down in their "The Use of S.P. Artillery in Support of a Beach Assault". The drill was found to be satisfactory and no amendments are considered warranted.
2. In general regimental fire fell in an area 400 to 700 yds wide and 400 to 600 yds deep measured from the forward line of enemy defences.
3. The maximum crater density in every case was plus of the target from 100 to 200 yds, and within 200 yds of being correct for line.
4. Correction of the fall of shot was apparently carried out by observing the effect on buildings in rear of the defences. These were extensively damaged showing shell holes through the walls above the first floor and through the roofs in many cases.
5. No serious damage was done to any of the defences by S.P. artillery fire. Communication trenches were collapsed in several cases but this did not effect enemy fire power.
6. The degree of neutralisation achieved was extremely difficult to assess. In general, German defences were constructed to provide a relatively narrow arc of fire, mutually supporting between strong points, along the beach. Very few weapons were capable of firing directly seaward. It is therefore not clear whether fire was held due to neutralisation or because weapons would not bear. In no case was there evidence that fragments from S.P. artillery shells had penetrated the defences through the embrasures.
7. Mortar emplacements were of concrete and built flush with the ground with a minimum sized aperture through which the weapon was fired. To achieve neutralisation it was therefore necessary for fragments to strike down through the opening with lethal effect or to depend on a direct hit. There was no evidence that either of these possibilities had occurred.
8. The German troops opposing the landing were members of 716 Div, consisting of category and over and under age troops with a foreign element of 15% to 20%, and with M.C.O.s from other theatres sent to Normandy for rest. As a consequence a greater degree of neutralisation may have been achieved than would have been the case had more resolute troops manned the defences.
9. It is safe to say that a degree of neutralisation was achieved, as there were several instances of weapons which had ample ammunition and had not been fired. No individual element of the fire plan can be said to have had a material effect, but the S.P. artillery in contributing to the cumulative effort which did produce a degree of neutralisation, performed a most useful role.

GENERAL.

Information has been gathered from the source indicated as to the effect of S.P. Artillery in the assault during Operation Neptune. This investigation has been confined to the 3 Cdn Inf Div Sector as being representative of the S.P. operation. The target areas were visited and the effects of the fire assessed. Owing to the elapsed time, the type of fire, the nature of the target area, and the fact that certain sections of it had not been cleared of mines when the examination was made, it was difficult to fix the Mean Point of Impact and to determine accurately the fall of shot in each case. However, it is felt that the views expressed are approximately correct and a sufficiently firm basis for appraising the effect of S.P. fire in an assault of this nature. Certain opinions are included, representing the views of the officers quoted only, which may be of interest in future planning.

The drill employed was that developed by the 3 Cdn Inf Div and opinion was unanimous that this was sound and would be difficult to improve.

For Regiments in this area the O.O. called for ranging to commence at 10,000 yds approx. H - 35, and fire for effect at 9,000 yds approx H - 30, continuing to the touchdown of L.C.A. at H + 5 or when within 1,500 yds of the beach, whichever was the earlier.

DESCRIPTION OF THE ASSAULT AND ITS EFFECT BY S.P. ARTILLERY REGTS.

The following section describes the individual procedure followed by S.P. Artillery Regiments in the assault as obtained from the officer indicated, together with an appraisal of the result achieved as disclosed by a study of the regimental assault area.

12 Fd S.P. Regt RCA-

Beach:	MIKE RED.
Section:	7 Cdn Inf Bde
Centre of Target:	965858
Nature of Target:	4 x 75 mm guns

FOO - Major B.M.R.D., 2 i/c 12 Fd S.P. Regt. R.C.A.

1. Ranging was commenced at H-35 and 10,600 yds. The Mean Point of Impact was reported on the target by the FOO and fire for effect was opened at H-32 at 9600 yds, and continued with one correction of 2° to 1500 yds at H + 7, when ammunition was expended. Approximately 100 r.p.g. were fired from 24 guns. Craft then circled out. The shoot was considered to be the best ever conducted by the regiment in this type of operation. One German 75 mm gun and MGs on left flank were considered silenced. The rounds fell in an area estimated to be 400-600 yds wide and 600 yds in depth.
2. Seasickness was experienced by 10% of personnel but had no effect on servicing the guns.
3. Regimental salvo ranging would have been of value in distinguishing artillery fire from other bombardment.
4. Coloured smoke would have been of value in separating fire of adjacent regiments.
5. The FOO party should not have been placed in the bow of LCA. Two FOO parties were lost through LCAs hitting mines.
6. There was no close support bombing from H-30 to H-15.
7. Rockets were late and fired to the left of the target. Rockets should have been ahead of S.P. artillery, under control of and deployed by SMO in ML to afford maximum value.
8. The hedgerows were not observed in action but they passed S.P. artillery around H:15 in some confusion.
9. There was not sufficient liaison between the flails and S.P. artillery.
10. The urgency of getting S.P. artillery ashore and into action was not sufficiently appreciated. All guns were not ashore until H + 7 hours.
11. Communications were extremely good and no breakdown occurred.
12. Infantry casualties would have been greatly reduced had other supporting weapons been able to conform to the timings of the fire plan.
13. The operation was sound in plan but owing to the weather, DD Sherman tanks, rockets, AVREs, and Marine Artillery were late.

Effect of fire from ground study.

1. It was particularly difficult to assess the fall of shot in this area as the terrain is sand with few buildings and the entire area is occupied by bivouaced troops who have obliterated all evidence of shell craters. Further, certain areas had not been cleared of mines and could only be examined with binoculars.
2. All buildings in the area show the effect of shell fire with large holes in the outer walls and internal walls and flooring had collapsed.
3. No damage was done to any of the concrete defensive positions, although communication trenches had been collapsed in some places from shell fire. There was evidence of S.P. fire having struck the masonry sea wall in several places.
4. The maximum crater density is estimated to have been approximately 200 yds plus of the target and 100 yds to 200 yds east for line. The area in which rounds fell was estimated to be 500 yds wide and 400 yds deep measured from the line of defences. It was impossible to appraise rounds landing on the beach owing to the elapsed time.

5. The claim of the FCO that HQs and a 75 mm gun were silenced appears optimistic although the crews may have been neutralised, but this appeared unlikely.

13 Fd S.P. Regt R.C.A.

Beach:	MAN GREEN
Sector:	7 Cdn Inf Bde
Centre of Target:	972856
Nature of Target:	Strong Point 972857; 4 x 75 mm guns.

FOO-Major GOLDIE, 2 i/c 13 Fd S.P. Regt R.C.A.
 Bn H.Q. - Lt.-Col. WEBB, C.O. 13 Fd S.P. Regt R.C.A.

1. Fire was opened with troop smoke salvoes at 9700, 10,000, 10,300, and 10,600 yds. Rounds at 10,000 yds landed on shore at H-35. Approximately 100 r.p.g. were fired from 24 guns until within 1800 yds of the beach, when the Navy stopped fire in order to circle out. The Mean Point of Impact was considered to be a little plus of the target. The shoot was considered to be the best ever conducted by the Regt. A 75 mm gun was claimed to have been put out of action.

2. The sea was rougher than had ever been experienced and seasickness was a considerable factor, rendering the briefing of personnel extremely difficult.

3. There was no apparent aerial bombardment although visibility was bad and bombs may have landed inland.

4. Rockets were late but fired landing well inland.

5. The hedgerows worked well but the effect on targets could not be seen.

6. The infantry were behind time and were approximately 1,000 yds from the shore when firing stopped.

7. Communications worked well and no breakdown was experienced.

8. Infantry casualties would have been greatly reduced if the infantry had touched down on time and DD tanks, Air Force, Rockets, AVREs, and Marine Artillery had arrived as scheduled.

9. Guns landed at H + 75 and went into action on the beach firing link shoots on call for F.O.Os.

10. The planning and conduct of the operation was considered excellent.

Effect of fire from ground study.

1. Approximately 90% of the buildings were destroyed along the sea wall and to a depth of 200 yds and the remainder of the town was severely damaged to a depth of 600 yds with 30 to 40% of the buildings affected. The buildings were of brick and masonry construction with tile or slate roof. The outer bearing walls were from 18" to 24" thick offering little resistance to shell fire. The inner curtain walls were of lath and plaster with negligible resistance to shell and SA fire. In most cases the inner fabric of the building had collapsed in whole or in part. The destruction was such that snipers would have been forced to evacuate buildings during the bombardment although the ruins would subsequently offer some cover and protection. There was no evidence of concrete reinforcement of the buildings.

2. The adjustment of Mean Point of Impact was evidently carried out by observing the effect of shot on buildings. Numerous instances of buildings being hit by S.P. fire high up and on the roofs were noted. The maximum crater density was estimated to have been approximately 200 yds plus of the target and correct for line. The area in which rounds fell was estimated to be 500 yds wide and 600 yds deep measured from the line of defences. It was impossible to appraise rounds landing on the beach owing to the elapsed time.

3. No damage was done to any of the concrete fortifications or communication trenches and there is no evidence of the S.P. artillery having caused any casualties, although some degree of neutralisation was undoubtedly achieved and snipers positions in buildings were rendered untenable. The gun claimed as put out of action was apparently damaged by a DD tank, since the shell in question was of A.P. type fired from the shore.

14 Fd S.P. Regt. R.C.A.

Beach:	MAN WHITE
Sector:	8 Cdn Inf Bde
Centre of Target:	997855
Nature of Target:	Strong Point 997855.

FOO - Major DOOGOD, 14 S.P. Fd Regt. R.C.A.
 Acting C.O. - Major YOUNG, 14 S.P. Fd Regt. R.C.A.

1. Ranging was begun at 10,000 yds and H-40 and was directed at the junction of sea wall and beach. Two salvos were observed as minus and the third as plus. Fire for effect was begun at H-35. The tide carried craft to the left requiring a change of course. Approximately 80 r.p.g. were fired from 24 guns, and fire was stopped 4000 yds from the beach due to notification of a postponement of H hour not being received. When it was received craft had started to circle out and it was too late to reform. The Mach Point of Impact was estimated by Major DOOGOD to be 100 to 200 yds to the left and just plus, the rounds falling in an area 400 to 600 yds wide by 400 yds deep.
2. The beach depth was only 100 yds instead of 300 and fire could not have been continued to touchdown of infantry without inflicting casualties on our own troops.
3. The Air Force did no bombing.
4. Communications on the whole were good. A breakdown did occur between two 68-R sets and messages had to be passed through a troop. Fire could have been maintained longer as the acting CO of the S.P. Regt was with the Bn Comd and could have adjusted the timings. An extra 509 set or 19 set, as mounted in HL, would have been of value in order to reach FOO.
5. Experience showed that two FOOs were definitely required.
6. The tent wire device for measuring progress of LCTs performed excellently.
7. The drill was soundly founded and could not be improved.

Effect of fire from ground study.

1. The buildings in BERNIERES-SUR-MER are similar to those at COURSEILLES-SUR-MER, although more widely dispersed in the immediate coast area. Approximately 90% were destroyed in the first row of buildings and the remainder of the town was severely damaged, with 30 to 40% of the buildings hit to a depth of 400 yds.
2. There was no evidence of concrete reinforcements of the buildings.
3. The maximum crater density was apparently east of the target and 100 yds plus. The area in which rounds fell was estimated to be 700 yds wide and 500 yds deep measured from the forward line of defences. It was impossible to appraise rounds landing on the beach owing to the elapsed time.
4. No damage was done to any of the defensive positions or communication trenches as the fire landed well plus and its effect in the defence area was not great.

19 Fd S.P. Regt R.C.A.

Beach:	MAN RED
Sectors:	8 Cdn Inf Bde
Centre of Target:	014850
Nature of Target:	1 x 75 at 014852
	1 x 75 at 015845
	Strong Point at 014851

FOO - Major PEENE, 2 i/o 19 Fd S.P. Regt R.C.A.

1. Fire was opened at H-35 at 1000 yds east of target due to the course being set on steeples of church in LANORUNE. Approximately 30 r.p.g. were fired, rounds falling in the area 082347 and starting three fires. The course was altered and, after dropping range twice by 400 yds, fire was reported on the target by the FOO. Approximately 100 r.p.g. were fired from 24 guns and fire was stopped at 2500 yds on orders reputedly from the FOO. The FOO did not send this order but fire would in any case have had to cease due to congestion on the beach. The HPI was estimated to be 200 yds plus of the target and rounds fell in an area approximately 600 yds wide by 300 to 400 yds deep.
2. The artillery bombardment went according to plan.
3. The Navy landed S.P.s 300 to 400 yds east of scheduled position which made it difficult to get off the small beach. Severe mortar fire put three guns out of action.
4. Communications by 509 set from HL to FOO were good. Control to guns by 68R failed but this was replaced by a spare 68R set without interruption to communications.

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permit fully legible reproduction.

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5. Artillery could have debarked at H + 120 as no fire was called for by FOOs for 3 hours.
6. The area was considered effectively neutralised.

FOO, Major STROMMICH, 19 Fd S.P. Regt., A.C.A.

1. The FOO was in agreement with the F.O.C.
2. The procedure laid down by 3 Cdn Inf Div was followed exactly except that the spare FOO was given a 509 set.
3. No casualties were caused to the enemy but some neutralisation was achieved.
4. Practically the only fire received by the town was from S.P. artillery.
5. Two thirds of the Air Force bombs landed in the sea. One third was well concentrated on the target area.
6. Two rocket craft fired, rockets landing 500 yds west of target area.

Effect of fire from ground study.

1. The buildings in ST RUBIN are similar to those in COURSEULLES although more compactly built along the sea wall. Approximately 90% of the buildings in the front row were destroyed and the remainder of the town was heavily damaged with 30 to 40% of the buildings affected.
2. The maximum crater density was again plus of the target on estimated 200 yds. Rounds fell over an extremely large area approximately 700 yds wide and 300 yds deep measured from the forward line of defences. Fire had apparently been corrected by the effect on buildings.
3. There was no evidence of concrete reinforcement in any of the buildings although in two places sandbags had been placed inside buildings to give protection for snipers. Slots for snipers had also been cut beneath window sashes at floor level on the first floor so as to conform with the general appearance of the buildings. These buildings had all been destroyed apparently by S.P. fire.
4. No damage was done to any of the defensive system. The fire in general landed well plus and its maximum effect was not developed in the defence area.

DISCUSSION OF OBSERVATIONS.

1. In general the Germans depended on massive reinforced concrete fortifications connected by communication trench systems with elaborate living quarters. Concrete varied in thickness from 3 to 7 ft, was of good quality, simply reinforced, with a low silhouette and camouflaged to conform with the general character of the locality. Coast defence systems were not in depth but were rather a fringe along the sea wall.

Communication trenches were unlined and at least 6 feet deep with occasional concrete bays roofed with a 9-inch concrete slab. Gun firing positions were mutually supporting with comparatively narrow arcs of fire, sited to bring fire on the beach. Relatively few guns were capable of firing directly seaward because of massive concrete protection against frontal fire. Weapon slits were of minimum size.

Mortar emplacements were also heavily constructed of concrete with the mortar, magazine and living quarters an integral unit. The aperture through which the weapon fired was 3 to 5 feet in diameter and flush with the ground.

There was no evidence of any of the hastily constructed defences having been used. In many cases they were overgrown with vegetation suggesting that they had not been occupied for some time.

The problem of neutralisation of these types of defences by orthodox methods is extremely difficult because in the case of guns and MCs the emplacements are to the side or rear with a heavy buttress to the sea front to direct hits and fragments.

Defending personnel are therefore vulnerable only to those rounds which fall to one side of the position and slightly short for range, because of the pattern of fragments from a bursting shell. The fact that guns were not distributed in depth made the required zone for lethality very narrow and required the Mean Point of Impact to be definitely on the defences to obtain any substantial degree of neutralisation against passive troops. The likelihood of seriously affecting crews or troops in mortar positions depended on fragments falling with lethal effect through the weapon apertures or on a direct hit through the apertures or on a direct hit through the aperture. The chance was therefore small.

In no case were the defences apparently affected by S.P. fire. Naval fire was also ineffective and in only one or two cases were positions seriously damaged.

The defences were overcome by DD tanks, engineer, and infantry assault. The degree of neutralisation actually achieved is difficult to assess because of the method of siting guns to enfilade the beach area only. As few guns could fire to seaward it is difficult to say whether the delay of the enemy in opening fire was due to neutralisation or to the fact that guns would not bear. In any event the defences were substantially intact when the infantry touched down and the enemy were able to deliver lethal fire in great quantity against our troops.

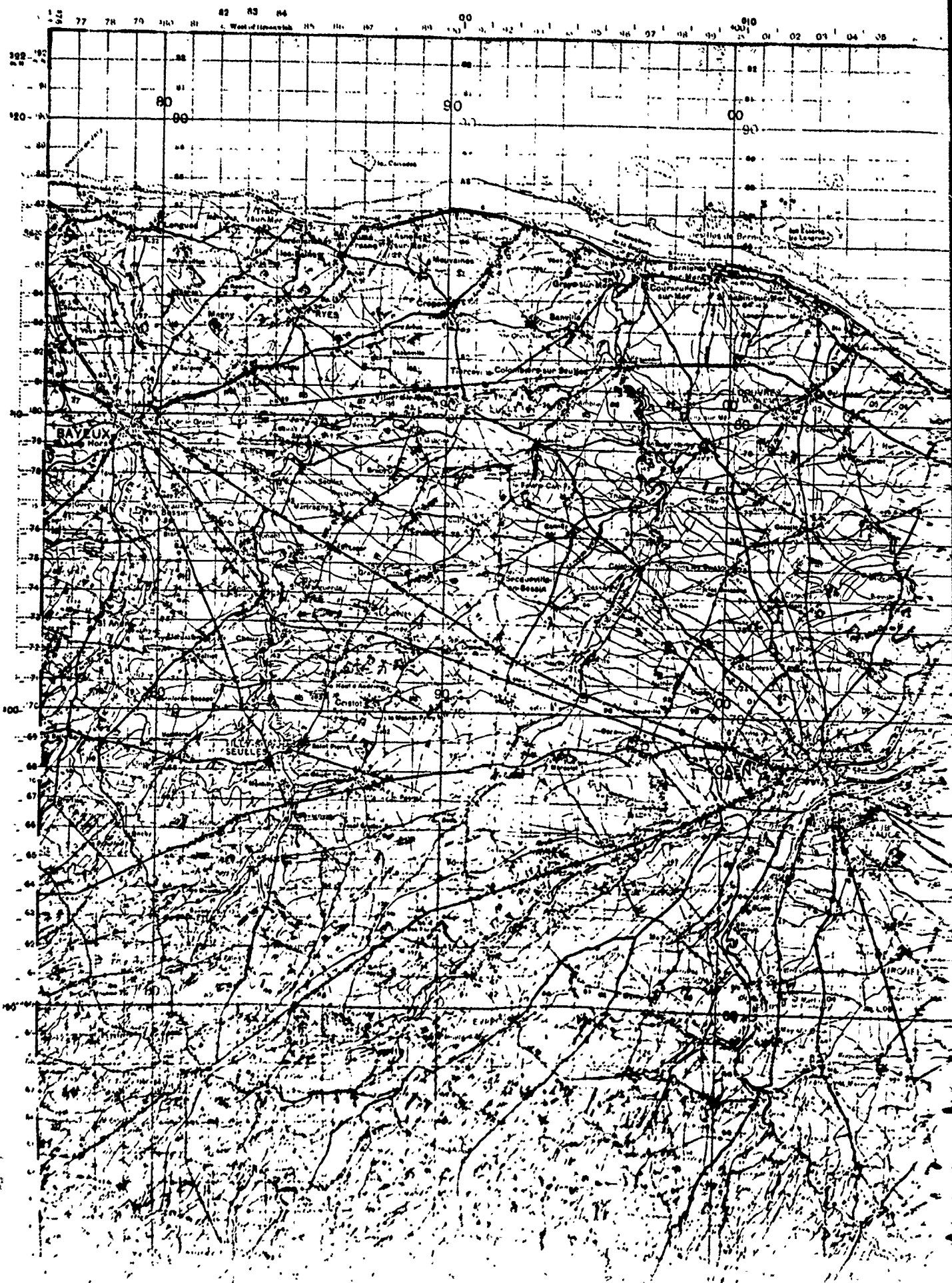
While it is apparently possible to say in this Sector that aerial bombing was ineffective, that Naval bombardment achieved little success, that rockets and S.P. artillery landed plus of the target, it is certain that considerable effect was achieved and it is difficult to say if any of the programme could be eliminated.

2. The enemy troops occupying these defences were members of the 716 Div which is understood to have been largely composed of category troops with a large foreign element of up to 15 to 20%. The NCOs are understood to have been veterans from other theatres sent to this sector for rest. Several instances of officers fleeing in civilian clothes are reported. Weapons were discovered with plentiful stocks of ammunition which had not been fired. Other weapons had put up only token resistance. However, many of the positions had been defended to the last.

From these reported facts it would appear that morale was bad. It is felt that the laxness of the defences and living quarters generally could not have failed to engender to some extent a Maginot line complex because of the apparent immunity from successful attack.

Apparently the Germans expected a prolonged bombardment for several days during which the massive fortifications could have been justified and then an assault, by which time reinforcements would have been available to meet it.

The degree to which S.P. fire neutralised snipers in buildings is unknown. If snipers were in the buildings during the bombardment undoubtedly a number were forced to retire. It is probable that snipers did not exist in numbers until street fighting started and very few of the buildings appeared to have been used, although two or three had sandbag reinforcements to provide additional safety.



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(FIRST EDITION)

Glossary

Deserting routes on the map have generally been single-lane gravel where they have part of a gravel road.

Age	Address	City	State	Zip	Phone	Occupation	Religion	Marital Status	Children	Spouse	Parents	Other	Notes
10	1000 Main St	Springfield	MA	01103	555-1234	Student	Catholic	Single	1	John	John	John	
11	200 Elm St	Springfield	MA	01103	555-2345	Student	Protestant	Single	0	John	John	John	
12	300 Oak St	Springfield	MA	01103	555-3456	Student	Jewish	Single	0	John	John	John	
13	400 Pine St	Springfield	MA	01103	555-4567	Student	Muslim	Single	0	John	John	John	
14	500 Birch St	Springfield	MA	01103	555-5678	Student	Hindu	Single	0	John	John	John	
15	600 Cedar St	Springfield	MA	01103	555-6789	Student	Buddhist	Single	0	John	John	John	
16	700 Elm St	Springfield	MA	01103	555-7890	Student	Sikh	Single	0	John	John	John	
17	800 Oak St	Springfield	MA	01103	555-8901	Student	Other	Single	0	John	John	John	
18	900 Pine St	Springfield	MA	01103	555-9012	Student	Other	Single	0	John	John	John	
19	1000 Birch St	Springfield	MA	01103	555-0123	Student	Other	Single	0	John	John	John	
20	1100 Cedar St	Springfield	MA	01103	555-1234	Student	Other	Single	0	John	John	John	
21	1200 Elm St	Springfield	MA	01103	555-2345	Student	Other	Single	0	John	John	John	
22	1300 Oak St	Springfield	MA	01103	555-3456	Student	Other	Single	0	John	John	John	
23	1400 Pine St	Springfield	MA	01103	555-4567	Student	Other	Single	0	John	John	John	
24	1500 Birch St	Springfield	MA	01103	555-5678	Student	Other	Single	0	John	John	John	
25	1600 Cedar St	Springfield	MA	01103	555-6789	Student	Other	Single	0	John	John	John	
26	1700 Elm St	Springfield	MA	01103	555-7890	Student	Other	Single	0	John	John	John	
27	1800 Oak St	Springfield	MA	01103	555-8901	Student	Other	Single	0	John	John	John	
28	1900 Pine St	Springfield	MA	01103	555-9012	Student	Other	Single	0	John	John	John	
29	2000 Birch St	Springfield	MA	01103	555-0123	Student	Other	Single	0	John	John	John	
30	2100 Cedar St	Springfield	MA	01103	555-1234	Student	Other	Single	0	John	John	John	
31	2200 Elm St	Springfield	MA	01103	555-2345	Student	Other	Single	0	John	John	John	
32	2300 Oak St	Springfield	MA	01103	555-3456	Student	Other	Single	0	John	John	John	
33	2400 Pine St	Springfield	MA	01103	555-4567	Student	Other	Single	0	John	John	John	
34	2500 Birch St	Springfield	MA	01103	555-5678	Student	Other	Single	0	John	John	John	
35	2600 Cedar St	Springfield	MA	01103	555-6789	Student	Other	Single	0	John	John	John	
36	2700 Elm St	Springfield	MA	01103	555-7890	Student	Other	Single	0	John	John	John	
37	2800 Oak St	Springfield	MA	01103	555-8901	Student	Other	Single	0	John	John	John	
38	2900 Pine St	Springfield	MA	01103	555-9012	Student	Other	Single	0	John	John	John	
39	3000 Birch St	Springfield	MA	01103	555-0123	Student	Other	Single	0	John	John	John	
40	3100 Cedar St	Springfield	MA	01103	555-1234	Student	Other	Single	0	John	John	John	
41	3200 Elm St	Springfield	MA	01103	555-2345	Student	Other	Single	0	John	John	John	
42	3300 Oak St	Springfield	MA	01103	555-3456	Student	Other	Single	0	John	John	John	
43	3400 Pine St	Springfield	MA	01103	555-4567	Student	Other	Single	0	John	John	John	
44	3500 Birch St	Springfield	MA	01103	555-5678	Student	Other	Single	0	John	John	John	
45	3600 Cedar St	Springfield	MA	01103	555-6789	Student	Other	Single	0	John	John	John	
46	3700 Elm St	Springfield	MA	01103	555-7890	Student	Other	Single	0	John	John	John	
47	3800 Oak St	Springfield	MA	01103	555-8901	Student	Other	Single	0	John	John	John	

REFERENCE

The next classification is not based on "normalizing" its reflecting
a character (the subject's subject)

Scale
1 Inch to
1.58 Miles

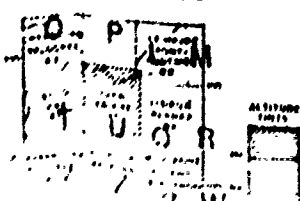
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REPORT NO. 2.

EMPLOYMENT OF ROYAL MARINE ARTILLERY DURING OPERATION 'NEPTUNE'.

The R.M. Artillery were allocated as follows:-

- One regt of 8 tps to 3 Cdn Div.
- One regt of 8 tps to 50 Div.
- One independent bty of 4 tps to 3 Br Div.

In general, the role assigned was to provide:

- (1) Direct fire on the beaches during the run in.
- (2) Close support fire for the infantry while the S.P. artillery were being disembarked.
- (3) Indirect fire from the beaches as called for by F.O.Os.
- (4) Thickening up of artillery fire under command of field regiments to which Marine regiments were all ceded.

The following is the role actually performed in the operations as obtained from the sources indicated, together with certain opinions deemed of value.

Rt Arty Regt in support of 3 Cdn Inf Div.
CO RMA Regt - Lt.-Col. JOHNSTON.

26 Centaur and 7 Sherman tanks were landed on D day, one troop at H + 10 mins and the remainder at H + 120 mins.

4 Centaur and 1 Sherman tanks were landed during D + 1 day.

2 Centaurs returned to U.K.

Direct Fire on the Beaches during the Run-in.

No direct fire was employed during the run-in on orders of OOC 3 Cdn Inf Div, owing to obscurity of targets and to lateness of arrival.

Close support fire for Inf while SP artillery were being disembarked.

Very useful close support was given and the guns were used extensively in eliminating snipers and strong points.

Indirect fire from beaches.

No indirect fire was provided from the beaches owing to:-

- (a) the lateness of arrival
- (b) casualties to F.O.Os
- (c) one troop being beached in very deep water when S.P.s were arriving, requiring the rapid clearance of the beach.

Initial period under command.

On the evening of D day, three troops were placed under command of SS Bde, 47th RM Cdo, and performed very valuable services for the Commandos in street fighting, destroying enemy strong points at point blank range and landing commandos down unobscured streets using Beas.

Remaining troops moved forward under command of RCA regiments, two troops per regiment. Owing to the fluidity of the Canadian front and the fact that F.O.Os were pre-occupied with SP guns, the Marine artillery was not employed until D + 3, when they assumed their normal role in close support of the infantry.

On D + 4 three troops in support of 46th RM Commando performed an independent operation providing concentrations on ROSEL and ROTB for 7 minutes. Subsequently, three troops were again used on ROTB when a heavy and very useful concentration was laid down.

Br RCA, 3 Cdn Div.

Marine artillery performed according to plan but, owing to lateness of arrival of the bulk of the guns, were unable to provide maximum effect. A very useful role was performed at ST AUBIN-SURMER in clearing out the garrison.

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RM Arty Regt in support 50 Inf Div
CU NL Regt - Lt.-Col. BESSETT.

Of sixteen LCTs, three beached on time, one on 69 Jde sector and two on 231 Jde sector. Between D and D + 2 four LCTs arrived which had been delayed by heavy weather. Four LCTs returned to UK and the fate of five other LCTs is as yet unknown. In addition to the severe weather the convey speed was apparently excessive from the departure.

Direct fire on beaches during Run-in.

No targets were engaged on run-in, on either brigade sector.

Close support fire for infantry while SP artillery were being disembarked.

At H + 6, three LCTs were ashore carrying six Centaurs and one Sherman, but two mechanical breakdowns occurred due to clutch and track failure. The Sherman was hit and burnt out on the beach. Beses and 95 mm fire was directed against targets of opportunity but, owing to the small number of Centaurs available, the effect was small.

Indirect fire from the beaches.

No indirect fire was provided from the beaches as no Sherman command tanks were available for communications.

Initial period under command.

At H + 7 three Centaurs under command 147 Fd Regt fired 33 r.p.g. supporting the attack of 47 RM Command on the LONGUES battery, providing useful neutralising fire. They then proceeded to LA BOSIERE in the evening but were forced to return to DUDOT owing to enemy action. On D + 1 they returned to LA BOSIERE and took up anti-tank positions, but did not see action in this capacity. Approximately 10 r.p.g. were fired against a gun on the cliff in the area of square 7887 providing adequate neutralisation for the infantry.

Five Centaurs on the left flank went under command of 86 Fd Regt instead of 147 Fd Regt and were able, with the subsequent arrival of LCTs, to form two complete troops by the evening of D + 1. The first shoot for these tanks, apart from using Beses against MGs and snipers in the area of 86 Fd RMQ on D day, was on D + 4 as part of the regimental fire plan on AUDRIEU.

Following this, they were employed to thicken up artillery in front of field regiments.

It was felt that, had 32 tanks been landed with the F.O.Os available, a vital role could have been performed in assisting the infantry at LE HAMEL, which held out for the whole of D day, and in coping with the numerous infantry and MG nests as well as two 88 mm guns on the NIEUVILLE RIDGE, which were available targets. Great assistance could have been provided 47 RM Cdo in operations against PORT-EN-LESSIN, had the necessary force been available. Very close artillery support was required and this could have been most effectively supplied by the Marine artillery.

Marine Artillery Ind. Bty in support of 3 Br Inf Div.
tp Offr - Ind Bty.

At H hour, eight Centaurs and two Shermans were landed on RED beach, but four of them were drowned, and four Centaurs landed on WHITE beach half an hour late without difficulty. One LCT returned to the UK and one LCT arrived at D + 1.

Direct Fire on Beaches during Run-in.

All craft fired on the run-in. Visibility was very bad on WHITE beach, but the beach was sprayed with Beses and a house occupied by snipers was set on fire.

Close support fire for infantry while SP artillery were being disembarked.

On RED beach the infantry were hard pressed and suffering heavy casualties and Centaur fire was considered of great value. On WHITE beach there was very little to do as there were no emplacements to cope with. Some shelling was done against buildings occupied by enemy snipers.

Indirect fire from the beaches.

No indirect fire was provided from the beaches because of casualties to F.O.Os and Centaurs.

Initial Period under command.
RM Arty, 3 Br Div.

Five Centaurs and two Shermans were placed under command 33 Fd Regt in a counter mortar role but were withdrawn to 4 SS Dde before employment.

2 IC 33 Fd Regt.

Marine artillery came under command at H + 4 and went into action NE of NEWMANVILLE. They were moved into the regimental area at H + 12 and placed on regiment grid and frequency and fired two or three shots on D Day. The only role performed was in thickening fire on LEON SUR MER, where they were extremely useful. They remained in reserve until D + 3 when they were withdrawn. More use could have been made of the Marine artillery by allocating some strong point or village as their responsibility instead of leaving them in reserve.

CRA, RMA
Brig. SHANDERS.

The role of the Marine artillery was seriously affected by the Navy's failure to land the LCTAs at the right time and place.

The bad weather caused disproportionate casualties, forcing a large number of craft to turn back to the UK, causing others to founder and seriously interfering with the timing so that a large percentage arrived late and were unable to fulfil their role as defined.

If there had been a high degree of resistance on the beaches, their use in the original role planned would have been extremely valuable. As there was not the resistance on the beaches that had been anticipated, they were used against targets of opportunity where 25 pdrs and SPs would have been adequate.

In subsequent operations they proved of great value in eliminating snipers and defended posts and as close support artillery.

Deputy CRA, RMA.
Col. HARVEY.

It is felt that the RMA should have landed their own FOOs at 4 hour as FOOs of SP regiments were fully occupied with their own units and were consequently unable fully to utilise Marine artillery resources. In addition, in later phases, tanks could have been allocated independently of SP regiments and greater value obtained from available weapons. This policy has subsequently been followed in 6 Airborne Division where three troops are being made up using Marine artillery equipment and available personnel and organised to provide two FOOs and the necessary battery staff. This will permit employment in an independent role under the direction of the CRA.

The present troop composition of one Sherman to four Centaurs appears satisfactory. It is possible that an M 10 chassis with 17-pr mounted is warranted to obtain improved performance against armour and fixed defences.

In view of the susceptibility of the Centaur in forward areas to anti-tank attack with the need for close infantry support, it would be desirable to have increased range up to the limit of the 95 mm.

A carrier should be provided for each FOO, as at present he must go forward in a Sherman which may not be desirable.

One 15-cwt per troop is required for ammunition, water, and food to avoid administrative difficulties which are unavoidable when dependent on extraneous sources.

If employed in a limited role, provision for first line repairs should be made by the inclusion of a small RBHE detachment in a 15-cwt for each four troops to diagnose troubles and arrange for their treatment. Fourteen tanks have been abandoned owing to inadequate facilities for their repair and recovery.

NEPTUNE

EMPLOYMENT OF MARINE ARTILLERY DURING "NEPTUNE" OPERATIONS.

General.

In the preparation of this report the following considerations governed the method of treatment and limited the amount of detail contained in it.

1. The Royal Marine Artillery were returning to the U.K. within two days from the time that the study was initiated.
2. Until the time of departure for the U.K. the RMA were engaged in operations in close support of infantry from the beach, owing to casualties sustained in the assault, it was impossible to detach an officer from each Regiment to return to the assault area to reconstruct the action which took place.

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Even had this been feasible, it is doubtful if a complete picture could have been obtained without questioning each officer who had participated, a process requiring a period of time much exceeding that available.

3. It was understood that the information was required as quickly as possible by the S.C.S. (S.D.), 21 Army Group.

The beaches were visited with the intention of reconstructing as far as possible the effect which the Marine Artillery had achieved. The analysis was extremely difficult and no exact conclusions could be drawn for the following reasons:

1. Fourteen days had elapsed since the assault and much of the evidence had been removed or obliterated. Knocked out Centaur tanks, which would have disclosed targets on which their effect could have been studied, had been removed.
2. Many of the fortifications were in the process of being occupied by our own troops as bivouacs and in the course of this many changes had been made. Damaged enemy weapons had been removed, shelters had been repaired and the scene had changed very considerably. Extensive beach clearing operations had been performed, thus further complicating the task of assessment.
3. The involved nature of the fire plan, in which many different weapons had been employed and which in the target area had produced a similar effect, had created an area of destruction on an extensive scale which made it impossible to differentiate exactly between elements of the fire plan or to isolate the relatively small effect of the Marine Artillery.

In view of the above considerations the report is dependent on the information available from the participants and it is felt that it contains all the conclusions which are warranted.

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PART III

TANKS

Chapter 10: Tank Casualties

Chapter 11: Organisation and Tactics

CHAPTER 10
TANK CASUALTIES

CONTENTS

Analysis of 75 mm Sherman Tank Casualties 6th June to
10th July, 1944 (Report No. 12)

Analysis of German Tank Casualties in France 6th June
to 31st August, 1944 (Report No. 17)

REPORT NO. 12.

ANALYSIS OF 75 MM SHERMAN TANK CASUALTIES SUFFERED BETWEEN 6TH JUNE
AND 10TH JULY 44.

1. INTRODUCTION.

The following survey of 75 mm Sherman tank casualties suffered in NORMANDY between 6th June and 10th July deals only with casualties and not with terrain, extent of enemy opposition, etc.

General information on tank casualties is collected by AFV on such subjects as total number of tanks damaged, total brow-ups and the seriousness of the damage inflicted, but at the suggestion of S.D. 2nd Army, more data was collected; in particular the number of hits to knock out a tank, the number of hits which have failed to penetrate, the proportion on front, sides and rear and their angles of penetration.

In order to obtain this information a representative sample of tank casualties was taken from those fronts where 75 mm Sherman tanks fought between 6th June and 10th July, data being collected both from recovered and unrecovered vehicles. To test that the evidence was, as far as possible, representative, the proportion within the sample of brow-ups, mined tanks and AP casualties was also found and this proportion compared with that given by AFV (Tech) and AFV, 2nd Army, who had access on these points to all 75 mm Sherman tank casualties. Agreement was good so that any further evidence given in this report on angles of penetration, etc., can justifiably be assumed typical till proved otherwise.

2. DATA COLLECTED.

The data collected is given in the following table:

ANALYSIS OF SHERMAN CASUALTIES

(i) Total tank casualties analysed:	45	Proportion of total tanks	
(a) Number penetrated by German AP shot:	40.	89%	
(b) Number mined :	4.	9%	
(c) Number damaged, unidentified but "browed up":	1.	2%	
(ii) Total "Browed up":	37	82%	
(a) Number penetrated by shot and "browed up":	33.	77%	
(b) Number mined and "browed up" :	3.	7%	
(c) Number "browed up" by unknown causes :	1.	2%	

(Note: In several cases it is difficult to distinguish between penetrations of 75 and 88 mm particularly after the tank had "browed up". Too much reliance must not be placed on the proportion of such penetrations though the proportion given agrees well with the estimated occurrence of such guns given by G.S.I.(A) 2nd Army, Main H.Q.

Estimates by fighting soldiers were found to be unreliable since many reported they had been knocked out by 88 mm, when in fact it had been 75 mm shot, while the reverse mistake has not yet been discovered.

(iii) TANKS PENETRATED BY GERMAN A.P. SHOT.

		Proportion of total hits	
A. (a) Total hits recorded:	=	63	
(i) 75 mm	=	53	82%
(ii) 88 mm	=	12	18%
(b) Number of penetrations	=	62	98%
(i) 75 mm penetrations	=	50	77%
(ii) 88 mm penetrations	=	12	18%
(c) Number of failures to penetrate:	=	3	5%
(i) 75 mm failures	=	3	5%
(ii) 88 mm failures	=	NIL	0%

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(d) Average number of hits to knock out a Sherman Tank: 1.63

(e) Proportion of hits which knock out a tank: 62%

B. Distribution of hits.

	<u>Front</u>	<u>Sides</u>	<u>Rear</u>
Hull	7	24	6
Turret	12	12	4
Total	19	36	10

Total: 65

C. Distribution of failures.

	<u>Front</u>	<u>Sides</u>	<u>Rear</u>	<u>Total</u>
Hull	0	0	0	0
Turret	1	1	1	3
Total	1	1	1	3

D. Distribution of number of hits required to knock out each tank.

Number of hits:	1	2	3	4	5	6	7	8
Tks knocked out:	25	11	2	1	-	-	-	1

E. Distribution of angles of penetration.

	<u>0-5°</u>	<u>5-30°</u>	<u>30-90°</u>	
Hull	20	12	5	
Turret	12	11	2	
Total:	32	23	7	Total = 62

Distribution:

Hull:	32	19	8
Turret:	19	18	3
	51	37	11

F. A further study of tanks that had fought but had not been penetrated was also made:

Total tanks inspected	124
Hits failing to penetrate	8

3. DISCUSSION.

1. The proportion of brewed up tanks is high and it is therefore important to know whether this must always be the case. A more recent examination of later battles, which is not yet complete, has shown that the 1st Bn Coldstream Gds (5 Gds Arm Div) have suffered fewer brewed ups than other units, e.g., during operation "Bluecoat" only 1 in 20 casualties, of which casualties at least 12 were due to penetrations. The unit concerned attributes this to the fact that they carry no extra ammunition outside the armoured bins. It should be recognised that in no recorded case in our sample has the extra outside applique armour resisted any hit, and therefore the protection afforded by keeping all ammunition in the bins is almost certainly due solely to the internal flying fragments failing to penetrate the ammunition.

2. The small number of AP hits failing to penetrate is noticeable. This small number has been confirmed by the opinions of technical adjutants, etc., who agree that the proportion was probably not above 5%. This opinion is in keeping with the calculated expectations of failures based upon penetration figures for 75 mm and 88 mm guns at the ranges of engagement estimated by tank crews. There have also been complaints at the apparently low resisting power of the present Sherman armour. REME, 5 Gds Arm Div state that an AP.300 and an AP.300 Brumby, both fired at 100 yds range, penetrated $\frac{1}{2}$ and $1\frac{1}{2}$ inches respectively into the turret armour. Added to this, it is at present the practice to recondition for service partially brewed-up tanks whose quality of armour might often be low.

3. From the data collected, it will be seen that the distribution of hits on the sides and front of the 75 mm Sherman tank is more or less equal and that, therefore, for up-armouring to be effective, a large area would need to be strengthened. For instance, up-armouring the front of the tank so that in the cases considered it would have given 50% protection on this face, would only have decreased penetrations by 15%. In consequence, if changes are required it would appear wiser to use the extra weight-carrying of the 75 mm Sherman to take a better gun; i.e., to make German tanks more vulnerable rather than to attempt to decrease our own vulnerability. This suggestion would appear to be in keeping with present policy.

4. Requests have been made by DTD for any additional battlefield data to assist decide on the optimum thickness of individual armour plates and on their optimum distribution. On the evidence of this report, where tanks are expected to attack in country as, or more, enclosed than Normandy, it is recommended that an almost homogeneous defence be assumed (a homogeneous defence being defined as a defence where the enemy are able to hold their fire so long, they are as likely to hit from the side or rear as from the front: for the use of this convenient term see DTD armour reports). Therefore, for optimum armour distribution, etc., a "p.d.v." (probability directional value) for an almost homogeneous defence should also be used.

It is considered that present homogeneous German defence is due to ease of concealment and that, until better methods of spotting tanks and A/T are found, such a form of defence will continue and can safely be assumed for similar terrain. It should be carefully noted, however, that the present sample of tanks has been taken from a series of battles where our forces were nearly always attacking, and it may well be that, in defence, more frontal hits will be recorded.

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REPORT NO. 17.

ANALYSIS OF GERMAN TANK CASUALTIES IN FRANCE

6TH JUNE 44 - 31ST AUGUST 44.

INTRODUCTION.

The period covered can be divided into two distinct phases, the comparatively static period between 6th June and 7th August 44 up to the break through and the stage of exploitation and pursuit between 8th August and 31st August 44. In the first phase the area covered included the whole of the British and American sectors with the exception of those parts of the American sector south of grid line F6 through CARENTAN. In the second phase the area covered only the British sector from the FALLISE pocket up to the SEINE. These two phases are dealt with separately.

The data used in this report have been collected by several observers, but principally by members of No. 2 C.R.S. and No. 20 M.T.S.F.P.

DATA RECEIVED.

The Static Phase (6th June - 7th August 44).

2. A representative sample of German tank casualties was not obtained as only those which fell into our hands could be examined, no data being available concerning those recovered by the Germans. Owing to lack of personnel no Pz Kw Mk III and only a small proportion of Pz Kw Mk IV were examined, but one or other observer examined every Pz Kw Mk V and VI of which they became aware.

3. In Table I are set out the total numbers of tanks examined together with the assigned cause of elimination.

TABLE I

ENEMY TANK CASUALTIES BETWEEN 6TH JUNE - 7TH AUGUST 44.

Assigned Cause of Elimination of Tank	No. of Tanks Eliminated			Total	Percentage of Grand Total
	Mk VI	Mk V	Mk IV		
A.P. Shot	7	36	10	53 +	48%
Hollow charge projectiles	-	7	1	8	7%
5.5" Artillery	-	7	2	9	8%
Mines	-	-	1	1	1%
Rocket projectiles from aircraft (R.P.)	-	6	1	7	6%
Air Cannon	-	2	1	3	3%
Boats	-	-	-	-	-
Destroyed by crew	-	6	1	7	6%
Abandoned	-	3	1	4	4%
Unknown Causes	1	13	2	16	17%
TOTAL:-	8	82	20	110	100%

4. Although the sample cannot be fully representative, the results clearly show that among the several methods by which tanks might have been destroyed, A.P. shot was by far the most important. Paragraphs 9 - 23 deal in more detail with tanks knocked out in this way.

- * A small number of these may have been abandoned before they were hit.
- 4 of these were knocked out by 5.5" in one bombardment.
- 5 were tanks with A.P. and Hollow Charge penetrations without evidence as to which was the original cause of elimination.

2nd Phase: 8th - 31st August 44.

5. The sample obtained in the 2nd Phase is considered more or less representative of German tank casualties during this period since the proportion of damaged tanks recovered by the Germans was small. The sample is considered to be approximately half of the total, and includes a full count of discovered Mk IIIs and IVs.

TABLE II.

ENEMY TANK CASUALTIES BETWEEN 8TH - 31ST AUGUST, 44.

Assigned Cause of Elimination of Tank	No. of Tanks Eliminated				Total	Percentage of Grand Total
	Mk VI	Mk V	Mk IV	Mk III		
<u>A.P. Shot</u>	1	11	11	-	23	11%
<u>Hollow Charge projectiles</u>	-	1	-	-	1	0.4%
<u>M.E. Artillery</u>	-	1	3	-	4	2%
<u>Mines</u>	-	-	-	-	-	-
<u>Rocket projectiles from aircraft (R.P.)</u>	-	2	5	-	7	3%
<u>Air Cannon</u>	-	1	-	-	1	0.4%
<u>Bombs</u>	-	-	2	-	2	1%
<u>Destroyed by crew</u>	20	44	41	3	108	48%
<u>Abandoned</u>	6	30	27	-	63	28%
<u>Unknown Causes</u>	-	6	7	-	13	6%
TOTAL:	27	95	96	3	223	100%
Percentage of Total:	12%	43%	43%	1%	100%	

6. During the later stages of the battle for France (8th - 31st August 44) the main causes for the elimination of enemy tanks was destruction by their own crews and abandonment. This subject has been dealt with in No. 2 O.R.S. Report No. 15, "Enemy Casualties in Vehicles and Equipment during the Retreat from Normandy to the Seine".

Comparison of A-Tk weapons in the two phases.

7. In order to compare the effectiveness of various types of A-Tk weapons in destroying enemy tanks in the two phases, the enemy's losses due to abandonment and destruction by the crew have been subtracted and the resulting percentages given in Table III.

TABLE III.

Assigned Cause of Elimination of Tank	Percentage of Destroyed Tanks in each Phase	
	1st Phase 6 Jun - 7 Aug 44)	2nd Phase (8 - 31 Aug 44)
<u>A.P. Projectiles</u>	63%	63%
<u>Hollow charge projectiles</u>	10%	2%
<u>M.E. Artillery</u>	17%	10%
<u>Mines</u>	1%	-
<u>Rocket Projectiles from aircraft</u>	9%	18%
<u>Air Cannon</u>	4%	2%
<u>Bombs</u>	-	3%
Total from which percentages are derived	81 tanks	39 tanks

8. It is clear that in both phases A.P. shot was the principal means of knocking out tanks. The numbers knocked out by Rocket Projectiles, which are comparatively new weapons, were not inconsiderable.

ANALYSIS OF DAMAGE BY A.P. PROJECTILES.

9. Because our own forces often practised A.P. shooting against knocked out enemy tanks, the detailed analysis of A.P. rounds has been confined to those tanks where the observer could interview the gun detachment or tank crew which had fired. Only where these accounts agreed with the rest of the evidence has the accuracy been accepted. By this now standard the following projectiles are dealt with:-

Mk IV - 5
Mk V - 22
Mk IV - 5

10. The fact that the sample includes only captured tanks may introduce a bias whose character will depend upon the enemy's choice of vehicles to be recovered. It is not known if this choice was influenced by ease of recovery or ease of repair, or by a combination of both as seems most likely. From theoretical reasoning alone it is impossible to forecast the nature of the bias.

11. Character of shots recorded, their penetrations, and failures.

TABLE IV.

Type of Projectile	Number of Penetrations	Number of Failures	Total	Percentage Penetration for each type of gun
17 pdr APCBC	21	4	25	84%
3" H-10	17	5	22	77%
75 mm	5	8	13	38%
6 pdr D.S.	9	4	13	69%
6 pdr APCBC	9	1	10	90%

Comment on Table IV

12. The samples for each gun are considered too small for the many variables to be sufficiently randomised and until further figures of a similar character can be added no conclusions should be drawn.

13. (a) Penetrations and Failures of A.P. Projectiles against various tanks.

TABLE V.

Type of Tank	Number of A.P. hits		TOTALS	Percentage Penetrations
	Penetrations	Failures		
Pz Kw Mk VI	13	8	21	62%
Pz Kw Mk V	42	14	56	75%
Pz Kw Mk IV	6	-	6	100%
TOTALS:	61	22	83	73%
(Sherman M-4)	-	-	-	(92%) *

* Includes five engagements against Mk IVs. Records for other guns only include engagements against Mk VIs and Vs.

3 All samples quoted in this report for Sherman M-4 tanks are taken from No. 2 O.R.S. Report "Analysis of Sherman Tank Casualties in Normandy, 6th June - 10th July 44", dated 15th August 44.

(b) Average number of hits to knock out each type of tank, etc.

TABLE VI.

Type of Tank	Average Number of hits to knock out a Tank	Average number of penetrations to knock out a tank
Pz Kw Mk VI	4.2	2.6
Pz Kw Mk V	2.55	1.9
Pz Kw Mk IV	1.2	1.2
(Sherman M-4)	(1.63)	(1.55) *

Comment on Tables V and VI.

14. (a) In these tables the chief advantages gained by the Pz Kw VI and V over the IV and the Sherman lies in their ability to keep out more shots; yet there are indications that they also possess some real advantage in an increased ability to accept penetrations without serious internal damage. It is considered that this important question of the best internal layout of a tank to prevent internal damage should be studied by controlled experiments in England. (See also Part. 18b).

(b) The difficulty of determining how many of the hits or penetrations were necessary to knock out the tank, and how many were subsequent rounds fired by our tank or anti-tank guns, may make Table VI very misleading. It should be taken as an indication only.

15. Distribution of number of hits required to knock out a tank.

TABLE VII

Number of hits required to knock out the tank	Number of Tanks knocked out			
	Pz Kw Mk VI	Pz Kw Mk V	Pz Kw Mk IV	(Sherman M-4)
1	-	7	4	(25)
2	2	6	1	(11)
3	1	4	-	(2)
4	-	2	-	(1)
5	-	2	-	-
6	1	-	-	-
7	-	1	-	-
8	1	-	-	(1)
Total of Tanks:	5	22	5	(40)

Comment on Table VII.

16. The main advantage the Panther possesses over the Sherman, as shown by this table, is its ability not to be so easily knocked out by the first hit.

17. Tanks Drawn Up when knocked out by A.P.

TABLE VIII

Type of Tank	Number of Tanks		Percentage Drawn Up of total for each type of tank
	Drawn Up	Unburnt	
Pz Kw Mk VI	4	1	(80%)
Pz Kw Mk V	14	8	63%
Pz Kw Mk IV	4	1	(80%)
(Sherman M-4)	33	7	(82%)

All samples quoted in this report for Sherman M-4 tanks are taken from No. 2 O.R.S. Report "Analysis of Sherman Tank Casualties in Normandy, 6th June - 10th July 44", dated 15th August 44.

TABLE IX.

Type of Tank	Average Number of hits received for each Brewed Up Tank	Average Number of Penetrations received for Brew-Up of a Tank
Pz Kw Mk VI	5.25	3.25
Pz Kw Mk V	4.0	3.24
Pz Kw Mk IV	1.5	1.5
(Sherman M-4)	1.97	1.89

Comment on Tables VIII and IX.

(a) From Table VIII it would appear that the percentage of brew-ups for the Panther (Pz Kw V) is materially less than for the Sherman. Too much importance, however, must not be attached to this difference by itself since British and German gunners may differ in their tendencies to fire.

(b) On the evidence of Table IX it is urged that the causes of brew-ups in tanks are due for detailed research. As shown, the types of tanks studied vary greatly in their susceptibility to catch fire as a result of any single penetration, and this is considered of great importance. This susceptibility depends on both the tank and the projectile and it does not appear that it can be elucidated by further observation on the battle-field but requires detailed research.

19. Distribution of L.P. Penetrations and Failures on Enemy Tanks.

Only the sample for the Pz Kw Mk V is sufficiently large to allow for this analysis.

TABLE X

PZ KW MK V	Upper glacis plate	Montlet and front turret	Turret sides	Hull sides	Turret rear	Hull Rear	TOTAL
<u>Penetrations</u>							
with:-							
17 pdr	-	1	4	9	1	3	28
3" M-10	-	-	1	5	-	1	7
75 mm	-	-	1	4	-	-	5
6 pdr D.S.	-	1	1	3	-	1	6
6 pdr APCBC	1	-	3	2	-	-	6
TOTAL:	1	2	10	23	1	5	42
<u>Failures</u>							
with:-							
17 pdr	2	-	1	-	-	-	3
3" M-10	1	1	1	-	-	-	3
75 mm	1	-	1	1	-	-	3
6 pdr D.S.	3	1	-	-	-	-	4
6 pdr APCBC	-	-	1	-	-	-	1
TOTAL:	7	2	4	1	-	-	14
GRAND TOTAL of hits:	8	4	14	24	1	5	56
<u>Penetrations to hits on each plate</u>							
	12.5%	50%	71.5%	96	100%	100%	-

Through H/O mounting.

Comment on Table I.

20. (a) The small success of our A.P. projectiles against the sloping glacis plate of the Pz Kw Mk V is outstanding. It is felt to warrant the claim that this plate has proved itself to be adequate for a modern tank and that its qualities and advantages be taken fully into account in deciding future tank design.

(b) It must be remembered that the full advantage of this relative immunity is only shown to a limited extent in a sample of captured tanks since many tanks which are hit only on the glacis plate will escape and in many cases a gunner will not fire against a head-on Panther. The full advantage is certainly greater than that shown in the Table.

(c) The side hull-armour of the Panther is shown to have been extremely vulnerable. This supports present teaching that gunners should if possible attack the hullside of this tank.

21. Distribution of A.P. Penetrations and Failures in terms of the different aspects of the Pz Kw V.

TABLE XI.

Aspect of Pz Kw Mk. V

	Front	Sides	Rear
Number of:-			
Hits:	12	38	6
penetrations:	3	33	6
Percentage of penetrations to hits for each aspect:	25	87	100

Comment on Table XI.

22. (a) Even if a gunner can hit any particular part of the side or rear of a Panther, the teaching that a Panther should not if possible be attacked from the front is justified by the above figures.

(b) The further question of how far a gunner or tank commander is justified in taking risks to obtain a side instead of front attack cannot be answered on the present data alone. The answer depends upon the combined chances of both hitting and penetrating the tank at various aspects, which chances cannot be deduced from the data in this paper. There is evidence that German authorities consider it worth while to collect the additional facts required from their gun detachments in the form of returns of details of all engagements against tanks.

Distribution of angles of Penetration.

23. The following table gives the frequency of the angles of penetration where they could be satisfactorily measured:

TABLE XII.

Angles of penetration to normal of plate struck

Numbers and percentages of Penetrations - on -

	All German Tanks	(Sherman M.4)
0 - 5°	20 (55)	32 (52)
5 - 30°	15 (39)	13 (37)
30 - 90°	3 (8)	7 (11)
TOTALS:	38 (100)	52 (100)

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TOTAL

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CHAPTER 11.
ORGANISATION AND TACTICS.

CONTENTS

Tank casualties during the Exploitation Phase after Crossing the Seine.	(Report No. 31)
Armoured Pursuit after Crossing the Rhine.	(Report No. 32)

REPORT NO. 18.

TANK CASUALTIES DURING THE EXPLOITATION PHASE AFTER CROSSING THE SEINE.INTRODUCTION.

1. The armoured drive from the SEINE northwards into HOLLAND presented a different form of warfare from that experienced in NORMANDY. Generally speaking it presented a phase of exploitation as opposed to a phase of "break in" against enemy lines. Data was needed as to how these new conditions affected tank casualties and requirements and whether these in turn demanded modifications in tank design.

2. To this end, the writer of this report lived, during the period up to the occupation of NIJMEGEN by Guards Armoured Div on Wednesday 20th September, 1944, with several of the tank units concerned and obtained at first hand as much information as was available,

3. The conditions were such that detailed examinations of individual causes of casualties were out of the question and this paper therefore only comprises a general analysis. In the circumstances the question of tank repairs was inseparable from that of tank casualties and some details of the operational aspect of this subject are included. The work has been much assisted by the co-operation of all concerned, in particular the officers of R.E.M.E.

RESULTS.Tank Casualties.

4. The following tables give a brief analysis for six tank brigades of the numbers of casualties that could not be repaired in 1st Line Workshops during the exploitation phase (roughly 28th August - 7th September 44).

TABLE I.

Unit	Majority of Tanks in Unit	Number of Casualties due to:-		
		Mechanical Causes	Enemy Action	Total
Gds Arm Div	Shermans	59	5	64
8 Arm Bde	Shermans	57	20	77
11 Arm Div	Shermans	44	6	50
7 Arm Div	Cromwells	38	12	50
1 Polish Arm Div	Shermans	50	30	80
4 Cdn Arm Div	Shermans	57	5	62
TOTAL:		305	78	383
Average per Arm Bde:		51	13	64

TABLE II.

Days in Pursuit	Average casualties per day due to:		Average Total	
	Mech. Causes	Enemy Action		
Guards Arm Div	9	6.5	0.6	7.1
8 Arm Brigade	12	4.8	1.6	6.4
11 Arm Division	9	4.9	0.7	5.6
7 Arm Division	7	5.4	1.7	7.1
1 Polish Arm Div	10	5.0	3.0	8.0
4 Canadian Arm Div	9	6.3	0.6	7.0
Average:	9.3	5.4	1.4	6.8

Table III gives casualties per 100 miles of travel:

TABLE III.

	Mileage	Average casualties per 100 miles due to:-		Average Total
		Mech. Causes	Enemy Action	
Guards Arm Div	450	13.1	1.1	14.2
8 Arm Brigade	350	16.2	5.7	21.9
11 Arm Division	270	16.3	2.2	18.5
7 Arm Division	250	15.2	4.8	20.0
1 Polish Arm Div	280	17.8	10.7	28.5
4 Canadian Arm Div	300	19.0	1.7	20.7
Average:	317	16.0	4.1	20.1

5. The average number of casualties due to mechanical causes both per day and per 100 miles is surprisingly constant in view of the large differences between total mileage.

No evidence, except for Guards and 11 Armoured Divisions, was found that the number of mechanical failures per 100 miles was increasing towards the end of the pursuit phase. In 11 Armoured Division 50% of the failures occurred in the last 50 miles. In the next phase of Guards Armoured Division, between the ALBERT and ESCAULT canals, where an average mileage of not more than 200 miles was travelled, 51 failures occurred; i.e., 46% of the combined totals of both periods.

6. For most units the maximum distance travelled on any day was about 80 miles and was done in long bursts at high speed. For instance, after crossing the SEINE Sherman tanks were driven more or less as fast as they would go - say 28 m.p.h. - for lengthy periods over rough sets. Cromwell tanks were not driven for so long or so frequently at their top speed, perhaps because of their higher maximum speed. Very little maintenance was, nor could have been, done in view of the distances and times travelled and of the necessity to be ready for instant action.

Tank Repairs.

7. The following difficulties were experienced in tank repairs:

(a) Locating casualties.

Owing to the speed of the advance many tank commanders found it difficult to pinpoint themselves accurately, particularly if they were off the axis. In consequence, if their tanks became casualties, the map references they gave to the Recovery Sections were often so inaccurate that long and tedious search was necessary before their tanks were discovered. From conversations with tank commanders afterwards, it is thought that many of them did not realise the extreme importance of accurate pinpoints during such pursuit phases and that an improvement might be obtained by greater emphasis on this point during training.

(b) Guarding casualties.

In consequence of the above difficulties, the driver who was left to guard the tank was sometimes lost to his unit for a matter of four or five days. The cumulative effect of the loss of skilled workers, who might otherwise have been helping in first-line repair workshops, was unfortunate. In addition, drivers left to guard vehicles were given only two or three days rations; when these were exhausted they had to leave their tanks to find food. During their absence their tanks were usually looted. It was suggested that each tank might have a small spot-welding plant so that where practical the hatches could be welded up, making the tank safe from looting.

(c) Returning repaired tanks to units.

Where tanks had been backloaded for repair great difficulty was found in getting them up again (e.g. 8 Armoured Brigade had 13 tanks at VERNON but were unable to move them). This was partly due to shortage of transporters and partly to their slowness.

(d) Workshop Organisation.

When 2nd Line Workshops moved every day or two they could not undertake their normal repairs since there was insufficient time to finish the work. (e.g. 8 Armoured Brigade Workshops moved to DOULENS for two days, but were unable to undertake any repairs; 1st Polish Armoured Division Workshops between 1st - 8th September, 1944, were only able to undertake normal repairs on the 4th and 5th owing to the number of moves they made; so also with other brigades).

(c) Separation from Workshops.

At the beginning of the pursuit most Brigades kept their workshops static. In consequence they were left the following distances behind their Main H.Q.s:

	Miles Behind	Number of days elapsed which Div or Bn H.Q. had preceded 2nd Line Workshops
Oscar's Armoured Div	164	2
8 Armoured Brigade	110	3
11 Armoured Brigade	145	2
7 Armoured Division	160	3
1 Polish Division	60	2
4 Canadian Division	75	2

This led to many difficulties. In particular:-

(i) Communication between Division and 2nd Line Workshops could only be obtained by leaving a relay van at a point half way between.

(ii) Personal visits by CREME or his staff to workshops were almost impossible.

(iii) Between Division and workshops many tanks were left unrecovered with only slight troubles which could quickly have been put right. These tanks, in consequence, were lost to the Division for many more days than was necessary.

8. The following changes in organisation of workshops in 4 Canadian Armoured Division illustrate the attempts made to overcome these difficulties:

Early

August: (a) AT CLEN ("Break in" period). 2nd Line Workshops kept in Administration Area (about 5 miles behind main forces); from this position they were able to recover tanks quickly and easily. Almost all were successfully repaired, few being backlogged.

12 - 27

August: (b) PALAISE Area. Movement forward was about 6 - 8 miles per day.

Because Administration Area was found not to be moving up and because Workshops were found to be involved in the troubles of Administration Group moves, 2 Composite A.W.D.s, covering A and B vehicles and wireless, were created, each of about 45 mechanics, moving forward in leapfrog bounds and keeping well forward. With moves of about 6 - 8 miles this was found to be satisfactory.

28th

August: (c) SEINE AREA.

By this time, Administration Area was 70 miles behind and A.W.D.s were carrying all the load and finding it beyond their capacity, largely owing to difficulties in liaison, in particular wireless communication and obtaining spares. The speed of advance was so great that recovery was to three widely separated points on the axis for each day's advance. A.W.D.s found themselves unable to cope with the repairs partly because of the time involved in making frequent moves and partly because of lack of personnel. A skeleton force had still to be left with 2nd Line Workshops though these were only dealing with minor repairs occurring in the Administration Area, and were therefore only partially employed. The stop in the SEINE area was too short to allow of any change in organisation.

29th

August: (d) Across the SEINE.

A.W.D.s were done away with. 2nd line workshops were moved up to Rear Division H.Q., moving with A Echelons. This system of movement worked satisfactorily for one day while Division was moving up on the axis, one armoured, the other infantry, but when owing to a broken bridge the advance was forced onto one axis, then the increase in the length of the Rear Division A echelons was considered too great.

It was planned that 1st line workshops should only do repairs normally done by the crews (i.e. undertake the tasks of a repair crew in the German army) while 2nd line workshops should undertake work normally done by 1st line workshops; 3rd line taking work done normally by 2nd line workshops, and so on.

30th

August -

15th Sep: (e) NORTHERN FRANCE:

2nd Line workshops were kept with Rear Division H.Q. but moved 24 hrs later subject to road clearance. This worked smoothly, the advantages being that this did not increase the length of the A echelons yet the workshops were kept well up, the moves could usually be made quicker than when moving with Rear H.Q. since the move was made alone, workshops were not blud by L.W.Ds, good wireless communication and centralised control were kept.

The next fortnight showed that this system avoided the danger of tanks with only small defects not being repaired for several days, and CROMIE of the division and his staff considered it the most satisfactory yet evolved.

Provision of Spare Parts.

9. Towards the end of the pursuit phase, and perhaps one of the causes of its end, the problem of spare parts became acute and many repairs could not be undertaken except by cannibalisation. This was particularly so with regard to bogie wheels and suspension parts. It is possible that more flexible priorities for tank spares would have avoided some of these difficulties. Table IV gives examples of these difficulties.

TABLE IV.

Stores asked for on or before
7 Sep 44.

5 Quercy Armoured Div.

250 Bogies	for Shermans
20 Idlers	-do-
30 prs of tracks	-do-
20 Top rollers	-do-
10 Sprockets	-do-
10 Sprocket hubs	-do-
500 Sprocket bolts	-do-
25 Engines	-do-

At this period all spare bogies had been used and though some of these requests were for replacements which were not at once needed, many of them were for immediate repairs. Most of these had not arrived by 14th September though opportunities for repair had occurred.

11 Armoured Division.

200 Bogies	for Shermans
(78 received by 12 Sep)	
100 Idlers	for Shermans
36 prs tracks	-do-
50 Top rollers	-do-

Other requirements were asked for but the above were considered essential to carry out repairs for which 13th and 14th September had been set aside. By the morning of the 13th these spares had not arrived.

10. In the event 30 Corps used air transport but tank spares did not arrive till a reserve of petrol had been landed.

REPORT NO. 32.

REPORT ON THE ARMoured PURSUIT AFTER THE CROSSING OF THE RHINE.INTRODUCTION.

1. The present paper is an appreciation of some of the experiences of our Armour in its break out after crossing the Rhine. It attempts to draw attention to the principal factors governing the speed of advance in these operations.

2. From previous personal experience and from conversations with other soldiers it was accepted that three main causes are responsible for slowing down an Armoured break-out or pursuit; namely:-

- (a) Enemy resistance.
- (b) Difficulty of supply and repair.
- (c) The desire of soldiers to enjoy the "fruits of victory".

3. The previous main armoured break-out of the campaign had been in September 1944 after the FALLISE pocket. On this occasion enemy resistance had been a minor factor and the pursuit had been ended by difficulties of supply and repair (No. 2 O.R.S. Report No. 18), and perhaps to a limited extent by the enjoyment of the fruits of victory. On the present occasion since the advance might be slowed down by hostile country it was expected that supply and repair would not be major difficulties and that the fruits of victory, in a land of non-fraternisation, would not prove a temptation. It is considered that the drive did, in fact, supply a test for overcoming enemy resistance freed from the complexities of supply breakdowns and of soldiers fraternising.

4. The present writer studied in the field the successes of the 7th and 11th Armoured Divisions during the pursuit up to the end of hostilities. The 7th Armoured Division was equipped with Cromwell and the 11th Armoured Division with Comet tanks.

RESULTS.

5. Difficulty was experienced in the investigation owing to the variety of opinions expressed as to the causes of any hold up and, above all, of their relative importance. The following causes were generally agreed to have been operative:-

- (a) German A.Tk and SP guns.
- (b) Hostile Infantry, particularly in woods, armed with hollow charge weapons for use against tanks.
- (c) Pockets of hostile Infantry, particularly in woods, armed with M.Gs. etc., able to attack soft-skinned vehicles.
- (d) Mined belts of ground.
- (e) Areas in which our tanks bogged.
- (f) River crossings and bridging problems.
- (g) Poor roads placing a strain on echelon personnel.
- (h) Difficulty in keeping wireless communication between different units.

6. Since the relative frequency of occurrence and importance of these causes varied greatly, the facts concerning each will be given separately before any general discussion is attempted.

German A.Tk and SP guns.

7. Only limited numbers of these were met. The difference, however, between the value of the towed or railway A.Tk gun and the SP Gun was marked. Generally speaking towed or railway A.Tk guns were either by-passed, out-flanked or taken without much difficulty. For instance, towed A.Tk guns were for long by-passed in the Forests of MUNSTER (MR.XR 6038) and LINTHE (MR.XR 6730); the 7th Armoured Division axis being the SOLTU - HAMBURG road on the west and that of the 11th Armoured Division to the east of the CELLE - LUNESBURG road. The guns in the forests were unable to be of nuisance except to those vehicles moving from one axis to the other. Similarly, at RETHEN (MR.XR 1267) a train with dual purpose 88 mm guns was destroyed when it was pinned down, the railway line in either direction being held by tanks.

* Fuller descriptions of areas quoted in the text are given in the Appendix.

8. By contrast, the SP guns met were more dangerous. For example 2 SP guns destroyed 6 Comet tanks and assisted in holding up 29th Armoured Brigade's advance at ENCKEN (HR. IX 3256) on 16th April, 1945. This difference in value between towed Lk and SP guns confirms American experience in the LADENWES battle (December 1944 - January 1945). There it was found that the large arc of fire of the American SP guns and their mobility under HE fire made them extremely effective against the German tanks that broke through.

In the present instance it was only where German morale had almost completely collapsed, as it did after our crossing of the Elbe, that their SP guns failed seriously to worry our forces.

Infantry armed with hollow charge weapons.

9. Concentrations of hollow charge infantry weapons were the most novel feature in the German defence. It was estimated by 11th Armoured Division CREME that at least half the tanks knocked out by the enemy after the break-out were damaged by these weapons. They were used in every conceivable manner, a small proportion fired by men who had climbed trees and aimed down on the tanks hitting either the hull dock or turret top (e.g. the defence of the area around and to the north of LOCCUM (HR. IV 0629)). The tank crews found the greatest difficulty in spotting such hidden infantry and were rarely able to destroy them unless the tank was missed. Most areas where such forces abounded had to be cleared by infantry supported by tanks. Owing to the speed of the advance between the NINE and ELBE the Armoured Divisions had often to rely upon their own infantry who were sometimes too few for the task. In consequence hostile pockets were often left behind close to supply routes (e.g. the hostile pocket in the forest of NIENBERG (HR. IX 0843), which was along one side of a main supply route of 11th Armoured Division).

10. No trace could be found that the Volksturm were willing to use hollow charge weapons, as if the courage needed were too great. Indeed, it is doubtful if any forces except the S.S. and Marines were at this period firing hollow charge projectiles on a large scale. The area was extremely wooded which helped give cover, but many instances occurred of men firing from ditches or hedges in the open. After this experience it is felt that the concentrated use of hollow charge weapons in the hands of determined men must be accepted as a growing menace to the tank.

Pockets of Hostile Infantry attacking soft-skinned vehicles.

11. Pockets of hostile infantry capable of attacking soft-skinned vehicles were frequently left behind, particularly in the large wooded areas between OSNABRUCK, BREMEN, HAMBURG and LUNEBURG (HR. VS 7821). Many of the infantry in these pockets, even when the opportunity came, did not interfere with operations or transport, though troops of good morale did so. It was rarely anybody was attacked on main axis routes but one or two cases daily would happen off those routes. Exact figures for such losses could not be obtained but they were certainly not serious from a military point of view. Most people, however, remarked upon their inability to use certain roads, the extra lengths of journeys and the slightly disturbing effect on the morale of the already tired drivers. Noticeable as these things were, it is doubtful if much military importance attached to them. Had the enemy troops been of better morale the matter would certainly have been otherwise.

12. The reason why such hostile pockets were left behind was undoubtedly the speed of advance of the Armoured Division in pursuit. By contrast, the first two days after 11 Armoured Division had crossed the ELBE they accepted a lower rate of advance in terms of the opposition met. In these circumstances far fewer pockets of resistance were left behind on the route which 29th Armoured Brigade followed. (The line SCHWARZENBERG HR. RS 8249 to BASTHOF HR. RS 8257 and northward).

Mined belts of Ground.

13. Except for a few cases of mined roads and verges (e.g. RIESSENBERG HR. RV 9307; HAMBURG HR. RW 9436; the verges between ELKHORST and TALKAN HR. RS 8756) there were few German Lk mines. The view was generally expressed that this was because the Germans were in their own land and would not endanger their own civilians. This may have been a deterrent but it must be remembered that in the previous pursuit from the SEINE to DUISBURG and AMSTERDAM equally few mines were met. The more likely explanation would seem to be that in a fast pursuit the enemy cannot lay mines because so many of their troops are up to the last minute trying to withdraw. In this view lack of mines is one of the advantages gained from speed in the pursuit.

Areas in which our tanks bogged.

14. Considering that operations were taking place in April the number of tanks that bogged was large. In several areas the percentage was between 20% and 30% of tanks engaged and sometimes higher. (e.g. area around HR. RW 7535). On occasions the recovery equipment was found not to be really satisfactory for the heavy soil encountered (e.g. area around HR. RI 0547).



15. The opinion of the crews of the Comet tanks, as well as of Brigadier R. Harvey, D.S.O. (29th Armoured Brigade) was that the Comet tank was not really liable to bog and was less satisfactory than the Sherman in this respect though in no other. It would be unfair on the evidence of one series of attacks to condemn the going of this tank absolutely but there is no doubt that on this occasion its going was not up to operational requirements. In certain cases bad driving was responsible, particularly a lack of awareness of the power transmitted by the engine to the tracks so that these were spun and cut into the soil; but in far more instances, in spite of good driving, the tank bogged. Fortunately because the enemy did not mount any counter-attacks all the bogged tanks were finally recovered. Out of a total of 66 tanks that were knocked out and studied the number that could be traced as actually dragged while bogged or in difficulties was 8 from the two armoured divisions, or about 12%. It is not certain, however, that 2, 3 or even 4 of these might not have been knocked out in any case and the fact that they were at rest only made their destruction more certain.

16. A study of the "tank going" maps for N.W. Europe issued by the Geological Section 21 A.Gp shows the difficulty of choosing ground free of bog areas and raises the query whether, in fact, a better performance for "going" would not be worth while even at some cost of manoeuvrability on roads etc.

River Crossings and Bridges.

17. At present the higher speeds of advance of an armoured division are largely governed by the division's ability to seize intact bridges; this in turn largely depends on surprise and speed in approaching the bridges. For instance, the success of 6th Airborne Division in capturing intact bridges with armed Jeeps was at least equal to that of 7th and 11th Armoured Divisions.

18. Though in a certain number of cases bridges were successfully taken intact (e.g. several of the bridges over the EIS - WESER canal) in other cases Bailey bridging had to be used (e.g. over the WESER, LEINE and ALLER rivers). This demand led to over-working of the R.E.s. of the division, including comparatively heavy losses, and to a shortage of bridging material. At MR. RX 3057 a Bailey bridge was set up across the ALLER river and 11th Armoured Division crossed it holding the right bank in rather narrow depth against opposition. Owing to enemy SP guns and Marine forces preventing our forward movement the axis of advance had to be shifted to the east along the line WIMSEN (MR. RX 4755) - BELSEN (MR. RX 4868). Due to shortage of bridging material the former bridge had to be taken down and put up on the new axis crossing at WIMSEN. This was done successfully but it would clearly have been safer had there been sufficient material for two bridges. Against this would have been the still greater load on transport.

19. Most of the units visited considered that river-crossing had been one of the chief factors governing their rate and direction of advance.

Poor roads on the lines of communication.

20. Several of the echelon personnel interviewed were of the opinion that some of the routing made their task difficult. They claimed that in many cases supply routes in forward areas were so rough that movement was slow and tortuous (e.g. Star route up between NIENBURG MR. RX 9951 and RETZEN MR. RX 1166). Then when they came to forward areas, often not fully cleared of enemy, they were expected to travel with dash and daring. They insisted that hours of slow and tedious driving were not the best preparation for such a task and that American drivers were not handicapped in this way.

21. The present writer has insufficient evidence to judge the comparative traffic performance of British and American military traffic. From brief studies of American traffic after their break-through on the right wing in Normandy and a quick survey in the Brunswick area of the American supply routes to Magdeburg it is his impression that American traffic in these cases did move more quickly but that as better roads were available it would be unsafe to generalize on this point.

22. It was also noticed in the British sector over the Rhine that traffic-congestion was sufficiently frequent for most drivers to have become resigned to long waits and that they made few attempts to find a remedy. By contrast with American traffic, the two main causes of such congestions were double-banking by convoys and failure to halt with proper spacing so that if a muddle occurred it was not easy to cure. Drivers insisted that if they kept proper spacing other convoys infiltrated, taking unfair advantage of good road discipline.

23. Until proper road discipline is enforced it is probably impossible to restore a sense of urgency amongst drivers. Even if supplies did not run short it is felt this lack of urgency amongst echelon personnel makes the general quality of dash and enterprise harder to maintain in the armoured division as a whole.

Difficulty in wireless communication.

24. Numerous moves had to be made by Divisional Headquarters to ensure good wireless communications. No instance is known of serious failures and though greater ease of communication is undoubtedly a worth while ideal, it is doubtful if this problem affected the pursuit after crossing the RHINE. This was in contrast to experience after the SEINE break-through.

DISCUSSION.

25. After studying the available facts and interviewing tank personnel it is considered that the key to success and safety in an armoured break-out against enemy resistance is an ability to move fast. The actual speeds required depend upon enemy resistance, but generally speaking the faster the movement the better. Thus the problem becomes that of deciding what factors have been most responsible for checking movement in the face of limited opposition.

26. It must be realised that at no time were the enemy able to maintain a continuous line of resistance. This, however, is normal in a break-out and is part of the general problem. The question to be solved is how against pockets of resistance the greatest speed of advance can be maintained.

27. The fact, however, that the enemy forms a discontinuous defence against armour needs to be treated with caution. In many cases the discontinuities are filled up by country which is either too bad for our present tanks to pass or else certain lines of advance are not worth making because they lead to a river without bridging facilities. Indeed, if it is accepted that woods are unsuitable for tanks, then by combining this with bad going it can be shown that apart from roads the area to be defended against tanks was small in the pursuit over the Rhine.

28. If the areas to be defended are small, it is hard to see how really fast advances can be made against a determined enemy. For fast advances it is essential to by-pass and outflank the enemy. To attain this there would appear to be two alternatives: to design tanks either invulnerable to hollow charge weapons or else tanks that do not bog; (or both).

29. There is also a requirement for the tanks of an Armoured Division to be able to cross small rivers at any point so as to prevent the enemy being able to anticipate lines of advance. This could be done either by designing tanks to wade or by providing better bridging facilities.

30. As far as can be told an Armoured Division that had these qualities would be capable of maintaining a fast break-out and pursuit against all but the strongest defence of SP guns. Moreover it is most unlikely the enemy will possess the necessary quantity of SP guns for this purpose since he will almost certainly have used them earlier to contain our forces. Such an Armoured Division could travel with safety over bad going and through woods and could maintain speed when rivers were to be crossed. It is considered that the enemy could be sufficiently spread-angled by such methods to be incapable of serious resistance.

APPENDIXDESCRIPTION OF EXAMPLES IN TEXT.Para in Text.

7 The forests of Munster and Lintzel covered about 200 sq. kilometres. The exact number of German troops in the area was estimated at the time as more than 1000 and it was known that they held at least four 88 mm A.Tk guns. These guns were responsible for knocking out several jeeps and two or three armoured cars but the main divisional axis supply routes were uninterrupted though the German force was not overcome for ten days. As far as is known these guns were never successfully moved so they could have been used to bear on our supply routes and had they done so they could almost certainly have been neutralised by our 25 pdr artillery that was held in readiness for such a task.

The railway line at Rethem runs roughly E and W and is south of the town so that it covers the town against any force attacking northwards. The Germans placed at this point a train mounted with five 88 mm dual purpose guns so that it denied the crossing of the Aller. The ground to the south of the train was open and any tanks attacking across it were exposed. Because, however, the train could be pinned down on the flanks and made immobile so that effective covering fire could be put down against it, the train was captured by direct assault of a squadron of tanks without loss.

6 The tanks destroyed close to Engelen had just crossed the River Aller and were deploying on the right hand side of the divisional axis up to Osterholtz (NR 3466). They were on flat ground facing a wood which lay on the north side of the Winsen - Budersleben road. The going was bad on the flat ground and two German SP guns were able to use their mobility to pick off our tanks, withdrawing safely into the wood as soon as they were observed. Under the same conditions a towed A.Tk gun would almost certainly have quickly been neutralised.

Para in text.

9 The forest of Nienburg is about 20 sq. kilometres and lies between the two axes up which 11th Armoured Division was moving: namely the Rehburg - Scheeren - Ellwase road and the Rehburg - Husum - Linsburg road. At the forest of Nienburg these two roads are separated by about 10 kilometres and, rather than clear this area immediately, the Division continued to advance for two days. Since the Rehburg - Scheeren - Ellwase road ran along the side of this wood the soft skinned vehicles of the echelons ran a certain amount of risk when they were not accompanied by tanks.

14 The areas RW 7535 and V. 0547 consisted of a peat soil. Through-out the lines of advance of the 7th and 11th Armoured Divisions such peat areas were continually met. Since in several cases these were marked on the maps as "floors" it may be wondered why tanks attempted to cross them. In actual appearance however, much of the area consisted of pasture fields which gave the appearance of firm going. If a tank was resting on such pasture it would sometimes hold up for several minutes before suddenly sinking. When once tanks had started to sink they would sometimes go down 7 or 8 ft before they could be recovered.

PART IV.**INFANTRY, ANTI-TANK, ETC.**

Chapter 12. Infantry.

Chapter 13. Anti-tank.

Chapter 14. Organisation.

CHAPTER 12.

INFANTRY.

CONTENTS

Infantry Officer Casualties	(Report No. 19)
Location of Enemy Mortars	(Report No. 11)

REPORT NO. 19

INFANTRY OFFICER CASUALTIES.Introduction.

1. The report describes an investigation into various aspects of Infantry officer casualties. The subject is dealt with under the following headings:

1. The proportion of Officer casualties to Other Rank casualties.
2. Officer casualties by appointments.
3. Officer mortality ratios.
4. Distribution and causes of Officer casualties -
By phase of the battle;
By weapons;
By activity at the time of becoming a casualty.
5. Reduction of Officer casualties.

2. The information has been collected from Infantry battalions and from the records of GHQ 2nd Echelon. The latter have been analysed with the help of A.O.R.O., Ministry of Supply.

3. Although most of the report is concerned specifically with officer casualties, it is likely that the conclusions on the reduction of casualties will apply in general to Other Ranks.

The Proportion of Officer Casualties to Other Rank Casualties.

4. The proportion of officer to other rank casualty rates for the infantry of seven different divisions are given below:

<u>TABLE I</u>	Proportion Officer to Other Rank Casualty Rates	by which other Divs exceed 15 and 53 Divs
15 Div	1.28	0
53	1.28	0
43	1.33	4
50	1.48	18
3	1.51	18
49	1.64	28
51	1.70	33

These figures are for the period 1st August - 6th November, for which fully reliable records are available. They take into account the relative strengths of officers and other ranks in the Divisions.

5. The variations between divisions are striking, but the reasons for these variations are not apparent.

Officer casualties by Appointments.

6. An analysis of 2,407 Infantry casualties from the same seven divisions, suffered between 6th June and 6th November, gave the following casualty rates for different appointments, per month.

<u>TABLE II</u>		
Rifle Pl Comd		31.2
Rifle Coy Comd		30.0
2 1/6 Rifle Coy		20.1
C.O.		18.0
1.O.		16.0
A/Tk Pl Comd		14.8
Carrier Pl Comd		13.9
Mortar Pl Comd		11.8
Pioneer Pl Comd)	9.8
Sig Offr)	9.8
Adjutant		9.5
2 1/6		7.7
Support Coy Comd		6.2
2 1/6 Carrier Pl)	5.9
2 1/6 A/Tk Pl)	5.9
HQ Coy Comd		3.5
Tpt Offr		3.0
Adm Offr		1.8

7. These figures assume the full establishment of a battalion, and take into account that various of the Divisions did not arrive in the theatre for some time after D-day. In fact, various appointments, in particular Pl Comd, were seldom on full establishment, so that their casualty rates were probably higher than they appear, but it is not possible to make any allowance for this. The figures may be of value in the allocation of personnel in the training and drifting stages.

Officer Mortality Ratios.

8. The percentage of officers killed out of officers killed and wounded varies in different appointments. In the majority of appointments the total number of casualties so far sustained in the seven divisions is not enough to give a firm mortality ratio but in some cases this is possible:

<u>TABLE III</u>	<u>% Mortality Ratios</u>	<u>Number of Casualties on which ratio is based</u>
C.O.	38.9	99
Coy Comd	32.6	389
Pl Comd	28.9	1190
2 i/c Coy	27.1	258
I.O.	26.4	53
Lt/Tk Pl Comd	22.9	46

9. It is suggested that the very considerable variations may be connected with the immediate availability of medical services, with the different types of risk to which various officers are exposed, and the extent to which various ranks carry on when wounded.

10. The officer mortality ratios in the different divisions also show considerable variation:

<u>TABLE IV</u>	<u>% Mortality Ratios</u>
51 Div	24.2
3	27.0
49	27.3
43	28.4
15	28.9
53	32.1
50	35.0

Distribution and causes of casualties.

11. 262 casualties, taken from 8 battalions out of 3, 15, 43 and 49 Divs were examined in as much detail as possible. The findings are tabulated and then discussed:

TABLE V Distribution of officer casualties casualties in different phases of battle (226 cases):

Attack (Forming up, attack, reorganisation)	69
Defence	23
Patrols	8
	<hr/>
	100

TABLE VI Weapons responsible for officer casualties (216 cases):

HE (shells and mortars)	57
SM.	35
Mines	6
Miscellaneous	2
	<hr/>
	100

TABLE VII Distribution of officer casualties according to their exact occupation at the time (163 cases):

Close fighting (within 500 yds of enemy)	40
Moving from one position to another, visiting troops, etc.	18

Table VII (Cont'd.)

In FUPs or concentration areas	13
In slit trenches in defensive positions	8
In command posts	8
On reconnaissance	6
Miscellaneous	7
	<hr/> 100

12. Of the 163 cases referred to in Table VII, 23, could be directly attributed to things going wrong:

TABLE VIII.

Wireless not working	5
Running into own mines	3 1/2
Bad reconnaissance or orders	3 1/2
Bad map reading or intelligence -	3 1/2
going into enemy lines	3
'Swarming' - unnecessary movement	2 1/2
Inexperience	2 1/2
Accidents with own weapons	2 1/2
Shot by own sentries	1 1/2
Conspicuousness	1
	<hr/> 23

Reduction of Casualties.

13. Table V shows that the defensive phase (Defence 23, Patrols 8) accounts for nearly one-third of all officer casualties. Casualties in defence are therefore particularly worth attention, as a reduction is most likely to be achieved in this phase, where there may be no actual fighting, or if there is, it is of a less confused nature.

14. Table VI cannot be considered completely reliable but it indicates in a general way that about two-fifths of casualties are caused by forward enemy troops and forward enemy defences (S.M. 35, Mines 6) and about three-fifths by guns and mortars sited further back (HE 57). The lesson to be drawn, which will be referred to again, is that there is at least as much to be done in reducing casualties by improving CB and CM methods alone as by improving the Infantry's tactics or training.

15. Tables VII and VIII give a more detailed idea of how, and to what extent, Infantry casualties might be saved. Two obvious, though minor, causes of trouble are command posts and wireless. With regard to the first, the complaint is often heard that we are not as careful or thorough as the enemy in choosing or building command posts, and the 7. of casualties caused actually in command posts should certainly be eliminated by more effort in this direction. As regards the second, although only 3 1/2 of casualties were directly attributed to wireless breaking down, the opinion was expressed by many officers that the failure or absence of wireless communications meant more moving round by officers at a critical period. In particular, some of the 18 of casualties caused in visiting or inspecting troops or positions might have been eliminated.

16. Except for the two improvements mentioned above, it is not possible to make firm recommendations for any particular action; it is however possible to give some idea of where the responsibilities lie. The casualties occurring in close fighting can be reckoned perhaps as half the Infantry's responsibility, to be improved if possible by better tactics, etc., and half the responsibility of the supporting arms, for adequate covering fire on forward defences. Those occurring on reconnaissance may similarly be accounted as a half and half responsibility. The casualties in FUPs and concentration areas, those incurred in moving from one position to another, and those suffered in slit trenches in defensive positions, are to be reckoned as a supporting arm responsibility, while the miscellaneous casualties, and those where things went wrong are an Infantry responsibility. This tentative allocation of responsibilities gives a "balance sheet" as follows:

TABLE IX	Infantry responsibility	Supporting Arm responsibility	
	Half of casualties in close fighting	Half of casualties in close fighting	5
	Half of casualties on reconnaissance	Half of casualties on reconnaissance	18
	Casualties in Command Posts	Casualties in FUPs, etc	3
	Miscellaneous casualties	Casualties in or moving from one position to another, visiting troops, etc.	10
	Casualties due to things going wrong (excepting wireless breakdowns 3/2)	Casualties in slit trenches in defensive positions	10
			6
	<hr/> 50		<hr/> 47

NOTE: The casualties caused by things going wrong have been removed from the various categories above, and put in as a separate entry under Infantry; hence the discrepancies as against Table VII

17. This means, in very broad terms, that about half of the Infantry casualties, if they are to be reduced at all, can only be reduced by the Infantry; the other half, if they are to be reduced at all, can only be reduced by the supporting arms. This conclusion is in general agreement with that of para. 16, arrived at in quite a different way.

18. Of the casualties that could be reduced by the Infantry themselves, we have already dealt with command post casualties. For the rest it would seem that a higher standard of training all round is the only way to get an improvement; this should save officers exposing themselves to risks so often, and should also cut out some of the casualties due to mistakes.

19. Of the casualties that could be reduced by the supporting arms, the greater part are caused by enemy mortar and shellfire from behind the lines. The greatest improvement is therefore to be expected from better CI and CS.

20. Finally, it should be explained that although in the course of this work we have heard a great number of reasons put forward for the high rate of Infantry officer casualties, we have not discussed them, mainly because, from their very multiplicity, it is evident that no one or two of them are outstandingly important. The arguments of the preceding paragraphs show that there are only two really important methods of improvement:

- (i) A higher standard of training throughout the Infantry.
- (ii) Better methods of CI and CS;

while there are two less important methods:

- (iii) First class forward wireless equipment.
- (iv) Well constructed dugouts.

REPORT NO. 11.

THE LOCATION OF ENEMY MORTARS

CONTENTS

- I. THE EXTENT OF THE PROBLEM
- II. THE PRESENT POSITION
 1. Organisation.
 2. Relative success of the methods of location.
 3. Details of the methods of location.
 4. Casualties due to mortars.
- III. A DISCUSSION OF THE PROBLEM
 1. The number of mortars and Nebelwerfers on a Divisional front.
 2. The requirements for effective CM: the extent to which present methods meet these requirements.
 3. The extent to which Q. III and the Four pen recorder may meet these requirements.
 4. Other possible Counter Mortar methods.
- IV. CONCLUSIONS.

I. THE EXTENT OF THE PROBLEM.

The German army uses mortars and Nebelwerfers in large numbers. These weapons are small and difficult to detect from the air; their trajectories make it possible to conceal them completely from ground observation, particularly in close country. The small noise of discharge of the mortar and the ripple fire of the Nebelwerfer make sound ranging difficult, while the flash and smoke from the mortar is slight and hard to spot. In defence the casualties from mortars and Nebelwerfers may be considerable, while the strain of holding a position and being mortared for days on end is intense. In attack the casualties in forming up areas and on the objective may be very heavy indeed, and are often decisive in throwing back an attack. In either attack or defence, mortars can make movement in forward areas difficult.

So much has long been realised. In the present campaign, however, casualties from mortars have been particularly heavy and have contributed as much as anything else to making advances slow and costly. The enemy's mortars are as much a weapon to be defeated as his tanks. This will continue as long as fighting goes on in undulating and cultivated country. Even on the plains of Picardy and Flanders, there is enough cover to conceal mortars, and although their importance may decline, they are still likely to prove a great source of trouble.

In view of this, a short survey has been made of the position in six different divisions in order to find out what methods have given the best results, what immediate improvements, if any, can be suggested, and what new methods could be applied. The survey is only concerned with the present and immediate future, and new equipments under development have not, therefore, been considered.

II. THE PRESENT POSITION.

1. Organisation.

There is at present no official organisation for Counter mortar work in the British Army. Within a generally agreed framework, formations have built up their own organisation. At Divisional HQ there is a Counter Mortar Officer, usually a gunner, with sometimes a deputy, and a number of other ranks to plot and run communications. The CMO is in touch by one means or another with some or all of the following:-

- | | |
|-----------------|---|
| (a) Gunner OP's | (In some cases specially deployed for mortar location). |
| (b) Air O.P.'s | |
| (c) APIS | |

- (d) Infantry Brigades (who may have an ACHO to collect and pass on all possible information from the forward troops).
- (e) Surrey Regiment (who may get mortar locations in the course of normal sound ranging).
- (f) Four pen recorder team.
- (g) GL III
- (h) Counter Mortar Group (a few guns and mortars are sometimes deployed, at the call of CMO's or ACHO's for counter mortar shoots).
- (i) Divisional HQ, RA. (to get concentrations put down as and when required).

Until further experience has been gained the variability of this makeshift organization and of its communications is inevitable. There is, however, unanimous agreement in Divisions that some sort of establishment is urgently needed, at least for a CMO and staff at Divisional HQ RA, and, if possible, for Gunner Counter Mortar OPs and Infantry ACHOs at Brigades. At present the necessary personnel are taken with difficulty from many different places, in particular the LAA Regiment.

2. Relative Success of the Methods of Location.

A large number of methods of mortar location have been suggested and are being tried out in the present campaign. These are:

- a. Aural sound bearings.
- b. Air photographs.
- c. Air OP.
- d. Flash spotting, visual spotting, etc.
- e. Normal sound ranging.
- f. Four pen recorders.
- g. GL III.

Two further methods have been suggested, but have scarcely been used so far:

- h. Flash - bang timings.
- i. Estimation from craters.

The success of these methods is difficult to estimate. In only a very few cases is any subsequent check possible as to whether the location was accurate or even genuine at all. In general it can be assumed that air photographs and Air OP locations are the most accurate. Four pen recorder and GL III locations second, and Sound bearing locations least accurate. But with every method there is the possibility that some of the locations are, for one reason or another, completely false. For purposes of comparison it can only be assumed that all locations recorded are, in fact, genuine.

At present, therefore, no attempt has been made to go beyond an analysis of some of the hostile mortar lists of four divisions. This analysis is set out in Table 1.

Table 1 Analysis of some hostile mortar lists of four divisions. 1, 2, and 3 had neither 4-pen recorder nor GL III. 4 had both GL III and 4 pen recorder for a time, but locations by these means are not included in this table. (Locations shown as %age of the total).

Method	DIVISION			
	1	2	3	4
Sound bearings	30	31	32	93
Air Photographs	54	46	37	Nil
Air OP	11	Nil	Nil	Nil
Flash or visual spotting	Nil	Nil	16	5
Normal SR	5	23	15	2
No. of locations on which based	85	26	67	52

It is clear from this table that the methods of the four divisions differ considerably. All have made extensive use of sound bearings, Division 4 to the exclusion of almost everything else. Divisions 1, 2 and 3 have used Air photographs, while Division 4 has not (this is understood to have been largely due to the fact that there was little Air photograph cover on this front). Only one Division has made successful use of the Air OP, and only two have used flash or visual spotting. Normal sound ranging has been used by all four with varying degrees of success.

This analysis does not give any indication of the number of locations per day. This is difficult to determine exactly, since hostile mortar lists are cumulative, and the other records kept are not usually sufficiently detailed for an accurate analysis. From what evidence could be collected, however, it appears that the number of locations on an active front does not vary much from Division to Division, and is usually about 10 per day. This was the case with Divisions 1, 2 and 3. Division 4 was on a fairly quiet front and only got about half this number per day. The percentage figures for Divisions 1, 2 and 3, therefore, must be divided by 10, and the figures for Division 4 by 20, to get the average number of locations per day by each method.

It is evident from this analysis that a more complete pooling of methods and ideas throughout the Army Group would be valuable, so that every Division should understand and use every method to the full. If each Division of the four under consideration were to do as well in every method as did the best of the four, the number of locations per day would be nearly doubled.

3. Details of the Methods of Location.

(a) Aural sound bearings. When mortar fire is put down, someone is nearly always in a position to get a rough bearing on the noise of discharge. This may not be the troops who are themselves being mortared; more probably it is the troops to one flank or a nearby Gunner OP. Such sound bearings should be passed on at once, together with the time, place and any other relevant information, to the CMO at Division, by whatever channels have been arranged. The extent to which this is actually carried out varies greatly. In some cases, sound bearings are passed back with a delay of only a few minutes, but there is no doubt that even in those Divisions most alive to Counter Mortar work far from all instances of mortaring are in fact reported.

A large number of sound bearings arrive singly and cannot, therefore, be satisfactorily correlated to give locations. Even single bearings, however, may help to determine which of previously located mortars is actually firing, may help to confirm a suspect position or may serve as a search bearing for the Air OP. But a certain number of bearings do come in from different places, referring to the same mortaring, and in the course of time a series of double, triple, or even quadruple intersections are obtained.

Whenever possible, locations obtained from sound bearings are cross-checked with other methods. In particular, a careful scrutiny of Air photographs in the light of sound bearing locations has often given exact fixes. Air OP's have also been used to examine a particular bearing or suspect location.

The accuracy of a sound bearing is uncertain. Some claim to be accurate within 2 degrees, others within 5 degrees. From a few estimates made in battle, it seems likely that both these figures are optimistic. This point is being examined further, and its effect on the accuracy of intersections and the degree of dispersal of fire for best effect, is being considered.

(b) Air photographs. High level air photographs seldom, if ever, show 8 or 12 on mortars, unless they are dug in and their positions poorly camouflaged. Nebelwerfers, on the other hand, usually do show up, and a considerable number may be spotted by APIS. As mentioned earlier, a careful re-scrutiny of a particular suspect area will sometimes show slight evidence that had previously been overlooked.

In some Divisions this method of spotting has been conspicuously successful. Of 46 locations (54%) obtained from air photographs by Division 1 (Table I) 27 were got by a re-examination after sound bearings. In others it has not been used, either because of a lack of photographic cover, or because of a failure to realise its possibilities.

The success of high level cover has led to the suggestion of a lower level cover of small trams of enemy FDL's, with a view to detecting mortars. This is being tried out at present by one Division.

There is one serious objection to Air photograph methods, namely that they are at best very slow and allow the nebelwerfers hours of time in which they can move positions. It is thought, however, that nebelwerfers have a limited number of alternative positions prepared in advance with trenches etc., and that they do not usually move outside them. At present, therefore, the delay in Air photographs is probably not very serious. When counter mortar methods improve, there is no doubt that the Germans will move more often, and that air photographs will become less useful. The same argument applies in some degree to all methods of location.

(c) Air OP. Air OP's have seldom, if ever, spotted mortars, either directly or from flash or smoke. They have, on the other hand, occasionally seen nebelwerfers, usually by means of the flash and smoke of discharge. At present the Air OP is unlikely to spot nebelwerfers if he is simply sent up with no indication, but if he is given an area to search, there is some chance of success.

When he has spotted a nebelwerfer, he can either report its position, and leave the artillery to do a predicted shoot, or himself direct a destructive shoot. The latter is seldom practised, but is in fact likely to be both more effective and far more economical.

There is some evidence that the Germans suspect the Air OP of being able to spot mortars and nebelwerfers, since there are various recorded cases of mortaring ceasing as soon as the Air OP went up.

The further possibilities of the Air OP are discussed later in the paper.

(d) Flash spotting, Visual spotting, etc. Because of their high trajectory, mortars are easily concealed on rear slopes and behind cover. Nebelwerfers, while not employing upper register fire, have quite a high trajectory, and are still fairly easy to conceal. Any form of direct visual spotting from the ground is, therefore, seldom likely to be possible. Occasionally, however, forward troops or OP's may be in a position to see flashes, particularly at night. Flash spotting from 60 ft towers in the wooded and undulating country of Normandy is not often effective, but has given a few locations. The further possibilities of flash spotting are discussed later.

(e) Normal sound ranging. SR bases are normally deployed about 4000 to 5000 yards behind our own FDL's. This ensures that they are reasonably safe, and does not appreciably affect the accuracy of gun location. It does, however, mean that the rather slight noise of discharge of a mortar is seldom picked up. While SR, deployed on normal Counter Battery work, may occasionally get mortar locations, it is not likely to get many unless deployed well forward, specifically for such a task. This is likely to be costly in equipment and trained personnel, neither of which can be spared. In general, too, CB is considered to be of primary importance.

(f) Four pen recorders. Only 3 Four pen recorders have so far been operating with 21 Army Group. Various reports have already been rendered on these equipments by those specifically concerned with them, and it is not, therefore, proposed to deal with them in any detail. In brief, they have suffered from various electrical troubles, and there has been a shortage of trained personnel to keep them in working order. There has also been difficulty in keeping the line base intact, because of shelling and our own tracked vehicles. When, however, the sets have been working satisfactorily, they have obtained a good number of locations. In one instance, a set deployed with a Division on a quiet front, obtained 37 different locations in 14 days. Much of this time the set was not working satisfactorily, and at its best, it gave 8 locations in one day (2 'A', 4 'B', 1 'C', and 1 'Area' location).

It has become apparent that the Regimental Survey Officer and a party of Gunners and Infantrymen cannot at present effectively operate the Four pen recorder. It is generally felt that 2 Officers and at least a dozen Other Ranks, specially trained for the job, are essential.

The accuracy of the Four pen recorder, under good conditions, is estimated as within 50 yards up to 2,250 and within 250-350 yards up to 5,000 yards. This is about the maximum range against mortars.

It is understood that a Four pen recorder base is not likely to be surveyed in and working in under about 24 hours of a move forward. Once the base is working, however, the production of locations is only a matter of a minute or two from hearing the noise of discharge.

Like all SR equipments, the Four pen recorder cannot operate in strong winds or in the presence of much activity from guns, mortars or machine guns. This, and the long time into action, is likely to limit the Four pen recorder to fairly quiet, static, or semi-static fronts. It will not, however, deal with the situations where Counter Mortar methods are most needed, namely in the various stages of an advance and consolidation.

(g) CL.III. An unmodified CL III was tried out in the early days of the invasion in an operational Mortar location role. It had little success, but after a period of training for the operators and a number of modifications to the set, it has been tried again. In the space of three days on a fairly quiet front it obtained 33 locations, on an average of 11 a day. It was later moved to two different sites and met with much less success. The indication of a mortar bomb on the tube is very characteristic, and it is reasonably certain that all the locations were in fact mortars, except for one which consisted of a number of brocks on the tube in rapid succession, and was presumably a nebelwerfer. Shellbursts and vehicles were also picked up on the set. The details of the performance of the set are being reported by the Corps and Division in question, and are not considered further in this paper.

It is clear, therefore, that GL III has considerable possibilities, but it seems likely that difficulty will be experienced in getting good sites, and that this may prove to be a limiting factor. Further GL's are to be deployed in operational roles in the near future and more definite information should soon be available.

So far, mortar bombs have been detected out to 7,000 yards, except for the nebelwerfer cluster referred to above which was detected at 11,000 yards.

Once a suitable site has been selected, the GL can be quickly in action and given a good site a very accurate location can be obtained with 3 or even 2 bombs.

The conspicuousness of the GL may render its use in open country difficult, and once the enemy is aware that it is being used for mortar location, it is a relatively easy matter for him to fix its position by DF and put down a concentration on it.

(h) Timings - Sound of discharge to Burst. This method of timing can be used to get quite an accurate range. There are, however, several difficulties, in that it is necessary to know what sort of weapon is firing, which probably means examining the craters for fragments, and it is necessary also to associate a particular noise of discharge with the right explosion. Even when this has been done there are always at least two possible solutions, depending on the charge that is being used, while any displacement of the observer from the line of flight introduces further complications. In practice there have been very few instances of this method being used, although there is no reason why it might not sometimes be successful in the hands of intelligent Gunner OP's.

The provision of some form of simple calculating ruler for this method is being considered.

(i) Crater examination. A means of locating mortars from various characteristics of their craters was devised by School of Artillery. This is not satisfactory for giving range, but is capable of giving a reasonably accurate bearing, on good smooth ground. The practical application of this method has several difficulties, and in fact there are very few instances in which it has been successfully used. Nevertheless, it is possible again that in the hands of trained Gunner OP's, it might sometimes be useful.

(j) Study of the Map. Study of the map is not in itself a means of locating mortars, but it is widely used to decide on likely places, to decide the most likely point in a suspect area, to rule out impossible positions and etc.

4. Casualties due to Mortars.

The casualties in the present campaign from mortars have been very heavy, heavier in fact than from all the other weapons put together, at least as far as the Infantry are concerned. This is due to a number of causes:-

- (a) The Germans have a large number of mortars and nebelwerfers, and use them widely, while they have relatively little Artillery.
- (b) Counter mortar methods are only partially developed and have not reached the degree of efficiency achieved by CB.
- (c) Mortar bombs have a high charge/weight ratio and an efficient fragmentation. Their angle of descent results in a well distributed fragment pattern, while there is some evidence that it also results in a higher density of fragments near the ground, and consequently the protection given by lying down is less than with a shell. This knowledge is borne out in a rough and ready way by medical information.

Exact figures for mortar casualties are hard to get. Medical records only show the weapon causing the casualty in a few cases. A number of Infantry battalion MO's, from four different Divisions all agreed in placing the proportion of mortar casualties to total casualties among their own troops as above 70%. This figure is widely accepted among Infantrymen, and it is thought if anything to be an underestimate.

The records of 'A' branch, 2nd Army give the total casualties among Infantry battalions of 2nd British and 1st Canadian Armies up to 25th July 1944, as 35,431. 70% of this figure is approximately 25,000. It is appreciated that the estimate of 70% may be appreciably in error, and that the figure of 35,531 includes a number of captured. On the other hand there are undoubtedly a large number of casualties due to mortars among units other than Infantry battalions. It is safe, therefore, to say that the casualties due to mortars and nebelwerfers among British and Canadian troops in the first 7 weeks of the fighting, have been over 25,000.

III. A DISCUSSION OF THE PROBLEM.

1. The number of mortars and nobelwerfers on a Divisional front.

The number of mortars and nobelwerfers opposite a Divisional front cannot be determined from the number of locations obtained, since there is no indication as to how complete they are. A rough estimate from what is known of the organization of the German army is however possible.

A German Infantry Division has 57 8 cm mortars, and at present a variable number, between 12 and 20, 12 cm mortars. A Panzer Division, having less Infantry, has only 20 8 cm mortars, and 12 12 cm mortars. Nobelwerfers do not form a part of Divisions, but are, on this front, usually deployed on the scale of one Regiment (54 projectors) to a Division.

Roughly speaking, one of our Divisions is faced in the line by one German Division, or its equivalent, so that opposite most of our Divisional fronts, between 40 and 80 mortars are likely to be present, and about 50 nobelwerfers. Some of these will be in reserve, and some of the units will not be up to strength. As an estimate of deployed and potentially active weapons we might take 60 - 80. Many of these, particularly the nobelwerfers, will fire in groups; on the other hand they will have a number of alternative positions. So that the number of Hostile Mortar positions to be located on a Divisional front is likely to be at least 60 - 80 and possibly more.

Various other types of mortar and nobelwerfer may be encountered, but not in any numbers.

2. The requirements for effective CM: the extent to which present methods meet these requirements.

To be fully effective, a CM organization must be able to provide locations rapidly and in quick succession, however much activity there may be, and to bring down fire equally rapidly on the locations provided. The latter part of the requirement is already met by the highly flexible Gunner organization for controlling fire. The provision of locations on the other hand has a long way to go.

It is uncertain what degree of success is achieved at present. By the expenditure of large quantities of ammunition on fixed and on suspected positions, mortaring can be silenced for a time, but often starts up again soon afterwards. There are a few reports from civilians of fire landing on mortar positions, and from PW's of their exposing and getting immediate retaliation. It must be remembered, however, that these reports are from relatively static fronts, where after a period of time a good proportion of sites are located, and that quite often the weight of retaliatory fire put down is so great that a few shells can hardly fail to land in the vicinity of positions.

After a period of some days in a static position, the present methods of sound bearings, air photographs, Air OP and occasional SR and Flash spotting, do locate a considerable number of mortar and nobelwerfer positions, some fixed (reasonably certain) and some unfixed (only suspect). These are made up into a hostile mortar list which is continually amended. The size of these lists vary considerably from Division to Division, and depend on the length of time there has been to build them up and on the amount of enemy activity there has been on the front in question. It has already been mentioned that on fairly active fronts, most divisions get on the average about 10 locations per day, so that at the end of a week if there has been no change of front there may be as many as 70 locations on the Hostile Mortar list. By this time the CM situation is reasonably in hand, in the sense that any mortaring can at once be met with effective counter fire, and enemy activity then usually declines. But with any move it breaks out afresh from new positions and the slow process of location has then to start again.

As indicated earlier, a more complete utilization of these simple methods should give a great improvement, and for the first few days in a new position should nearly double the number of locations. This would mean getting the enemy mortars more or less under control in perhaps half the time.

It should be noted that the figure of at least 60 - 80 hostile mortar positions on a Divisional front tallies with the figure of about 70 locations on a hostile mortar list, required in order to get the Counter Mortar position in hand. In view of this it is recommended that as a target, we should aim at being able to get 70 locations in one day. Ideally, of course, we should be able to locate every mortar that fires. This, in a period of activity, is a complete impossibility, and likely to remain so. The ability to get 60 - 80 locations a day will, however, mean that whatever the degree of activity during the day, we shall be able to get and act on a considerable number of locations at once, and at the end of the day, will know the majority of locations on the front opposite.

3. The extent to which GL III and the Four pen recorder may meet the requirements.

The straightforward methods at present practiced by Divisions are inherently slow. It is only with the introduction of special methods that the process can be speeded up, and result in any degree of control over the outburst of mortaring during and after an attack.

GL III and the Four pen recorder have at their best, on a fairly quiet front, produced 11 and 8 locations per day respectively. With more experience, and with more mortars to be located it is probable that both would do better.

Since a Full SR base considers 15 locations a day good work, it is unlikely that a Four pen recorder will do any better than this, particularly in view of its line base deployed far forward. And under conditions of considerable activity it will probably not do as well. It does not record nebelwerfers.

The GL is not likely to be upset by great activity, so that given a good site there is no reason why it should not do very much better than 11 locations a day.

These estimates are only tentative, but they do indicate that even three Four pen recorders on a Divisional front, in addition to the straightforward methods, will only just reach the target figure of 60 - 80 locations a day. GL's, provided the difficulty of sitting can be overcome, may do better.

Neither GL nor the Four pen recorder can move forward and set themselves up in less than 24 hours a day, so that the critical phase of a battle will still be without effective Counter mortar fire. To a certain extent this situation can be, and is being overcome, by putting down GL fire on locations obtained previously. This may be successful for the early stages of a battle, but the enemy mortars are likely to move as soon as the attack progresses and distance, so that the problem remains.

4. Other possible Counter mortar methods.

There are a very large number of ways in which, theoretically, mortars might be located. All the obvious ones have been or are being tried: most of the rest are not immediate practical possibilities.

With the exception of Air photographs, almost all the attention has been given so far to methods of location from the ground. The majority of these methods are slow and cumbersome, and nearly all are indirect. The air, however, has the advantage of being able to overlook the enemy, from such a height as to see even his mortars. (Although in theory, mortars - but not nebelwerfers - can be concealed from an angle of depression of less than 15 degrees, in fact for reasons of convenience of siting, they seldom are concealed from an angle of depression of less than about 15 degrees, and often only 5 or 10).

Two possibilities are therefore suggested:-

a. Spotting from the Air OP. This is normally impossible with mortars as different with nebelwerfers. However, even with the 8 cm mortar, the flash is visible in daylight up to about 400 yds. A spectral analysis of the flash of the various weapons, as well as of the background of grass, may indicate a suitable filter to increase the intensity contrast, or probably better the colour contrast, and so make the flash visible enough to be spotted more easily by the Air OP. It is not very likely that this method will give enough improvement to spot mortars, though it may make the difference as regards nebelwerfers.

In addition to this possible method (which, if it were successful at all would involve no more than a pair of goggles) there is a chance that another type of special equipment might be useful. The use of this equipment is being investigated.

b. Flash spotting from balloons at night. A small balloon, flown at night at 1000 - 3000 ft., with an automatic camera, and ground markers, could readily obtain the bearing and range of any flash in its field of view. No new equipment and no new principles are involved.

Flash spotting from balloons is neither rapid nor particularly suited for the critical phases of the attack and consolidation. It might, however, be a useful adjunct on a static front. Spotting from Air OPs on the other hand is almost the only hope for this phase, and it is recommended that this and any other method of enabling the Air OP to spot mortars and nebelwerfers, is worth every attention.

IV. CONCLUSIONS.

The following conclusions on the problem of enemy mortar location are put forward for consideration:

1. No single method at present in use, or shortly coming into use, is likely to prove a complete solution to the problem. For the time being all methods must be used.
2. In order effectively to use and co-ordinate all these methods a proper Counter Mortar staff is needed.
3. As a target figure, we should aim at being able to get 60 - 80 locations per day. Ability to do this would mean that we should know the majority of hostile mortar positions and be able to bring accurate fire on to them at the end of one day, whatever amount of activity there was at the time.
4. The average number of locations by the straightforward methods at present in use is 10 per day. This might be doubled by a complete pooling between Divisions of all methods and ideas.
5. Further Q. IIIa and Four pen recorders are needed for trial in operational roles before firm conclusions can be drawn. It is unlikely, however, that the target figure could be reached by less than 3 Four pen recorders on a Divisional front operating together with the existing methods. Q. III may possibly do better than this.
6. Neither the straightforward methods, nor the Q. and Four pen recorder, will ever be able to operate effectively during the later stages of an attack and consolidation. It is, therefore, suggested that every possible means be tried to enable the Air O³ to spot mortars and mortar fire, and that as a start the possibility of using special filters be considered.

CHAPTER 13.

ANTI TANK.

Anti tank guns in the Ardennes

(Report No. 27)

Use of Panzerfaust in the N.W. European Campaign

(Report No. 33)

REPORT NO. 27.

ANTI-TANK GUNS IN THE ARDENNES.INTRODUCTION.

1. An attempt has been made to ascertain, where possible, the ability of anti-tank guns to repel attacks by enemy armour.
2. Recapitulation of actions fought in NORMANDY has not yielded sufficiently complete information to be of any value. The data on which this report is based have been collected only from actions fought by American T.D. units in the ARDENNES mostly between 16th December, 1944, and 10th January, 1945.
3. During the course of the enquiry it was soon realised that no very precise results would come of it. Nevertheless the enquiry was continued since it was hoped that much of the information gathered might be of some assistance even though it could not by itself answer any specific question.

METHOD.

4. Data were collected from Divisional, Corps and Army records, and by interviewing personally those who took part in the battles including representatives of all ranks from divisional commanders to section leaders and gunners.
5. In order to facilitate the investigation the evidence has been collected and arranged in such a form that it should, if possible, answer two main questions:

- (a) The number of towed or S.P. anti-tank guns, unsupported by infantry, which had stopped given weights of tank attacks.
- (b) The number of towed or S.P. anti-tank guns, supported by infantry, which had stopped given weights of tank attacks.

RESULTS.

6. Descriptions of the engagements studied are given in Appendix A, the following facts deriving from them:

RATIO OF TANK TO A.TK GUN LOSSES:(1) Unsupported A.Tk guns.

7. The comparative casualty figures between attacking tanks and defending unsupported A.Tk guns are shown in Tables I and II for towed and S.P. guns respectively.

TABLE I.Towed Guns.

Unit:	643 TD Bn	801 TD Bn	820 TD Bn	630 TD Bn	Total
Tanks destroyed	0	4	11	1	16
Guns Lost	2	12	31	4	49
Total number of tanks destroyed					16
Total number of A Tk guns lost					49
					0.3

TABLE II.S.P. Guns.

Unit:	814 TD Bn	644 Th Bn*	Total
Tanks destroyed	21	4	25
Guns lost	13	0	13
* No record of infantry presence in this case.			
Total number of tanks destroyed			25
Total number of A Tk guns lost			13
			1.9

8. The figures in Tables I and II demonstrate a decided superiority of SP over towed guns. This superiority was explained by both towed and SP teams as due to the greater mobility of the SP guns which were able to withdraw more easily when required and to the greater area of fire that could be quickly obtained. No evidence was found to throw doubt on either of these explanations.

(iii) Anti-Tank Guns Supported by Infantry.

9. Tables III and IV give a comparative casualty figures for Anti-Tank guns supported by infantry.

TABLE III

Towed Guns

Unit:	801 TD Bn	690 TD Bn	802 TD Bn	643 TD Bn	621 TD Bn	Total
Tanks destroyed	2	21	4	1	3	31
Guns lost	3	13	0	0	8	24
<u>Total number of tanks destroyed</u>						
<u>Total number of guns lost</u>						
			=	31		1.3
				24		

TABLE IV

S.P. Guns

Unit:	814 TD Bn	702 TD Bn	705 TD Bn	644 TD Bn	703 TD Bn	811 TD Bn	634 TD Bn	TOTAL
Tanks destroyed	33	3	43	16	3	19	15	132
Guns lost	9	0	6	2	0	3	3	23
<u>Total number of tanks destroyed</u>								
<u>Total number of guns lost</u>								
						=	132	6.0
							23	

10. The superiority of the SP over the towed guns was again explained as due to the former's greater mobility and area of fire: once again no evidence was found to disprove these explanations.

11. The points that emerge from these tables are that, in the circumstances of the actions concerned,

(a) anti-tank guns supported by infantry had an advantage of 3 or 4 times over those that were unsupported,

(b) S.P. anti-tank guns had an advantage of 5 or 6 times over towed guns.

TANK LOSSES THE GERMANS HAVE ACCEPTED BEFORE RETREATING.

12. In cases where an estimate of the numbers of attacking tanks had been made, the percentages of tanks lost by the Germans in successful and unsuccessful attacks have been derived. The results are shown in Tables V and VI. An unsuccessful attack had been taken as one in which the enemy withdrew and a successful attack as one in which our troops either withdrew or were overrun.

TABLE V

Losses suffered by Germans in unsuccessful attacks.

Serial No. of engagement	Number of Tanks attacking	Number of Tanks Destroyed	Percentage losses
3	2	2	100%
8	6	1	17%
10	2	1	50%
33	16	14	87%
32	8	1	13%
34	4	1	25%
37	12	4	33%
36	7	3	43%
TOTALS:	57	27	

Percentage based on totals: 47%. Average percentage: 46%.

TABLE VI

Losses accepted by Germans in successful attacks.

Serial No. of engagement	Number of Tanks attacking	Number of Tanks destroyed	Percentage Losses
7	10	0	0%
12	10	4	40%
22	25	4	16%
31	30	2	6%
TOTALS:	75	10	

Percentage based on totals: 13%. Average percentage: 6%.

13. These figures are too few and varied to be satisfactory. If any deductions are to be made from them, two points should be borne in mind, (a) that the number of attacking tanks was probably never less than that stated and may well have been more, (b) some of the losses were almost certainly suffered after the enemy had decided to withdraw. It was therefore probable the case that the enemy were not prepared to accept more than 50% casualties without admitting defeat.

14. An attempt was made to examine the strength of the T.O. element of defense systems incorporating infantry support against German attacks varying in strength. It did not prove possible to obtain accurate information as to the actual strengths engaged but the estimated figures are shown in Table VII.

TABLE VII:

Attacks against Tank Destroyers with Inf Support.

Serial No.	UNSUCCESSFUL			SUCCESSFUL		
	Strength of Tds	Type	Strength of Attack in Tanks	Strength of Tds	Type	Strength of Attack in Tanks
1	Coy	SP	Unknown	-	-	-
2	Coy	SP	Unknown	-	-	-
6	P1	SP	Unknown	-	-	-
7	-	-	-	Section	Towed	10
8	2 P1s	Towed	6	-	-	-
9	Coy	Towed	Unknown	-	-	-
10	Section	SP	2	-	-	-
11	One	SP	Unknown	-	-	-
12	-	-	-	P1	Towed	10
15	-	-	-	Coy	SP	Unknown
17	2 P1s	SP	Unknown	-	-	-
19	2 P1s	SP	Unknown	-	-	-
20	P1	SP	Unknown	-	-	-
21	P1	SP	Unknown	-	-	-
22	-	-	-	P1	SP	25
23	-	-	-	2 P1s	Towed	Unknown
24	-	-	-	P1	Towed	over 15
25	-	-	-	Sec	Towed	Unknown
26	-	-	-	6	Towed	Unknown
27	-	-	-	Sec	Towed	Unknown
32	P1	SP	8	-	-	-
33	P1	SP	16	-	-	-
34	P1	SP	4	-	-	-
35	Sec	SP	16	-	-	-
36	P1	SP	7	-	-	-

The following points may be noted:

(a) S.P. guns were successful on 44 out of 16 occasions and towed guns on 2 occasions out of 9.

(b) On two occasions an anti-tank defence system, incorporating not more than a platoon of S.P. guns, were able to fight off 16 tanks, and on one occasion were overcome by 25. There is therefore an indication that in a properly balanced defence system S.P. guns were able to cope successfully with up to four times their number of enemy tanks.

15. In Table VIII the details are given of an analysis of our tank destroyer losses. In cases where it was not possible to determine exactly by what means individual guns were lost, the principle was adopted that when a number of guns were stated to be lost due to a tank and infantry attack, half that number were credited to infantry and half to tanks. It can be seen that with towed guns the percentage lost to enemy infantry is much greater than due to enemy tanks and artillery. The reverse state of affairs holds with S.P. guns. The reason for this can probably be ascribed to the greater mobility of the S.P. gun, and the protection it affords against small arms fire.

TABLE VIII
ANALYSIS OF TANK DESTROYER LOSSES.

Serial Number		LOSSES DUE TO:			
		Tanks,	Artillery	Infantry	
7	TOWED GUNS	-	1	1	
12		-	1	2	
13		-	1	3	
14		-	4	4	
23		-	-	8	
24		-	1	3	
25		-	-	2	
26		2	-	4	
27		1	-	-	
28		1	-	1	
29		1	-	1	
38			Not recorded		-
TOTAL:		5 (12%)	8 (19%)	29 (69%)	
1	SELF PROPELLED GUNS	2	1	-	
2		3	3	-	
4		-	-	4	
5		Not recorded			-
15		1	1	-	
21		-	3	-	
30		3	3	-	
35		-	-	2	
36		1	-	-	
TOTAL:		10 (37%)	11 (41%)	6 (22%)	

16. Only very limited information was available as to the success or otherwise of 57 mm anti-tank guns manned by infantry. It appeared that their losses had been considerable and their successes small. The worst example noted was in X Division when, in two days, 21 guns were lost and only one tank knocked out.

17. No evidence was found that the different calibres of guns of the T.D. battalions had been a matter of any particular significance.

18. The subject was discussed with U.S. Army officers as to how far the actions could be regarded as typical. The view expressed was that the nature of the country varied so much that, as regards terrain, a wide range of possibility was covered.

19. It is our belief that many of the actions fought were not typical on account of the thinness of the defences. This imposed a higher degree of dispersal of anti-tank guns than would normally be considered safe and resulted in inadequate mutual support and lack of all-round defence. It seems likely that the towed guns in particular were put to a serious disadvantage on this account and were made to appear in a worse light than would have been the case had the sector been more strongly held.

20. Most of the facts in this paper have been collected from Tank Destroyer Staffs and Tank Destroyer Battalions of the 1st and 3rd United States Armies. We would like to express our appreciation of the willing help we received from all Tank Destroyer officers and men whom we met.

REPORT NO. 33

THE USE OF PANZERFAUST IN THE N. W. EUROPEAN CAMPAIGN

INTRODUCTION.

1. The present report deals with the operational importance and use of German hollow charge weapons in the N.W. European campaign. Because of difficulties in collecting evidence on the subject only a limited quantity is available. Attacks with hollow charge infantry weapons are often made with such surprise and in such out of the way places that little can be discovered.

RESULTS AND DISCUSSION.

A. Operational Importance of German Hollow Charge Infantry Weapons.

2. The following table gives estimates of the proportion of tanks knocked out by enemy action that was disabled by hollow charge infantry weapons in the various stages of the campaign. Except for those suffered after crossing the RHINE, for which evidence could still be collected after the end of hostilities, the estimates are based only on samples.

TABLE 1.

Area	Size of Sample	Tanks lost by HC.	% Lost by HC.
* Normandy. Jun-Sep 44.	83	5	6%
N. Belgium and Holland Sep 44 - 8 Feb 45.	76	7	9%
Germany, W of Rhine 8 Feb - 24 Mar 45.	30	2	7%
Germany, E of Rhine 25 Mar - 3 May 45.	274	94	34%
(German tanks in Normandy by British HC weapons)	(81)	(8)	(10%)

* Losses for 7th Armoured Division in the Bocage country are not included since it was impossible to collect a representative sample owing to our partial withdrawal. From hearsay it is thought these losses may be higher than those quoted for the rest of Normandy. The explanation for such higher losses given after the partial withdrawal was that the woody nature of the district gave excellent cover to the German infantry. This was the universal opinion of those interviewed.

3. Except for East of the Rhine, tank losses due to hollow charge infantry weapons are fairly constant at slightly under 10%. The causes for the increased percentage after the crossing of the Rhine are thought to be a decrease in the number of A.Tk guns at the disposal of the enemy and possibly a large number of woods making Panzerfausts easier to use. There was also almost certainly an increase in the numbers of Panzerfausts available but it is by no means certain that mere quantity has at any time been a limiting factor. It is more probable that the availability of men of sufficiently high morale is the true limit. This problem is discussed in more detail later.

4. The figures in Table 1 indicate only tank losses actually suffered and not the indirect effects of defence by Panzerfausts. From conversations with Squadron and troop commanders, etc., the following two indirect effects are thought to be important:-

(a) Delays due to the need for obtaining infantry support.

(b) Delays due to avoiding woods and other areas where hollow charge infantry weapons may be used.

* All data on crew casualties and most of the facts used in this report concerning tank casualties East of the Rhine were collected by the Medical Research Council's Team for Survey of Casualties Amongst Tank Personnel. Their help and co-operation is gratefully acknowledged.

5. It is felt that the operational importance of the Panzerfaust should not be measured merely in terms of the casualties they inflict but also in terms of the caution and delay they impose upon attacking troops. A second of the number of Panzerfausts available the latter rule may well be the more important of the two. For instance, after crossing the Rhine our tanks were often held up by strong detachments armed with Panzerfausts for periods of 12 - 24 hours. Had there been enemy S.P. guns available to be called up as reinforcements such delays might have been extremely serious.

It is thought that the rate of advance of our armour after crossing the Rhine was in fact reduced by about one third though this estimate is based upon only a limited number of examples. It suggests, however, that it would be unwise to ignore the Panzerfaust because for long periods it only produced 10% of tank losses, and that a broader basis of judgment should be accepted.

B. Operational use of Panzerfausts.

(a) Ranges used.

6. Panzerfausts have scored hits at ranges between about 10 and 100 yards though beyond 40 yards the frequency falls off rapidly. A sample of the frequency with which hits have been made at various ranges on AFVs East of the Rhine is given in Table 2 and similarly for misses in Table 3.

TABLE 2.

Hollow Charge hits against AFVs

	Range in yards:					
	0-20	21-40	41-60	61-80	81-100	100
Frequency of hits:	35	22	9	4	3	3

TABLE 3.

Hollow Charge misses against AFVs

	Range in yards:					
	0-20	21-40	41-60	61-80	81-100	100
Frequency of misses:	15	14	13	5	4	7

The sample used in Table 2 is not the same as that in Table 3 since it includes certain cases where only hits were recorded. In consequence it is unsafe to compare Tables 2 and 3 in terms of the proportion of hits to misses. In order to overcome this difficulty those cases where only hits were recorded have been eliminated in Table 4. Even here, however, it has been impossible to trace all misses so that it is only the comparative, and not the absolute, values for the ratio of hits to misses which can be accepted.

TABLE 4.

Range at which attack was made: (yards)

	0-20	21-40	41-100
Number of hits:	17	13	10
Number of misses:	15	14	22
% of hits at given range:	53	43	31

8. The most noticeable feature in the above table is the disproportionately large number of misses at short range. This may perhaps be explained by the fact that a close shot is more likely to miss than a longer one because of the increased angular velocity of a crossing tank is liable to make him miss. Whatever the explanation the fact of a disproportionately high ratio of misses to hits at short range remains. If the causes of this cannot be eliminated then the most hopeful line for improvement might be to adopt shooting at longer range and to make such shooting more accurate. It is likely that accuracy and other trials would assist in deciding which of these courses is preferable.

(b) Effect of a moving target.

9. A moving target is apparently more difficult to hit than one at rest.* The figures for a sample of attacks on Armoured Cars are given in Table 5. The number of such attacks is small and the results can only be taken as an indication.

TABLE 5

ARMOURED CARS ATTACKED.

	Moving	Stationary	Total
Hits	4	5	9
Misses	12	5	17
% hits of total for each class of attack	25	50	35

In this case movement halved the chance of hitting so that if this is typical it would appear that one form of defence against hollow charge infantry weapons is speed.

(c) Proportion of hits obtained.

10. In Table 5 the proportion of hits to total rounds fired is 35%. Owing to the difficulty in most cases of recording misses, only a rough estimate can be given. The estimated proportions recorded from other battles in N.W. Europe lie between 10% and 50%. It is thought that the best 12% average figure is somewhere between 10% and 30%.

(d) Causes of missing.

11. Little is known of why or how the firers of Panzerfausts miss. Tank Crews have been asked as to whether the miss was in elevation or in range but their estimates are open to doubt as they have to judge both where the bomb fell and whence it came. The following figures, therefore, should be accepted only as an indication of what happens.

CAUSES OF MISSING:

	Over	Short	Direction incorrect
Number of misses:	16	13	19
% of total misses:	33	27	40

Therefore misses were due 60% to errors in elevation and 40% to errors in line. The reason for this difference is not known, though it may be due to difficulties in estimating range.

(e) Distribution of hits.

12. The following distribution of hits from Panzerfausts on tanks East of the Rhine was obtained:

TABLE 7.

ASPECT OF THE TANK.

	Front	Side	Rear	Roof
Number of hits:	33	54 (Average per side 27)	10	9
Percentage of total hits:	31	51 (Average per side 25.5)	9.5	8.5

* This statement might at first sight appear obvious but it does in fact need proof. For instance, the normal advantage of protection by a valient might well have been counteracted by the greater difficulty the commander has in spotting from a moving, and thus unsteady, tank.

The corresponding distribution of AP hits during the same period is given in Table 8:

TABLE 8.

ASPECT OF THE TANK.

	Front	Side	Rear	Roof
Number of hits:	52	82 (Average per side 41)	5	0
Percentage of total hits:	37%	60% (Average per side 30%)	3%	0%

13. The distribution is roughly of the same order for hits by Panzerfaust and AP shot. Moreover, this order is approximately that which has been found with AP for battles in Normandy, Belgium and Holland. Since the ranges, tactical use, etc., of AP guns and Panzerfausts are totally different it would almost seem that the distribution of hits on a tank depends less upon the attacking weapon than upon opportunity, terrain, etc. If this is so it would simplify the problem of deciding, as far as N.W. Europe was concerned, the best position for armour on a tank by eliminating variable, namely the distribution of hits.

(f) Damage to tank.

14. In order to measure the damage the Panzerfaust is capable of inflicting on a tank the results have been compared to AP during the same period, namely the armoured attacks after crossing the Rhine. (See Tables 9 and 10 overleaf).

From these tables it will be seen that the Panzerfaust has been less effective in blowing up tanks. For each penetration it has been one third less effective than AP (i.e. 37% to 56%), and operationally where the AP gun is in a position to continue to fire at the tank the Panzerfaust has been only half as effective (i.e. 27% to 52%).

(g) Crew Casualties.

15. Table 11 gives details of crew casualties caused since the Rhine crossing by A.P. and hollow charge projectiles penetrating different types of tank. In order to compare the effectiveness of these two weapons in causing casualties only those hits which penetrated into the crew compartment have been considered.

NOTE:- Tables 9, 10 and 11 are reproduced by courtesy of the Medical Research Council form. The facts on which these tables are based will be dealt with by them more fully in a later report.

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TABLE 9
TANK CASUALTIES.

Type of Tank	HOLLOW CHARGE										A.P.			
	All Hits					Single hits					All hits		Single hits	
	Z & Y		Non-Pen.		Totals	Z & Y		Non-Pen.		Totals	Z & Y		Non-Pen.	
	Z	Y	Z	Y		Z	Y	Z	Y		Z	Y	Z	Y
Cromwell	8	13	10	31	19	7	12	0	5	18	4	5	1	9
Challenger	0	0	1	2	2	1	2	3	0	4	1	0	1	1
Sherman 75 mm	10	8	4	22	16	25	7	3	14	42	13	12	5	25
Sherman 17 pr	2	6	5	13	7	13	5	2	5	20	10	5	5	11
Coast	2	13	5	20	17	14	12	2	6	22	6	5	2	11
Stuart	3	2	0	5	5	2	2	2	3	7	2	3	3	5
All Tanks	25	43	25	93	64	62	40	18	35	113	36	30	16	66

TABLE 10
PERCENTAGES OF DIFFERENT TYPES OF CASUALTY

Type of Tank	HOLLOW CHARGE										A.P.			
	Percentage of total tank casualties for each cause of tank					Percentage of tank casualties of tanks penetrated once					All hits		Single hits	
	Z & Y		Non-Pen.		Totals	Z & Y		Non-Pen.		Totals	Z & Y		Non-Pen.	
	Z	Y	Z	Y		Z	Y	Z	Y		Z	Y	Z	Y
Cromwell	26%	42%	32%	32%	32%	77%	57%	37%	28%	37%	33%	33%	45%	45%
Challenger	0%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Sherman 75 mm	46%	36%	18%	18%	39%	58%	29%	60%	33%	33%	75%	75%	56%	56%
Sherman 17 pr	13%	46%	39%	39%	39%	29%	29%	29%	29%	29%	10%	10%	66%	66%
Coast	10%	53%	25%	25%	25%	33%	33%	25%	27%	27%	29%	29%	55%	55%
Stuart	60%	40%	0%	0%	0%	37%	37%	58%	16%	16%	16%	16%	40%	40%
All Tanks	27%	46%	27%	27%	27%	37%	37%	58%	16%	16%	16%	16%	53%	53%

* Most of the casualties caused by non-penetrating projectiles were relatively minor.

TABLE 11

Type of Casualty	MALLAH CHANGAL PENITENTIUM					A.P. PENITENTIUM					Total exposed to risk of injury	No. of penetrations	Total exposed to risk of injury	No. of penetrations
	Killed	Wounded	Mounded and burnt	Burnt	Unhurt	Killed	Wounded	Mounded and burnt	Burnt	Unhurt				
Type of Vehicle	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.
Crowne	9	12	2	3	35	7	11	1	7	20	61	15	46	10
Sherman 75 mm	15	9	-	4	35	15	20	-	2	36	63	12	75	17
Sherman 17 mm	10	7	-	-	10	8	12	-	9	20	27	7	49	11
Comet	12	19	2	1	37	11	9	6	10	14	71	11	60	12
Stuart	3	2	-	-	6	-	-	-	-	-	11	3	-	-
Challenger	3	4	-	-	3	-	-	-	-	-	10	2	-	-
Total, all vehicles	52	53	4	8	126	51	52	7	28	92	213	53	230	50

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NOTE: The number of tanks on which data are given in Table 11 is less than the number in Tables 9 and 10. This is because information could not always be obtained on casualties in tanks which had been examined.

16. Table 11 shows little difference in numbers killed and wounded by Panzerfaust and A.P. projectiles but it does show a higher proportion of burned casualties in tanks penetrated by the latter. This is in agreement with the figures given in the previous section for tank blow-up casualties, as would be expected from the fact that the same tanks are considered in both sections.

C. Tactics Against Panzerfaust Attacks.

(c) Effect of terrain, etc.

17. Judging from first hand accounts, the firer of a Panzerfaust normally requires cover if he is to be successful. He hides behind this cover, if possible, the whole time and, if not, before and after firing. Because of this requirement Panzerfausts are usually fired from:-

- (a) Wooded and close country
- (b) Buildings
- (c) Slit trenches in country that is partially enclosed.

A few cases have been found of Panzerfausts fired in the open either by soldiers standing up or from unenclosed slit trenches. The following table gives recorded instances of the frequency with which various firing positions were used and the successes obtained from them.

TABLE 12.

Site from which fired.	Hits	Misses*	Total	% of grand total	% hits for each class of site.
House or built up area	4	6	10	23%	40%
Slit trench with ground cover	7	12	19	43%	37%
Trees or bushes	2	9	11	25%	18%
Open ground	0	4	4	9%	0%

* Once again the number of misses is probably an underestimate so that the derived percentages should only be used for comparative purposes.

18. The above figures support the generally accepted view that in open country Panzerfausts are less effective than A.Tk guns; in built-up and wooded areas they are efficient. Thus by suitable combination, defence against tank attacks has become possible in almost all terrains. Only in quickly rolling country where A.Tk guns have limited fields of fire and the firers of Panzerfausts are too exposed have tanks been helped by terrain; as for example the German tanks were helped in their attacks in certain parts of the Ardennes. Unfortunately the number of such areas is extremely small and it would normally be impossible to plan tank attacks to use such areas only.

19. Because of these facts it is considered unlikely that tanks will defeat the Panzerfaust by a better use of terrain.

(b) Tank Tactics and Supporting Arms.

20. Judging again from first hand accounts the usual tactics adopted by armoured formations when Panzerfausts are encountered are:-

- (i) The call-up of supporting infantry.
- (ii) Infantry riding on the tanks.
- (iii) Heavy HE or SA fire against all likely targets.
- (iv) Rush tactics
- (v) The use of covering fire and observations by mutually supporting tanks.

21. All of these have at one time or other proved successful and it is considered that a fully trained tank crew should be conversant with all these methods. The choice of which is to be used must depend upon the situation of the moment.

(c) Morale needed to fire a Panzerfaust operationally.

22. It is generally believed that only troops of excellent morale will fire a Panzerfaust at a hostile tank. The majority of those who do fire will fire only once and then give themselves up or try to get away even if they have missed. A few cases occur where people have fired two or even three times at a tank.

The following figures which were all that were obtained illustrate the above points. Due to the smallness of the numbers concerned too great a stress should not be placed on the percentages.

TABLE 15.

Part 1. Firing at Panzer IV's:

Result of shot	Not put out of action	Put out of action by:		Chance of escape
		Tank	Supporting Infantry	
Hit:	4	3	1	50
Miss:	4	7	4	27
Totals:	8	10	5	average 35

These figures support the first point that there is more chance of escaping when the tank has been hit than when it is missed. They also show that only in about 1 in 3 cases does the firer escape when he himself or the round he has fired is observed. This figure, however, cannot be taken as the chance of the firer escaping since it is not known how often such observation occurs, although an upper limit of 50% for the chance of escaping can be set since it is safe to argue that no hit will pass unobserved.

23. These figures indicate that the danger when firing at a tank may be high. Thus the solution to countering the Panzer must be as much in still further attacking the morale of the firer as in any other method.

CHAPTER 14.

ORGANISATION.

Speed of Build-up in the Assault Crossing of The Rhine (Report No. 30)

REPORT NO. 30.

SPEED OF BUILD-UP IN THE ASSAULT CROSSING OF THE RHINE.

SUMMARY.

1. The build-up went smoothly and very much according to plan. The traffic control organisation worked well, and the system for calling over vehicles out of their priority order was rapid and efficient. However, a study of 12 Corps Build-up records, and observation on the river banks in 12 and 30 Corps sectors made it clear that the Build-up was not going quite so quickly or evenly as it might have done.

2. The unevennesses in the flow over the ferries was due partly to the considerable number of vehicles called up out of their turn, which inevitably delayed the rest, and probably also to the failure of the organisation as a whole to seize every possible opportunity of pushing vehicles over the river.

3. The speed over the ferries and bridges was not as great as it might have been, largely because of small difficulties, which it is thought could have been put right on the spot by someone in authority without detailed administrative ties. The actual rates over the river, and the rates which, in our opinion might be achieved given the best of conditions, are given in the following tables:

Ferries

Type of Ferry	No. of rafts etc. per Corps	Average No. of vehicles per hour observed		Possible No. of vehicles per hour
		12 Corps	30 Corps	
L.V.Ts. (Buffaloes)	2 Rafts (96 per Regt)	45	37	192
Cl. 9 & 12 Rafts	8 Rafts	21	4	24
Cl. 50/60 Rafts	4 Rafts	4	5	9

During the hours of darkness these rates will inevitably fall to some extent.

Bridges

Type	Average No. of vehicles per hour per bridge observed	Possible No. of vehicles per hour per bridge
F.D.E.	50	100
Bailey pontoon bridge	200	400

The difference between 12 and 30 Corps sectors was largely that the former was very little shelled and the latter quite a lot. The shelling did not much upset the LVTs, as might be expected, but had a serious effect on the Class 9 rafts. The Class 50/60 rafts on both Corps sectors had more mechanical difficulties than anything else.

4. From our results it would seem that the two LVT regiments per Corps were more than was necessary, and that one regiment per Corps could have managed one and probably two divisional build-ups of the type of this operation. Eight Class 9 rafts and four Class 50/60 rafts should be capable of managing the heavier build-up of one Division and necessary troops on quite a lavish scale, although subject very much to the shelling encountered.

NO. 2 OPERATIONAL RESEARCH SECTION.

SPEED OF BUILD-UP IN THE ASSAULT CROSSING OF THE RHINE.INTRODUCTION.

1. During the crossing of the river RHINE, as much information as possible has been collected on the speed of the early Build-up. This, it is hoped, will help in deciding what must be provided for an assault river crossing, should another ever be necessary. The information has been got mainly from Bank Control 12 & 30 Corps, formations and units of 15 (Scottish) and 51 (Highland) Divisions, 11 and 13 AGRE's, units of 79 Armoured Division, and from our own observations on the river bank. Since the assault over the Rhine is being fully described by G.S.O.-1 (Liaison) of 21 Army Group only a minimum of the general background is included.

2. The report is not intended as a criticism of the operation, which was quite conspicuously successful. It is a detailed examination of one aspect of it, put forward so that another time, the build-up can be accomplished even more rapidly and efficiently.

OUTLINE OF THE PLAN.

3. In both 12 and 30 Corps the assault was to consist of two Brigades. Two assault Battalions of each Brigade were to be taken over at H-hour in Buffaloes, together with a small quantity of essential preloaded vehicles. The reserve Battalions of the assault Brigades were to be put over somewhat later in Stornobots. As soon as practicable after the assault wave, essential transport was to be ferried over for the assault Brigades by Buffaloes, and while this was still in progress the reserve Brigade in the case of 12 Corps, and the two reserve Brigades in the case of 30 Corps, were to be taken over in Stornobots, followed in turn by their essential transport in Buffaloes. By this time, Class 9 ferries should have been ready to take over heavier transport belonging to the Brigades, essential Div transport, and in the case of 12 Corps, Airborne transport as well. Class 50/60 rafts were also planned to be ready at an early stage to carry over considerable quantities of armour, SP arty and SP anti-tank guns. DUKWs were to start as soon as exits and entrances were made, carrying over all forms of supplies. The next step in Build-up was to be the opening of Class 9 FBE bridges, which were to be followed by Class 12 and Class 40 Bailey pontoon bridges. Over these would go all the residues and further Divisions. On both Corps sectors, but especially in 12 Corps, this sequence of events was closely followed.

4. The organisation for feeding vehicles over the river started with Marshalling Areas some way back, which were kept full by Q (Mov) of Corps acting on the information of the Corps Bank Control Organisation. Subsequently Bank Control called serials forward from the Marshalling Areas to Vehicle waiting areas, from which they were called up to the ferries as required. On the far bank vehicles went into Assembly areas and were sent out as traffic allowed. Bank Control worked on a priority list laid down by Corps and Divisions, but was in constant touch with Divisions and Brigades, and at any time a serial could be called forward from the Marshalling or Waiting areas out of turn. This organisation worked, on the whole, excellently. Brigades said that they could always get over any vehicle they wanted in a very short space of time, while dispersal on the far side went rapidly and smoothly.

12 CORPS BUILD-UP.

5. The rate of the early build-up is shown on the Diagram, made out from Bank Control records. Immediately after the assault Battalions of 44 Brigade, essential transport went over in LVTs and the bulk of it, some 160 vehicles, was put over in 8 hours. The essential transport of 227 Brigade however was delayed until the banks could be cleared of enemy, but, once it started, went over at much the same rate, some 180 vehicles in 8 hours. About the same time as 227 Brigade's essential transport, 46 Brigade started to move over, some on the right and some on the left sector. The bulk of their essential vehicles, some 215, were put over in 10 hours. While these movements were still in progress, the Brigade build-ups carried on with heavier stuff on Class 9 rafts and continued through D, D+1 and into D+2. The Divisional troops build-up went on over a similar period. Lastly came the Airborne build-up which did not start till late on D-day and continued until the early hours of D+2.

6. A Class 9 FBE bridge was opened late at night on D-day but was damaged by a carrier and did not take any quantity of traffic till 1400 hrs on D+1. Not long after, the Class 40 Bailey pontoon bridge was opened. A Class 12 Bailey pontoon bridge opened on the morning of D+2, and thereafter very little went over by any means other than bridges, except for Class 50/60 rafts which operated until the afternoon of D+2.

7. The rates of ferrying are given below:

TABLE I

Type of Ferry	No. of craft involved in ferrying	Operating for hrs	Total vehs carried	Average vehs ferried per hour
LVT	2 Regts - approx 180 LVTs.	46	2070	45
Cl. 9	8 Rafts	46	1030	21
Cl. 50/60	4 Rafts	46	190	4

Note: 1. The total of vehicles carried by LVTs was obtained from the Regiments. It does not include assault wave trips, and is greater than the total obtained by adding up the build-up diagram, which is evidently not quite complete.

2. The total of vehicles ferried by Cl. 9 rafts was obtained from 11 AGEE, and is slightly greater than the total obtained from build-up diagram.

3. The total of AFVs ferried by 50/60 Rafts does not include some soft vehicles carried on the rafts at the same time as the armour.

8. The most striking feature of the build-up, especially clear from the totals of vehicles ferried by LVTs and Class 9 rafts, is the variation from period to period. This can only mean that the flow of traffic to be taken over was not organised evenly, or that the ferries varied from hour to hour in what they could get over. The first of these difficulties certainly arose, for both Buffaloes and Class 9 rafts complained from time to time that they had no vehicles to take over. The possible causes are mentioned in the next paragraph. But traffic control was not the only reason for an uneven flow; the actual operation of the ferries was probably more important. This is dealt with in a later section.

9. Unevenness in supply of vehicles to the ferries may have been due to defects in the mechanism of calling up vehicles; but the whole system was arranged to have a number of 'cushions', in the Marshalling and Vehicle Waiting areas, and actually by the ferries. The cushions should have overcome this sort of difficulty and, as far as could be judged, it had done so. It is suspected that the trouble lay more in the frequent calling up of vehicles out of their normal turn, which, though it was usually managed rapidly, tended to result in jams and delays. It is felt too, that traffic was going over at the speed it chose, rather than being 'forced over' at the greatest possible rate, possibly because there were insufficient personnel to supervise all the links in the chain of control.

30 CORPS BUILD-UP.

10. Because of stiffer opposition, the build-up on the 30 Corps front did not go entirely according to plan and full records were not kept. In brief Buffaloes did very well and operated much as on 12 Corps front. Class 12 rafts did not work nearly so well, partly because of shelling, while Class 50/60 rafts, in spite of difficulties, were distinctly successful. Again because of shelling, bridges were not put across as rapidly as on the 12 Corps front, and the various types of ferry had therefore to operate for longer. Although in the case of 30 Corps there are not the same detailed two-hourly loads available, observation on the banks showed that the rate of flow was not even, partly because of traffic control difficulties, but largely because of actual unevenness of operation of the ferries. The first of these difficulties has already been discussed. The second is dealt with in the next section.

11. The rates of the various ferries are given below for comparison with 12 Corps:

Table II

Type of Ferry	No. of craft involved in ferrying	Operating for hrs	Total vehs carried	Average vehs ferried per hour
LVT	2 Regts - approx 180 LVTs	61	2240	37
Cl. 12	8 Rafts	About 25	About 100	Operation of rafts was sporadic. Up to 10 per hr. but average about 4.
Cl. 50/60	4 Rafts	63	320	5

No. 3. Total of AFVs ferried by 50/60 rafts does not include some 120 soft vehicles taken over at the same time as armour.

THE OPERATION OF THE FERRIES.

12. Although the report so far as been concerned with LVTs, Class 9 and Class 50/60 rafts, while watching the operation from the banks of the RHINE we saw the functioning of stern ramps, LUXs and Bridges, and for the sake of completeness have included them all.

LVTs.

13. The actual time spent by LVTs in making a crossing is small. Where the current was favourable it was accomplished in 2 1/2 minutes, and at the worst in only 5 minutes. These times were only small in comparison with the times spent making circuits on the near and far banks and in maintenance. On the near banks, the landing areas were, in the first instance, purposely kept well back to be out of range of observed fire, but when the bridgehead was securely held and this was no longer necessary, the landing areas in several instances were moved forward. The rate of flow of Buffalo ferries was therefore being largely limited by the length of inland circuit, although the need for frequent maintenance was a contributory cause.

14. One Buffalo circuit, on 12 Corps front, was for a short time on the afternoon of D-1, a most impressive sight. There were never less than 5, and sometimes as many as 10 Buffaloes in the water going east, giving a rate of flow of about 120 an hour. Supposing half of the 96 Buffaloes in a Regiment to be actually functioning (the other half being out because of repair, maintenance, crews resting and so on) this represents about 2 1/2 trips per Buffalo per hour - or a circuit time of about 25 minutes. Nevertheless, this rate was only achieved for a short time by certain Buffaloes, and, as can be seen by examining two hourly totals in the build up diagram, was never achieved by all Buffaloes, even at the height of their activity on the afternoon of D-1.

15. The general impression with the Buffaloes was that, given shorter inland circuits, a much higher rate could have been achieved. The capacity of Sappers to make tracks may however limit this, particularly in bad weather. A target figure of a half-hour circuit seems reasonable and allowing 48 Buffaloes per Regiment actually working, this means 96 trips an hour per Regiment. In fact, the average on 12 Corps front for the whole operation was only 22 1/2 trips an hour per Regiment, and for the period of maximum activity (Airborne Build-up) about 50.

Class 9 and 12 Ferries.

16. The time for a complete circuit of a Class 9 raft varied greatly; on the six visits paid to these ferries circuits were averaging: 13, 16, 19, 23, 26 and 31 minutes (each figure based on about 5 circuits). The trips from shore to shore always took 5 - 6 minutes, and the variability came in at the loading and unloading of vehicles. The troubles were mostly trivial - fouling of breakwaters, failure of vehicles to run on to the rafts rapidly, delays in pulling on awkward gun and A.E. loads. The impression was that most of these troubles could be eliminated, and at least a 15 minute turnover reasonably achieved. Allowing further that 25% of rafts will unavoidably be out of action because of breakdowns, crews resting, etc., this would give, for the 8 rafts on a Corps front, a turnover of 24 vehicles per hour. In fact, on 12 Corps front an average of 21 was achieved.

On 30 Corps front, Class 12 rafts were much less successful, largely because of shellfire. The 8 rafts averaged only 4 vehicles per hour. It is very evident that these rafts cannot successfully be operated in face of much shelling, partly because they involve a lot of men standing about, partly because they are quite liable to damage themselves.

Class 50/60 rafts.

18. There was never a shortage of vehicles to go over on Class 50/60 rafts, although there was a certain amount of wasted effort in that ordinary soft vehicles were often sent over alive (particularly on 30 Corps sector before Class 9 rafts started working) when they could have been sent over on the same raft as a tank. The limiting factor was once again the actual operation of the rafts. Here, there were purely mechanical troubles with winches, cables were broken by Buffaloes and there was interference from shellfire. Even so, there was the same variability of turnover times as with Class 9 rafts. On various visits, the following average times for individual rafts were noted: 20, 22, 24, 30, 35 minutes. (Each figure based on about 3 circuits). The actual time from one shore to another was only 5 to 6 minutes and, much as with Class 9 rafts, the rest was made up by trivial difficulties - fouling breakwaters, going in slow, and going aground when the tank got on the raft. Again there was the impression that many of these troubles could have been eliminated and a turnover of 20 minutes made possible. Allowing again that

- * A point arose in connection with the Buffaloes used on 30 Corps front for supplies. These were quite definitely limited by 1-hour for loading and unloading and not by the length of inland circuits.

23. of rafts will be unavoidably out of action. This would give a flow of 9 tanks an hour from the 4 rafts, whereas during the operation an average of only 6 per hour was achieved on 12 Corps and 5 an hour on 30 Corps fronts.

19. The 50/60 rafts on the 30 Corps front were not troubled by quite so much shelling as the Class 9 rafts, and their working was not seriously affected by it. But it must be expected that their turnover would drop seriously if they were heavily shelled, for they and their crews are equally as vulnerable as Class 9 rafts.

Storm-boats.

20. There is little to say on storm-boats. They were very successful, and transported infantry over exceedingly rapidly, taking only about 14 minutes to make the crossing. In fact, they had little to do for much of the time, but the number required must be dictated by the number of infantry required simultaneously on the far bank, rather than by the most economical number of boats to perform the job.

DUKWs.

21. Only the DUKW crossing on the 12 Corps sector was examined. It was felt that the control left much to be desired. Large numbers of DUKWs were waiting on either side to go across, but there was only one combined exit and entry on each bank. For this reason only one way traffic was allowed, followed after a time by one way traffic in the other direction. The actual crossing took 3 - 5 minutes and never more than 3 DUKWs were allowed in the water, since the exits were difficult, and occasionally DUKWs failed to get out, while others piled up behind. Communication with the far bank was by loud hailer which was notably ineffective.

22. As a result, the rate of flow was only 14 DUKWs per minute in one direction - giving an average rate of flow over a period of time of 1 in 3 minutes or 20 an hour. At least two passages down to the water on each bank, and preferably 4 should have made it possible to achieve a flow of 40 or 60 an hour, when no doubt the limiting factor would have been loading and unloading.

Bridges

23. The flow of traffic over bridges was not good, as the following figures show:

TABLE III

Type	Rates of flow observed during uninterrupted periods (about 15 minutes each)	Effective rates of flow (includes major delays)	Possible uninterrupted rates of flow	Possible effective rates of flow (includes major delays)
CL 9' FBE	48,57,75,75,80, 88.			
	Av.70	55	140	105
CL 12 BFB	170, 210, 280			
	Av.220	165	540	415
CL 40 BFB	98,240,276,312, 290,480			
	Av.280	210	540 +	415 +

The possible rates of flow are arrived at as follows:

CL-9 FBE. Wide spacing and low speeds are essential on these bridges; 30 Corps for instance enforced 200 ft spacing. At 5 mph this represents 140 vehicles an hour, uninterrupted flow. Discounting any major delays due to changing the direction of traffic etc there should be no difficulty in maintaining such a speed and spacing.

CL-12 BFB 80 ft spacing is necessary on these bridges. Allowing a speed of only 8 mph, which should be maintained, an uninterrupted flow of 540 vehicles an hour should be possible.

+ CL-40 BFB As for CL-12 BFB, but closer spacing can be tolerated and slightly higher rates of flow should be possible.

In all three cases, the effective rate of flow is taken as being 25% less than the uninterrupted rate; i.e. for 15 mins in every hour the bridge is assumed to be taking no traffic at all because of breakdowns in the approaches, switching of traffic, maintenance of the bridge, etc etc. During darkness these rates must inevitably fall to some extent.

24. The actual rate of flow was everywhere about half what we have estimated as being possible. The causes were several. Occasionally, but not often, it was genuine congestion on the left side of the bridge. Much more often it was poor traffic discipline and a failure to clear up to the correct spacing or to "step on it". This was no doubt aided by the "common" widespread but quite erroneous belief that it is necessary to crowd over pontoon bridges (including of course F&E). Here and there were notices announcing no speed restriction on the bridge, but these seem to have little effect. In several cases traffic control was solely to blame in instituting their own speed restrictions, and enforcing quite unnecessary spacing. On the Class 12 Bridge on 12 Corps sector, there was actually a notice on the approach to the bridge announcing "5 MPH OVER BUND". This was removed several times by the F&E concerned only to be replaced by Traffic Control. It is clear that traffic movement on bridges leaves much to be desired. It should be noted that the approaches to the bridges are on the whole well laid out and made up by Sappers, and were not such as to limit the flow of traffic over bridges in any way. It is also, apparently, not generally realized by traffic control, that Cl.9 or 12 loads do not need to maintain 80 ft spacing on Cl.40 bridges.

Lay-out along the river.

25. On the 12 Corps front:

- 3 Bridges
- 3 Buffalo circuits
- 4 Class 9 Ferries (8 rafts)
- 2 Class 50/60 Ferries (4 rafts)
- 1 DUKW crossing
- 2 Stern boat crossings

were arranged in 8500 yards (just under 5 miles)

On 30 Corps front:

- 5 Bridges
- 4 Buffalo Circuits
- 4 Class 9 Ferries
- 2 Class 50/60 Ferries
- 1 DUKW crossing
- 2 Stern boat crossings

were arranged in roughly the same length of river.

This averages out at one bridge or ferry roughly every 500 yards.

26. Although there were occasional troubles of LVTs, DUKWs and Class 9 rafts colliding with bridges and Class 50/60 rafts, these were due to bad management rather than overcrowding. In fact, the impression was that more could if necessary be operated on a similar stretch of river. A much more serious limiting factor is likely to be the number of approaches to the river that already exist or that can be made up, although in fact this operation was favoured by the weather, and the ground was hard enough to take vehicles almost anywhere. Had this not been so, the crossing would have been made immeasurably more difficult. Such an operation is in fact very largely governed by the road situation.

Conclusions on the operation of the ferries.

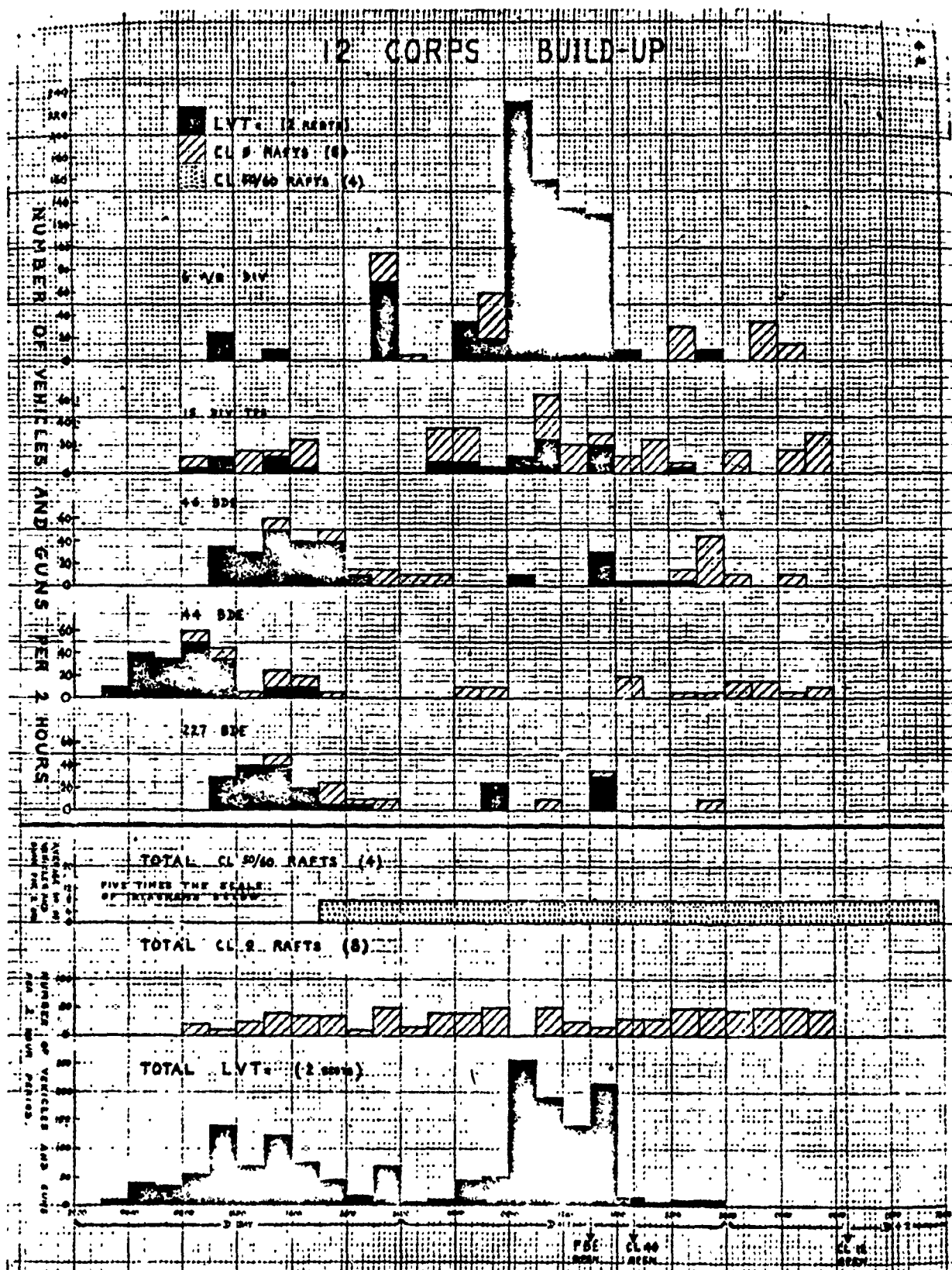
27. Without entering into details, it is evident that all means of getting across needed attention, mostly in small points. The impression was that the planning at all levels had been excellent, that where changes had to be made, they were made, but where things were running not so badly as to demand immediate changing, no attempt was made to improve matters. It was our opinion that had there been anyone whose sole job was to watch the general functioning of the build-up, he could have made innumerable small changes as the operation progressed and speeded up the whole process very considerably. It has also been suggested that an officer, preferably F&E, on the telephone of each rafting and ferrying site, in communication with the Vehicle Waiting areas, could hasten the feeding over of vehicles.

DISCUSSION.

28. The operation, on both Corps fronts, went very successfully, but it is also certain that the various means of ferrying were not working anything like as fast as they might have done and that the early build-up was consequently slowed down. The reasons for this have been pointed out.

12 CORPS BUILD-UP

12 CORPS BUILD-UP



29. Occasionally the opinion was heard expressed that more vehicles and troops would only have been an encumbrance, but after the first few hours, the bridgehead was never so cramped, nor the roads so crowded, that they limited the vehicles and troops being fed in. Occasionally of course this may occur, and in the case of 227 Brigade it did occur for a short while at first light on D-day when they only held a 400 yard deep bridgehead. But excluding such special occurrences, the bridgehead is seldom likely to be too small to accommodate the flow that can be achieved purely on rafts and ferries. The advantage of the fastest possible build-up are too obvious to need mentioning. One of the main problems of any assault crossing is indeed "which side can build up the faster".

30. Referring to Table I it will be seen that LVTs and Class 9 rafts averaged about 65 vehicles an hour on 12 Corps front. Referring to the section on the operation of the Ferries it can be seen that, in our estimation, they might have achieved about 310 vehicles an hour. Table III shows that this was very much what in fact was going over the Bailey pontoon bridges. In other words, the ferrying facilities might have been more or less the equivalent of a Class 12 Bailey bridge, available from the very early stages of the operation.

31. If the rate of 96 vehicles an hour for a Buffalo Regiment can be reached, then two Regiments could put over the 800 or so essential vehicles for a 3 Brigade and Divisional troops build-up of this type in 4 hours. The implication is that the allowance of two regiments to an assault division is unnecessarily lavish and that one regiment could deal with 1 division, and indeed probably two divisions in the period before the opening of bridges.

32. The Class 9 rafts, however, cannot achieve the same rapid turnover, and the 800 or so Class 9 vehicles selected for the essential build-up of 15 Div would take at the best about 32 hours. It would seem that an allotment of 8 rafts to a division is certainly not excessive for an ideal build-up.

33. The ferrying over of armour needs rather separate consideration. Excluding D.Ds, which, while excellent if they succeed as they did in this instance, can only be considered chancy, Class 50/60 rafts are the only means of transport until a Class 40 bridge is opened (after 40 hours on 12 Corps front). Under these circumstances, rafts could get over (allowing 12 hours to get into operation) 250 AFVs. Excluding the SP A/Tk guns, Bulldozers, etc., etc., this represents 2 regiments, which must be considered very adequate for one division.

34. A last point concerns the safety margin required. It must be recognised that if the river banks are heavily shelled, rafts may become more or less unusable while the shelling is going on. A safety margin in rafts is therefore largely a question of how much shelling is anticipated and to what extent it can be silenced. LVTs, on the other hand, should not be unduly upset by shelling on the banks (since they can load inland) but they are sensitive to mud, and careful reconnaissance is therefore essential. Whatever safety margin is in the end allotted, if things go well, then the fullest possible use should be made of it to speed up the operations beyond what was originally planned and facilitate the subsequent breakthrough.

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COUNTS

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CRATER

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D.U.K.
DURY
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