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ITEM No. 2

RESTRICTED

GERMAN COAST ARTILLERY EQUIPMENT EMPLOYED IN THE DEFENCE OF THE WEST COAST OF DENMARK

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BRITISH INTELLIGENCE OBJECTIVES SUB-COMMITTEE

LONDON—H.M. STATIONERY OFFICE

1129. For Tony

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GERMAN COAST ARTILLERY EQUIPMENT EMPLOYED IN THE DEFENCE OF THE WEST COAST OF DENMARK

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GERMAN COAST ARTILLERY EQUIPMENT EMPLOYED IN THE DEFENCE OF THE WEST COAST OF DENMARK.

Preamble.

The German Coast Artillery defences in France, Belgium and Germany itself were disrupted by Allied attacks. Although many of the mountings remained intact, their systems of communication, control and fire direction were, generally speaking, obliterated. It was therefore decided to send a small party of Officers from the United Kingdom to carry out a general inspection of the Coast Artillery defences in Western Denmark since these defences were intact and work had continued on them until the date of the German capitulation.

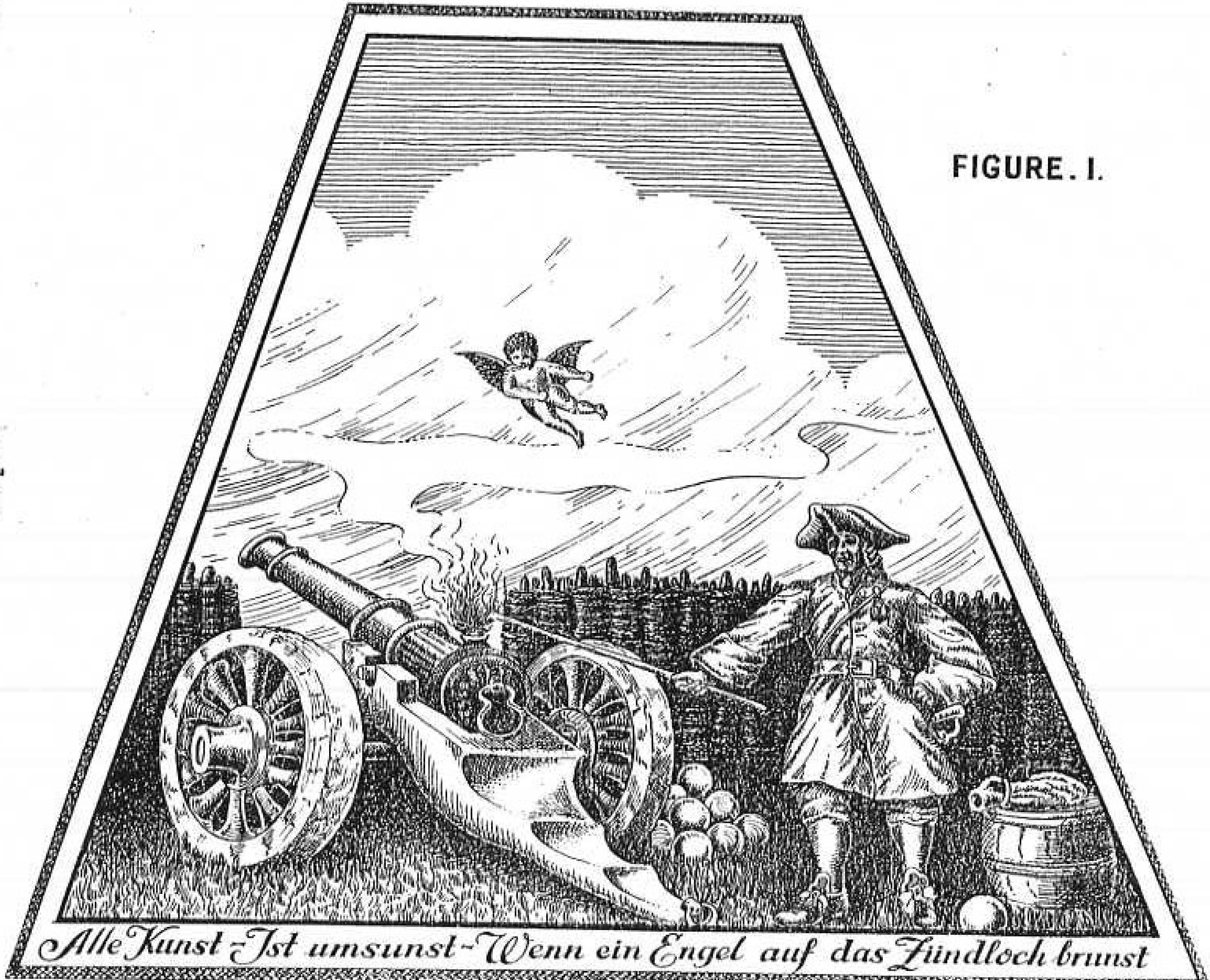
The initial German programme for a "blitz" war included the provision and installation of a number of super-heavy Coast Artillery batteries. We are of the opinion that these batteries were definitely inferior to the British 15-inch batteries, e.g., at Singapore, except perhaps in sheer range and methods of protection. They had the range, but how they ever hoped to use it effectively is beyond comprehension.

When forced back on the defensive the Germans had to meet an unforeseen requirement for Coast Artillery equipment They appear to have had no standardised design except in the 15-inch and 16-inch calibres and were, therefore, compelled to instal a wide variety of Naval mountings, German Field Army artillery and captured equipment in a C.A. role.

As a result of our inspection we conclude that from both the technical and user points of view we can profit very little by a detailed study of German Coast Artillery equipment and methods. We were less impressed than the Military Correspondent of "The Times" and submit that we enjoy a clear lead in this field of Military Science.

We wish to acknowledge the unstinted hospitality and help afforded us during our tour by the Danish Resistance Movement. We dedicate Figure 1 to them; a copy of a German work of art which we "liberated" in the Officers Mess at TISTED. "In vino veritas". Apart from its artistic or philosophic worth, this is probably the earliest pictorial record of the complete neutralisation of Coast Artillery by an airborne dual purpose weapon.

FIGURE. I.



Alle Kunst - Ist umsunst - Wenn ein Engel auf das Zündloch brunst

SECTION I.

THE LAYOUT OF THE GERMAN COAST ARTILLERY DEFENCES.

The General Plan of the Defence System.

The German High Command considered that the stretch of coast line from NYMINDEGAB to RIBE in SOUTH JUTLAND was the part of Denmark most vulnerable to Allied invasion. The position is indicated on Figure 2 (inset). The hinterland is flat and well drained and yet it affords good cover for airborne troops. The undulating beaches shelve steeply, the sand is firm and there are no cliffs. In addition, ESBJERG was considered a suitable base port. The German Coast Artillery defence system was planned on the assumption that if any seaborne attack was launched against Jutland, the landing would take place in this area.

The Equipment Deployed in an Anti-invasion Role.

The following equipments were deployed or planned in the defence of the area referred to in the previous paragraph, the approximate location of each battery being shewn in Figure 2:-

(a) Super-heavy.

Four 38-cm.(15-inch) Siegfried Kanone on two 38-cm. "Tirpitz" type twin Naval mountings at OXSBY. This battery was scheduled to be in action in September, 1945, and the Todt organisation had continued work on it until the date of the German capitulation in Denmark.

(b) Medium and Light.

(i) Four 15-cm. Naval guns in two twin turrets at GRADYP on the ISLAND of FANO. These equipments originally formed part of the secondary armament of the German battleship Gneisenau.

(ii) Four 10.5-cm. single mountings of French design (Le Creusot 1917-1918) on Fano.

(iii) Four 15-cm. Bofors M'06 on Fano. These had been withdrawn from the Danish cruiser Peder Skram which was scuttled in Copenhagen in August, 1943.

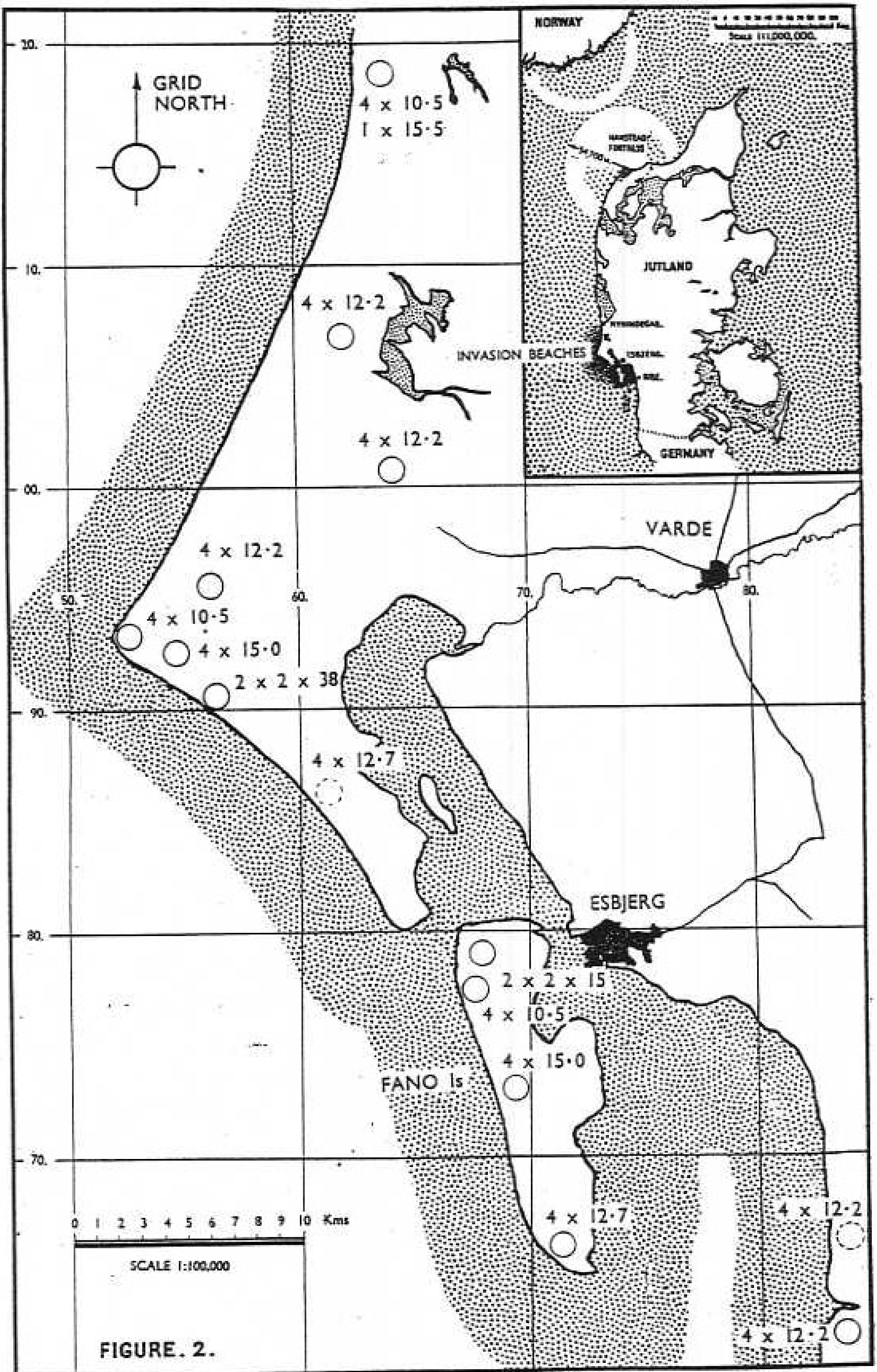

GRID NORTH
20.
10.
00.
90.
80.
70.
50.
60.
70.
80.
4 x 10·5
1 x 15·5
4 x 12·2
4 x 12·2
4 x 12·2
4 x 10·5
4 x 15·0
2 x 2 x 38
4 x 12·7
VARDE
ESBJERG
2 x 2 x 15
4 x 10·5
4 x 15·0
FANO Is
4 x 12·7
4 x 12·2
4 x 12·2
NORWAY
JUTLAND
INVASION BEACHES
GERMANY
0 1 2 3 4 5 6 7 8 9 10 Kms
SCALE 1:100,000

FIGURE. 2.

(iv) Four 12.2-cm. Russian field equipments on the southern tip of Fano.

(v) Four 10.5-cm. (French) single mountings at NYMINDEGAB.

(vi) One 15.5-cm. field carriage in an armoured cupola at NYMINDEGAB.

(vii) One battery of four 12.7-cm. mountings from a German destroyer, installed north of ESBJERG.

(viii) Four 12.2-cm. Russian guns at HEUNE.

(ix) Ditto at BORSINOSE.

(x) Ditto at VROGUM.

(xi) Four 10.5-cm. French equipments at BLAAVANDS HUK.

(xii) Four 15-cm. K39 German Field equipments mounted in a C.A. role at BLAAVANDS KRO.

(xiii) Four 12.2-cm. Russian guns at WEST WEDSTED.

(xiv) Four 12.7-cm. German Naval mountings south of ESBJERG.

3. Fire Power.

(a) The fire power, although not uniform, amounts to one battery of four medium guns every five miles. In addition, most of the Coast Artillery batteries were equipped with three 3.7-cm. A.A. guns for local defence, these weapons were sited so as to have a seaward arc of fire.

The German Officer Commanding the defences considered that six guns were required per Coast Artillery battery and six would have been provided but for the shortage of equipment and personnel. He was also of the opinion that the A.A. defences were inadequate, but held the view that even after sustained aerial bombardment, sufficient Coast guns would have remained in action to repel a landing.

No guns of special design were provided for defence against motor torpedo boat attack, for this role they relied upon 5-cm. anti-tank guns (of which 14 were mounted), and the 3.7-cm. A.A. guns mentioned above.

(b) Manning Detail.

The Coast Artillery batteries were manned by German Naval personnel and two specially trained Regiments of German Field Artillery, the senior commands being held by Naval Officers. One Infantry Battalion was provided for general defence against airborne troops.

4. The Skagerak Defences.

A super-heavy battery was also installed at HANSTEAD in N.W. Denmark. This battery consisted of four 38-cm. SK. L/52 guns on four Schiebgerust C39 "single" mountings. A 3-gun battery of similar equipments was emplaced at KRISTIANSANDSUD in SOUTH NORWAY, their joint role was to close the Skagerak. The distance between these two batteries is approximately 120,000 yards and the maximum gun range with a special type of shell is 60,000 yards. They can thus be said to have covered the Skagerak, the mid-channel was, however, very heavily mined. See Figure 2(Inset).

In addition to the 15-inch battery there was a 4-gun Coast Artillery battery of 17-cm. guns and six A.A. batteries (four 10.5-cm. and two 3.7-cm.).

Work on the Hanstead Fortress began in November, 1940. Two "super-heavies" were in action by May, 1941, and the main armament was completed in September, 1941.

SECTION II.

THE SUPER-HEAVY BATTERY AT HANSTEAD, SKAGERAK DEFENCES. (4 x 38-cm.)

1. Projectiles.

A.P., S.A.P., H.E. and a special design of light H.E. shell were provided for operational use. The first three each weigh 800 Kg.(1764 lbs.) and have the same ballistic characteristics. With top charge they have an M.V. of 2690 f.s. and a maximum range of 46,000 yards.

The light H.E. shell weighs 1091 lbs and is used with an increased charge to give a maximum range of 60,000 yards; M.V. 3445 f.s.

All four shell have the same external characteristics and are of conventional design with a ballistic cap and three driving bands. Below the driving band there is a thin lead band which may act as a decoppering agent. The possibility of its being used to prevent gas from getting over the driving band before engraving is considered unlikely.

Diagrams of each shell, including cross sections, are reproduced as Figures 3 to 6.

The H.E. filling of the light shell is divided into an upper and lower section, each of which is separately fuzed. The "distance piece" (diaphragm) may be to prevent set back on firing with a low density filling or to prevent set in, or merely to position the two pre-formed block charges which constitute the main filling. A quantity of A.P. and light H.E. shell are being shipped to the U.K. for a more detailed examination and will be reported on through the normal British Military channels.

2. Armour Piercing Performance.

The armour piercing performance of the A.P. and S.A.P. shell is as follows:-

SECTION II.

Penetration of Armour Plate by 38-cm. A.P. and S.A.P. Shell.

Range.	A.P. Pzgr. L/4.4. Penetration. Face hardened armour in mm.			S.A.P. Sprgr. L/4.5 Bdg. Penetration. Face Hardened armour in mm.		S.A.P. Sprgr. L/4.5 Bdg. Penetration. Homogeneous armour in mm.	
	N.	20°	40°	20°	40°	20°	40°
Metres.							
100	minimum of 460	minimum of 460	395	minimum of 320	minimum of 250	minimum of 240	minimum of 240
1000			386				
2000			376				
3000			366				
4000			357				
5000			348				
6000			339				
7000			330				
8000			322		245		
9000			313		239		
10000			306		233		
11000			298		227		
12000			291		221		
13000		447	284	319	215		
14000		432	276	309	210		
15000		417	268	300	204		
16000		403	262	290	199		
17000		388	254	281	194		235
18000		375	247	272	188		229
19000	443	362	241	262	183		222
20000	426	349	234	254	178		216
25000	352	290	203	215	155		187
30000	294	242	177	181	136	228	162
35000	248	205	157	156	121	190	141
40000	218	175	137	135	109	157	123

SECTION II.

3. Time of Flight and 50% Zones.

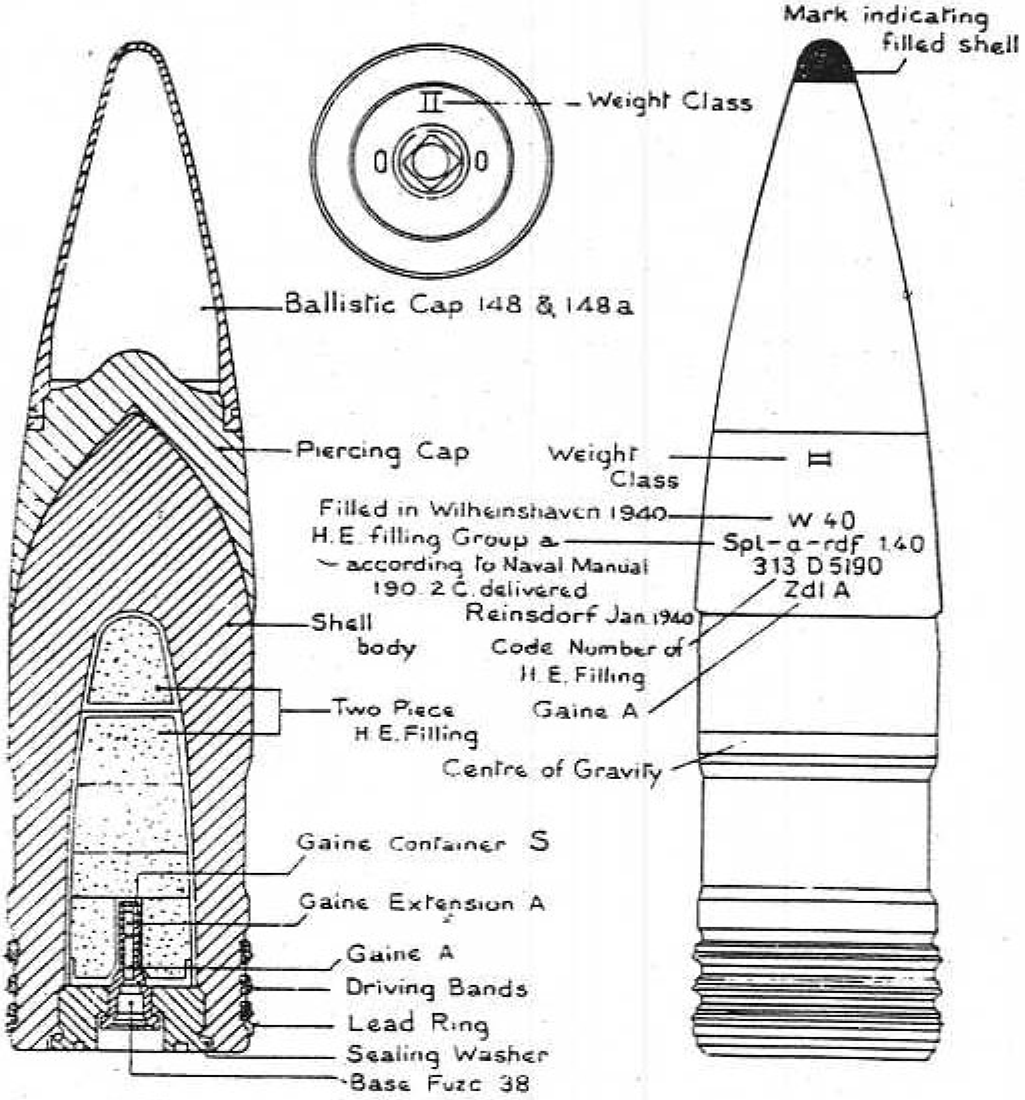
The following figures for Time of Flight and 50% Zones have been extracted from the Range Tables:-

800 Kg. Shell (A.P. or H.E.)

Range Metres.	T. of F. (seconds).	50% Zones. (Metres)		
		Length.	Breadth.	Height.
10000	13.9	95	1.9	9.7
20000	32.0	108	5.0	32.0
30000	55.5	142	10.0	89.0
40000	88.2	227	20.0	-
42100	103.0	291	24.0	-

495 Kg. Shell (H.E.)

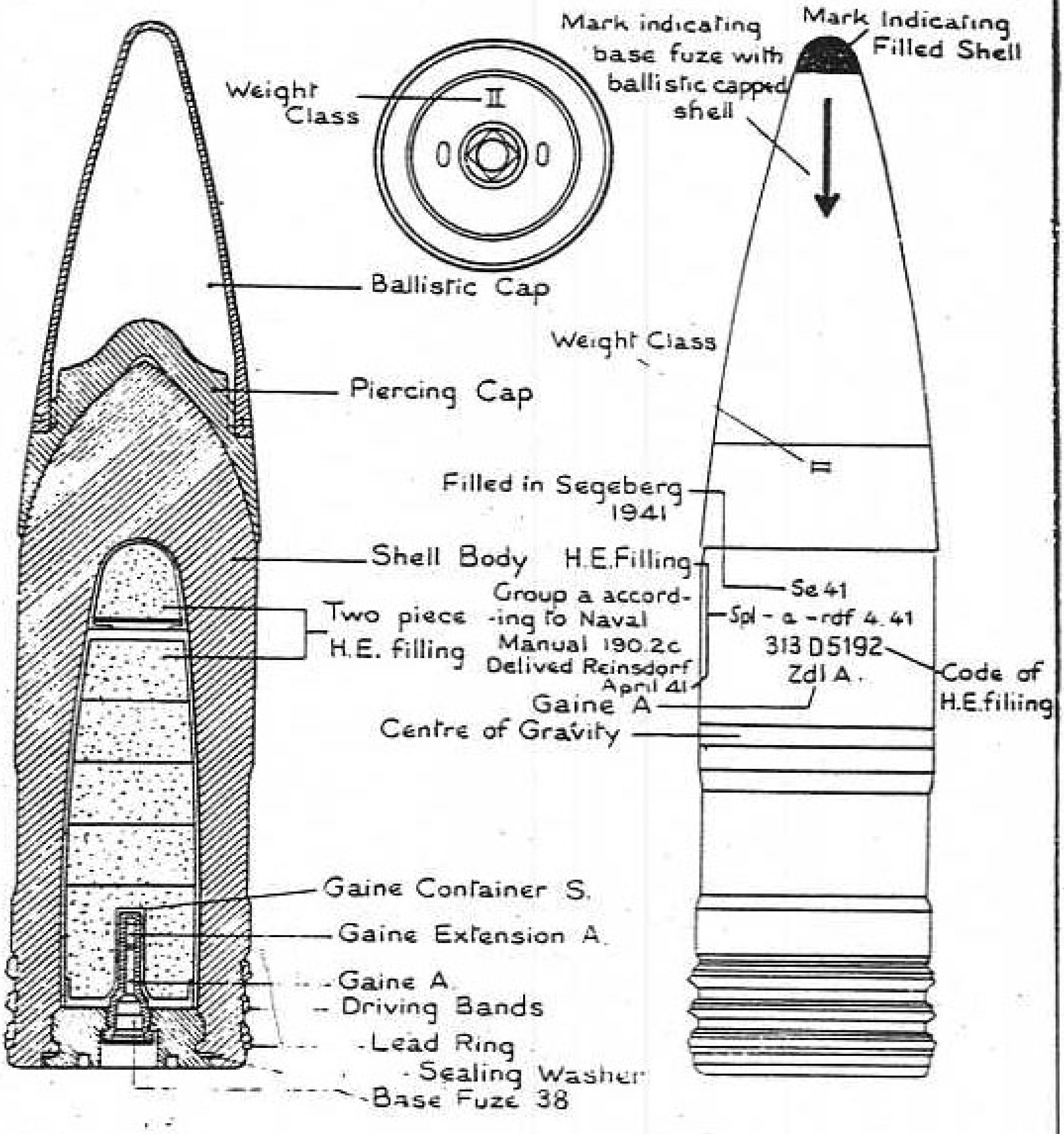
Range Metres.	T. of F. (seconds).	50% Zones. (Metres)		
		Length.	Breadth.	Height.
10000	11.4	103	.5	7.3
20000	27.7	105	3.4	25.0
30000	50.1	131	11.0	76.0
40000	76.2	219	23.0	-
50000	104.5	410	46.0	-
54900	128.0	715	72.0	-



38cm A.P. Shell L/4·4 with Ballistic Cap

38cm. Psgr L/4.4 (m.Hb)

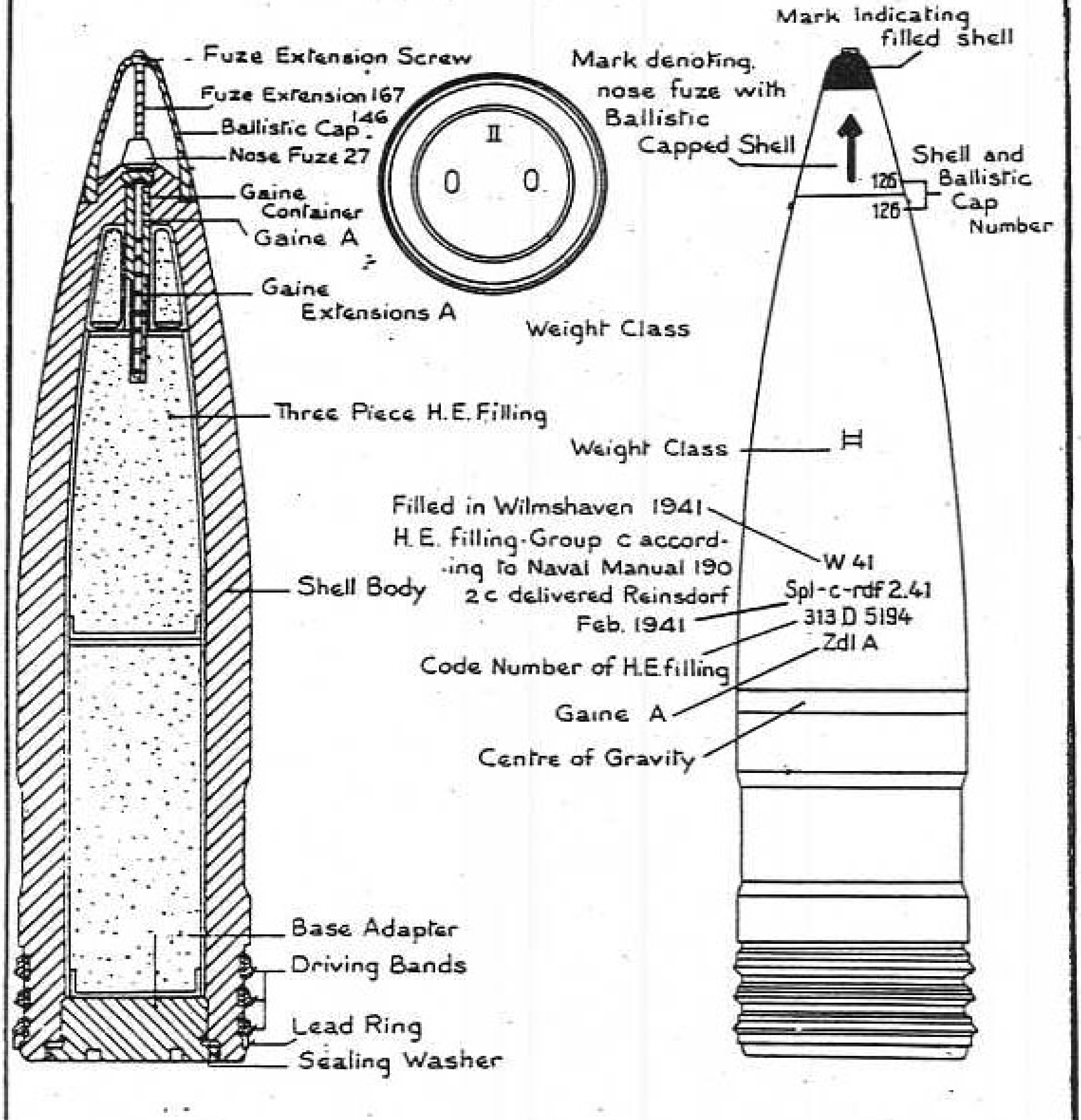
Fig. 3



38cm S.A.P. Shell L/4·5 with Base Fuze & Ballistic Cap.

38cm Spgr L/4.5 Bdz (m.Hb)

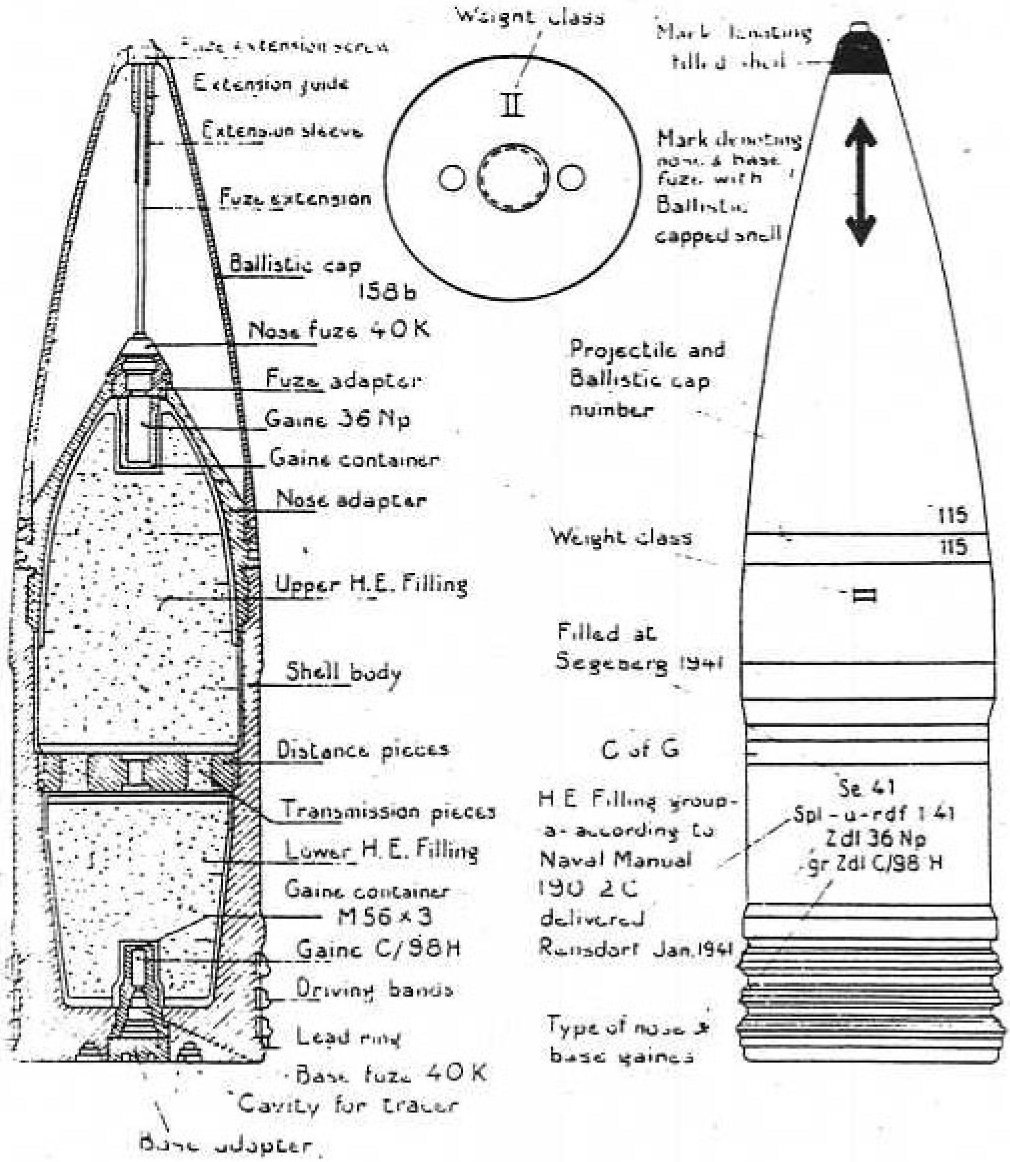
Fig.4



38cm H.E. Shell L/4·6 with Ballistic Cap & Nose Fuze

38cm. Spgr L/4.6 Kz (m. Hb)

Fig. 5



Long Range H.E. Shell L/4·5 with Ballistic Cap, Nose, & Base Fuze

Si-Gr L/4.5 Bdz u. Kz (m.Hb)

Fig. 6

SECTION II.

4. Charges. (See Figures 7 to 13).

The two groups of operational charge used with the 38-cm. SK C/34 are:-

(a) Normal charge (Gefechtsladung).

Long range charge (Grosse Gefechtsladung).

(b) Normal charge (Naval) (Gefechtsladung Schiff).

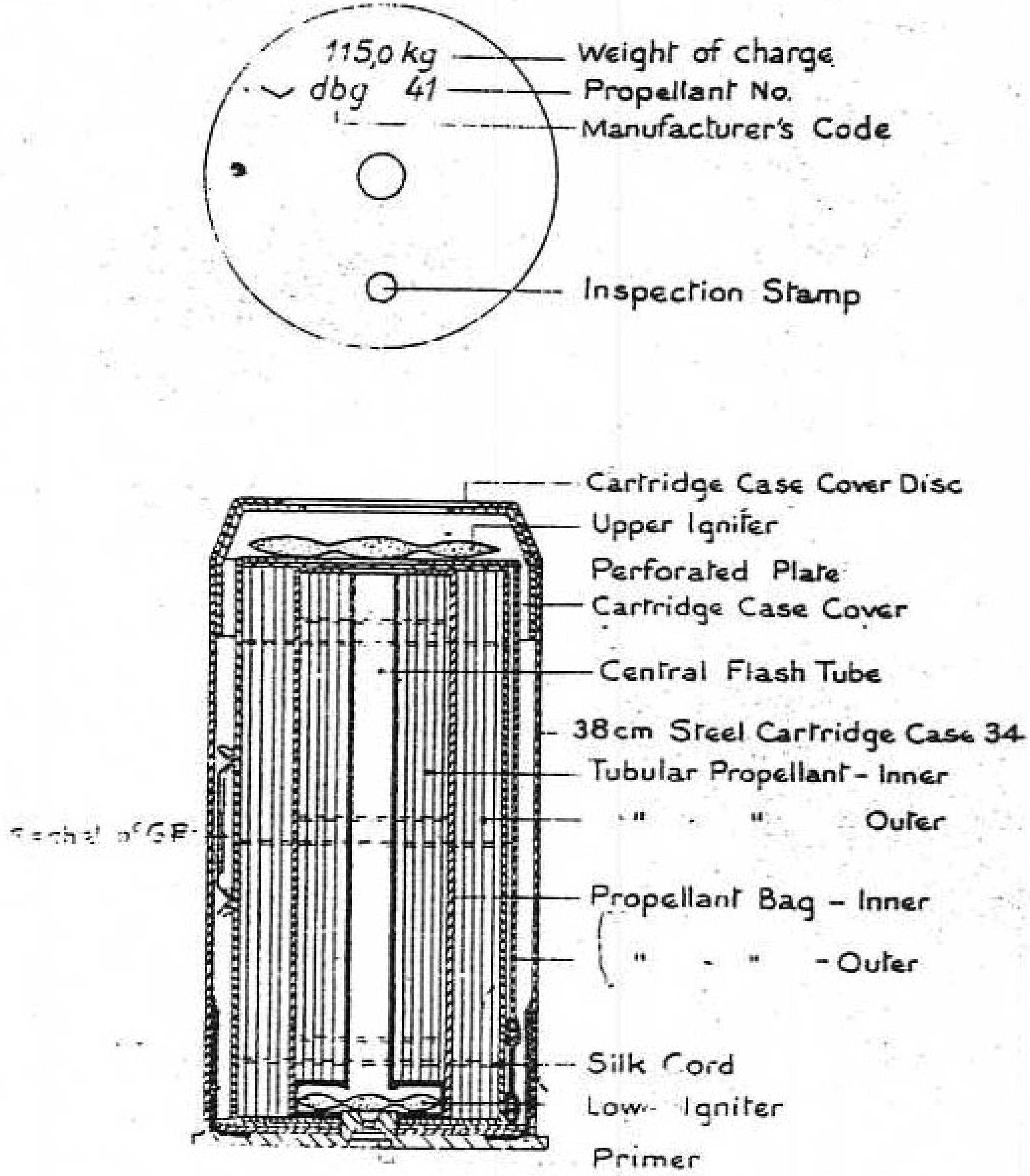
Long range charge (Naval) (Grosse Gefechtsladung Schiff).

The two charges under (a) are each made up of two increments, a basic rear section and a forward section. The rear section is common to both normal and long range charges and is contained in a steel cartridge case fitted with a C/12 K St percussion primer. The forward sections for normal and long range charges differ in weight, the former weighing 146 Kg. (322 lbs) and the latter 183 Kg. (403 lbs). In both forward sections the tubular propellant flash tube and igniter bags are contained in a cylinder with covers at both ends. The cylinder and covers are made of cast propellant. The whole section is contained in a silk bag of double thickness which has two handles at the forward end and one at the rear end. The front section for normal charge has "s G" (schweres G Geschoss - heavy shell) stencilled on the side of the silk bag and the front section for long range charge has "l G" (leichtes Geschoss - light shell) similarly stencilled. Stencilled at the forward end of both sections is "V" (Vorderseite - front end) and at the rear end "Beil" (Beiladungseite - Igniter end). Each rear and forward section bears a colour marking denoting the propellant lot number. On the rear section it is a coloured ring on the base of the cartridge case and on the forward section a coloured band round the silk bag. When a complete charge is made up only increments bearing similar colour markings are used.

The charges under (b) are made up of three increments each and consist of a rear section, a centre section and a front section. The rear section is contained in a brass cartridge fitted with a C/12 K St primer. The centre section consists of a cast propellant cylinder containing tubular propellant, cast flash tube and igniter, the whole being contained in a silk bag.

SECTION II.

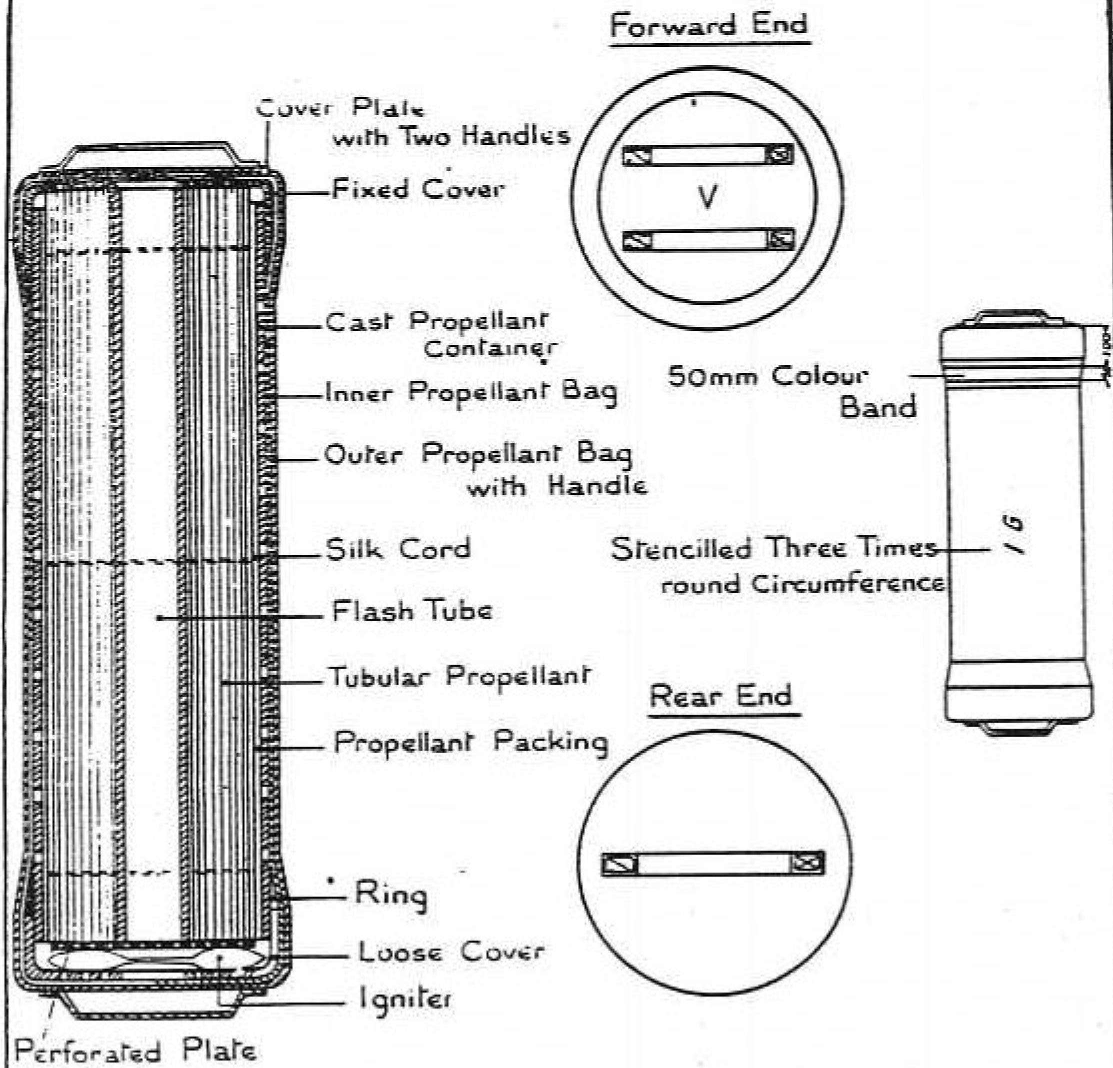
For both normal and long range charges the rear and centre sections are common. The front sections differ in weight, that for the normal charge marked "s G" weighing 14 Kg.(31 lbs) and that for the long range charge marked "l G" 46 Kg.(101 lbs). All three increments have a colour marking according to the propellant lot number and the same ruling applies when making up complete charges as mentioned above.



Rear Section of Charge

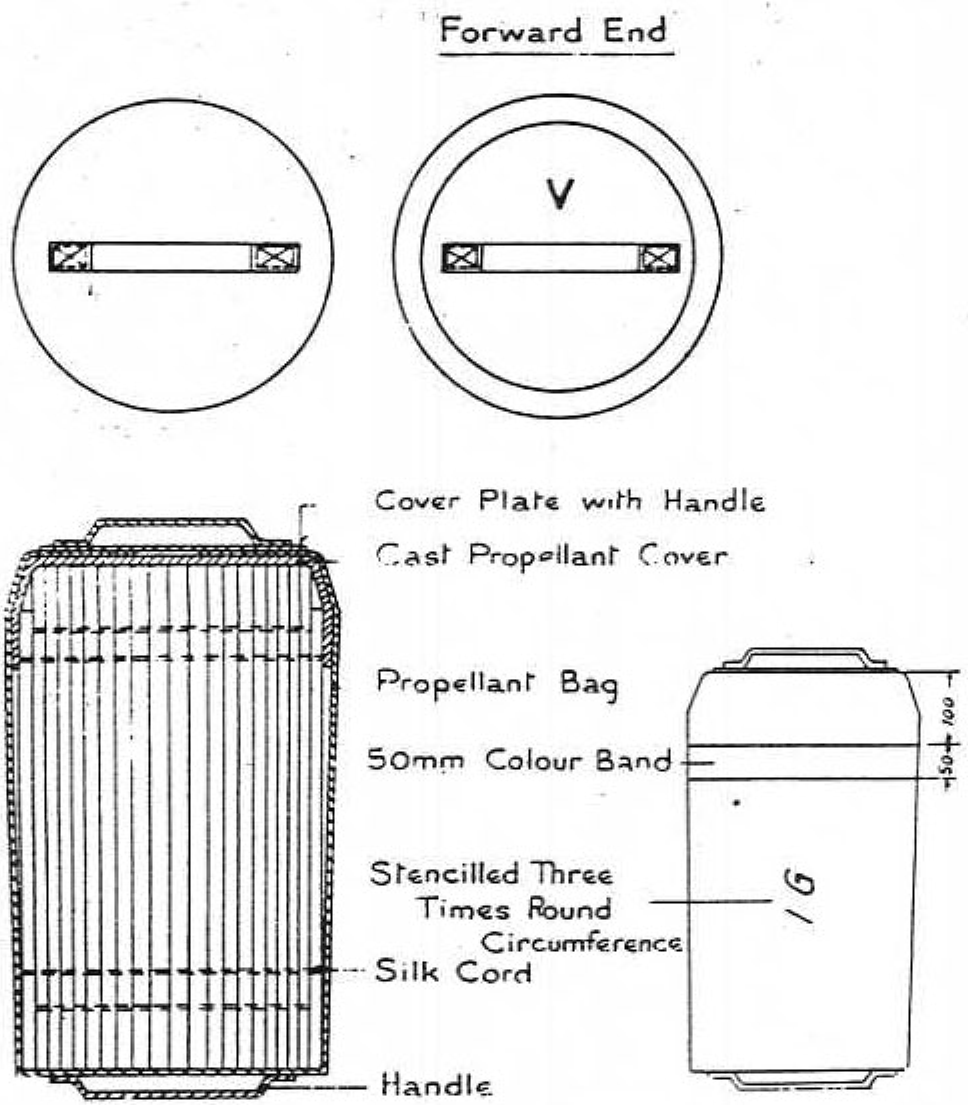
Hülsenkart f. Si Kanone - Gefechtsladung

Fig. 7.

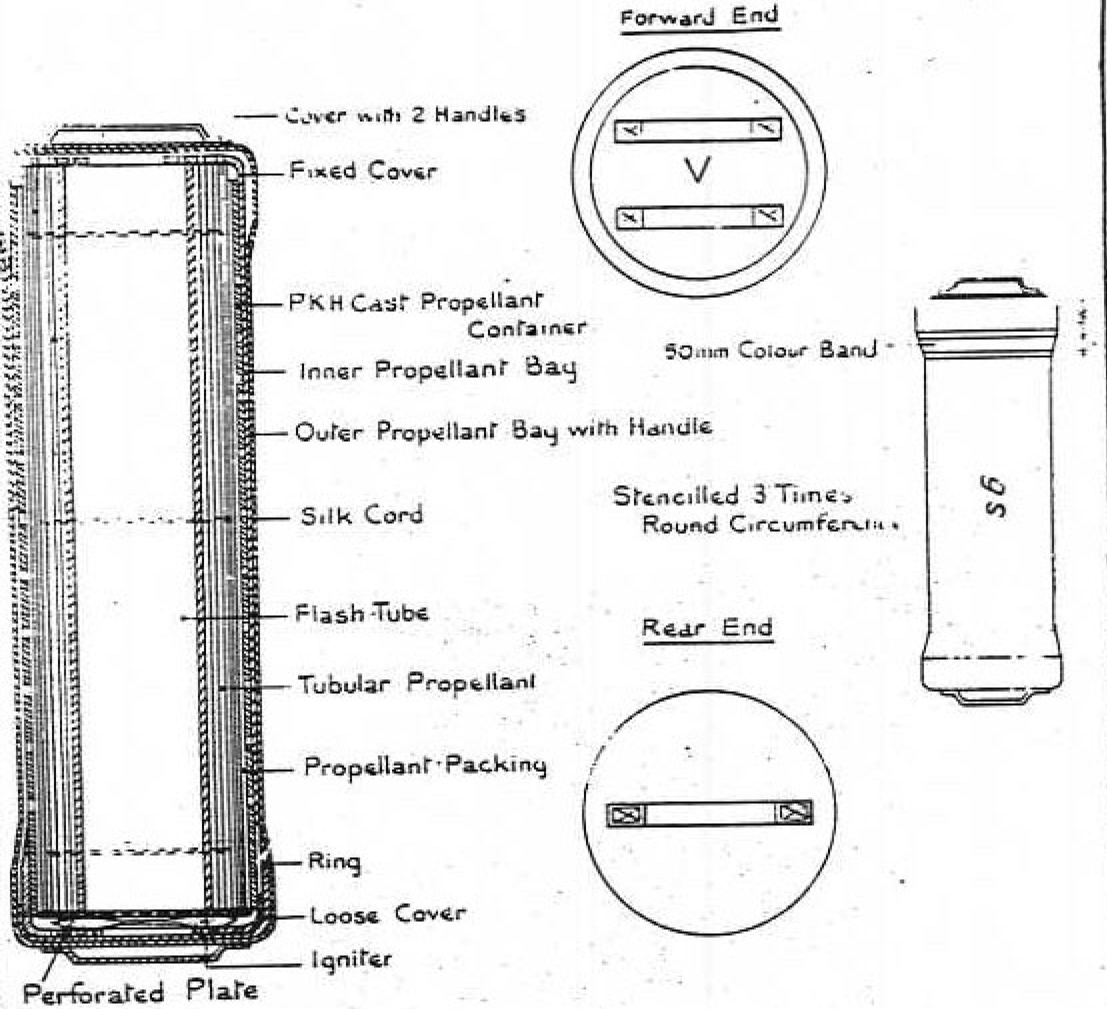


Forward Section of Long Range Charge
Vorkartusche für Si-Kanone- große Gefechtsladung

Fig.6



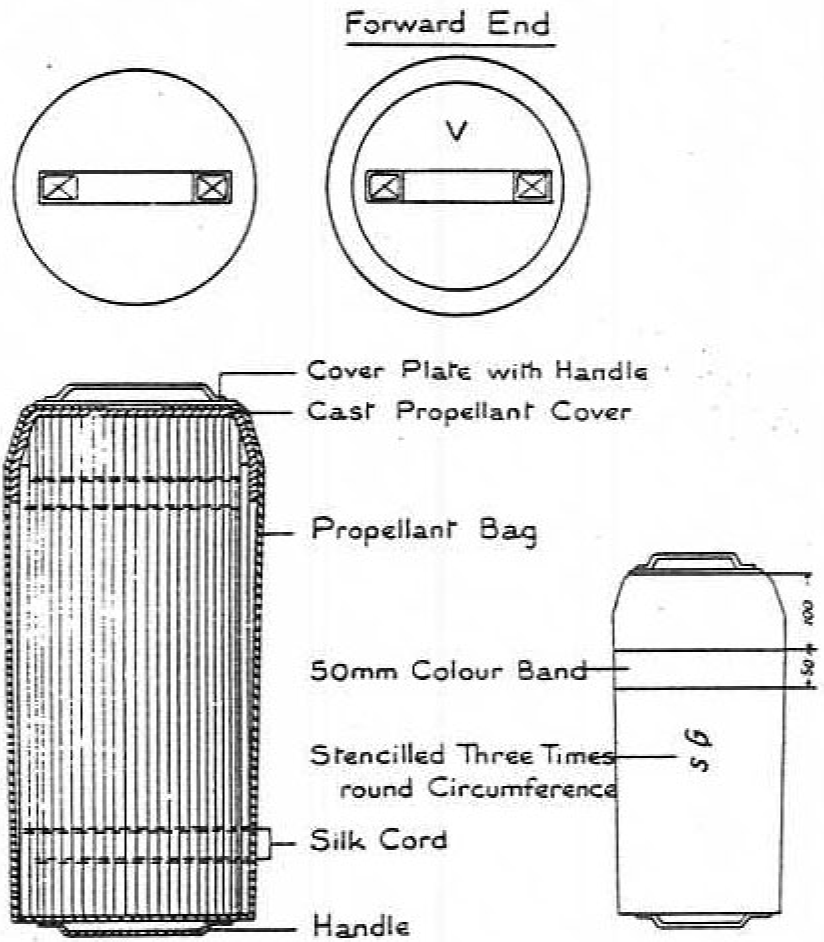
Front Section of Long Range Naval Charge
Sonder-Vorkartusche für Si-Kanone
-große Gefechtsladung-
Fig.9



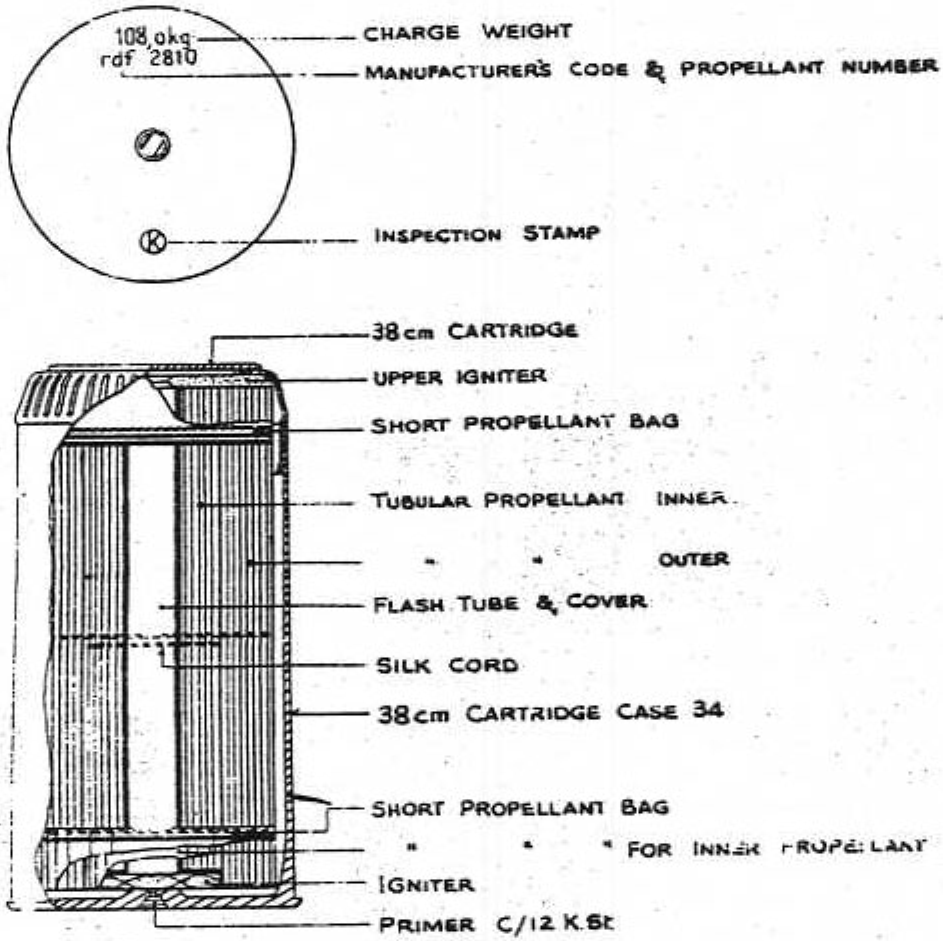
Forward Section of Normal Charge

Vorkartusche für Si.-Kanone - Gefechtsladung

Fig. 10

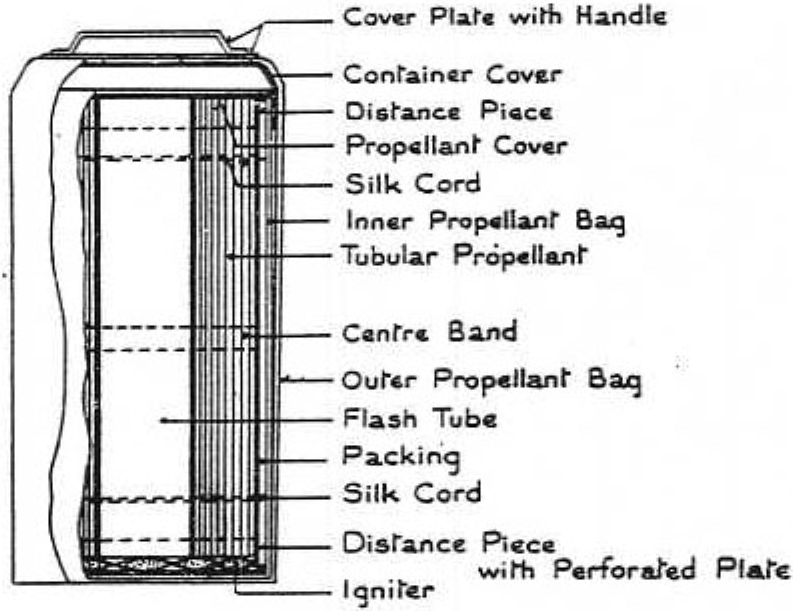


Forward Section of Normal Naval Charge
Sonder-Vorkartusche für Si-Kanone
-Gefechtsladung-
Fig.11



Rear Section of Naval Charge
38cm Huls Kart 34-Gef Ldg-(Schiff)

Fig.12



Centrè Section of Naval Charge

38cm Vorkart 34 - Gef Ldg - (Schiff)

Fig.13

SECTION II.

5. The Guns, Mountings and Emplacements.

(a) The guns and mountings are the same as the 38-cm. equipments installed in the Pas de Calais, full details of the latter are given in C.E.A.D. Technical Report No. 13/45.

The Germans assessed one 800 kg. shell or one 495 kg. shell with top service charge as one E.F.C. and the average life of a gun liner is said to be 286 E.F.C. 300 of the heavier shell are quoted as corresponding to 82 m.s. drop in M.V. or to 540 mm. extra ram (normal ram 2464 mm.), whilst 350 of the 495 kg. light shell correspond to 105 m.s. loss in M.V. or to 540 mm. extra ram (normal ram 2479 mm.). A special tool is provided to measure ram and it is interesting to note that the Germans regarded length of ram as a criterion of the life of the gun and muzzle velocity. They regarded the liner as worn out when the loss in M.V. reached 10%.

(b) No loose liners or loose "A" tubes (containing a liner) were held by the battery as replacements, nor were there any in the arsenal at Tisted. A thorough search also failed to reveal any special gear for the changing of liners or tubes. The Fortress Commander stated that he had carefully questioned the Krupps representatives on the subject of the renewal of worn out guns and the procedure was to be as follows:-

(i) A baulk platform was constructed behind the turret to position a cylindrical support for the worn out liner. The cylindrical support also served as a transporter casing for the liner.

Note. The withdrawal of the liner entailed pulling down part of the emplacement wall which had accordingly been constructed in masonry.

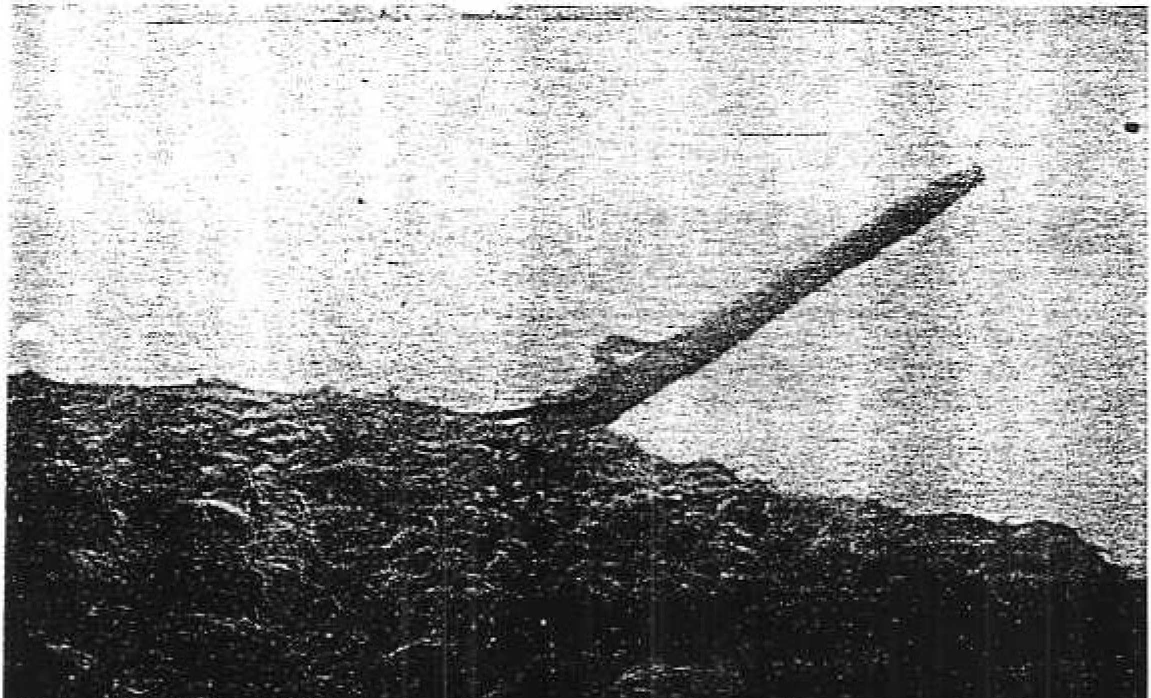
(ii) The rear end of the shield and the securing rings on the breech face were removed.

(iii) A hydraulic press was attached to the muzzle end of the "A" tube to displace the liner which was then withdrawn into the cylindrical container.

(iv) The procedure was reversed to fit the new liner.

If the Commander s description is correct, then there can be no doubt that the liner was originally intended to be removed without the "A" tube.

(c) In contrast to the casemated 38-cm. in the Pas de Calais, the HANSTEAD mountings were only provided with a splinterproof shield and were, therefore, capable of an all round arc of fire. Camouflage covers had been placed over each emplacement and rigorous discipline had been maintained in all matters appertaining to camouflage.



The above photograph shows a camouflaged emplacement with the gun elevated; it was otherwise difficult to pick out the emplacements from the ground.

SECTION II.

We were, in fact, so impressed with the camouflaged emplacements that we called for such aerial photographs of the Hanstead Battery as were held by the Joint Photographic Reconnaisance Committee. A sample of their work is reproduced as the easiest means of shewing the layout of the battery. The distance between Nos. 3 and 4 guns is 300 yards.

The key to the photograph (on Page 23A) is:-

(a) A.A. Battery.

(b) No. 4 Gun.

(c) Reserve B.P.R.

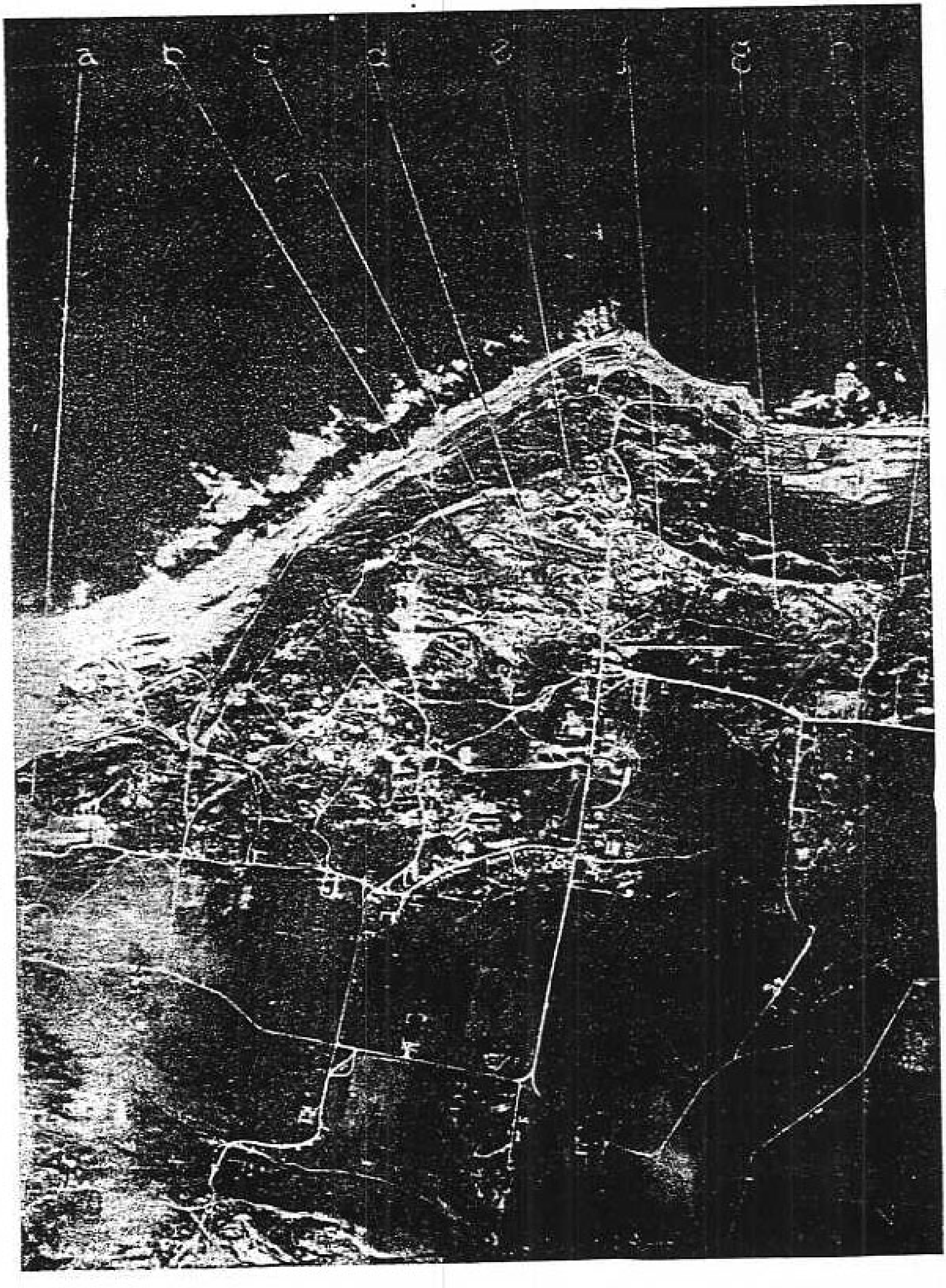
(d) No. 3 Gun.

(e) Battery Plotting Room.

(f) No. 2 Gun.

(g) No. 1 Gun.

(h) Radar O.P.


a
c

(d) The rate of fire obtained during practice series was said to be one round per gun in 70 seconds. Having regard to the low degree of automaticity - 18 men on the rammer! - this rate of fire is considered good, but the fire power of the battery as a whole was totally inadequate to deal effectively with targets taking evasive action at the ranges the Germans would have been called upon to fire had it been necessary for Allied Naval units to negotiate the Skagerak.

6. The Fire Direction System.

(a) The Long Range Base System of Optical Cross Observation.

Eight optical directors were installed in O.P's over a sea frontage of about 97 kilometres. The target bearings obtained from the directors were transmitted by telephone to the Battery Plotting Room. Angular deviations of fall of shot from the line of observation to the target were also passed to the B.P.R. by telephone. Examples of German C.A. directors have been examined and reported upon at the Military College of Science, Bury, (report No. MCSB/T/CA/6, Parts 4 and 5, distributed by M.I.10, War Office, refers).

(b) Radar Position Finding.

The Fortress was also equipped with two Wurzberg Riese radar sets. This set is well known in the U.K. and full details of its design are available at the Air Ministry (A.D.1.Science).

The radar sets under reference are normally mounted on a heavy concrete base about six feet high in order to give clearance for the 25 ft. diameter parabolic reflector, but the two sets at Hanstead had been erected on concrete towers 20 to 30 feet high in order to obtain an increase in range in the C.A. role. The radar equipment, including the turning gear, is carried in a cabin on top of the concrete base and has an all round arc of observation. The aerial and parabolic reflector are mounted on the cabin with free movement in elevation.

The wavelength used can be varied between 53 and 67 centimetres giving an effective beam width of about 7°. The pulse recurrence frequency is 1875 c/s which is equivalent to a theoretical maximum range of 80 kilometres. In practice the range is limited by the size of the target and, in the coast role, by the height of the set above sea level. The accuracy claimed by the manufacturers is ± 35 metres in range at all ranges and 3/16° in bearing and elevation, but the average performance of this instrument is not likely to be better than ± 50 metres and ± ½° in range and bearing respectively. The displays consist of a circular time base for ranges up to 80 km. and a fine range tube presenting either the 0 - 40 km. or 40 km. to 80 km. range bands. A "Split" presentation is employed to obtain bearing and elevation.

I.F.F. has been designed for these sets, but the sets examined had not been modified to incorporate it.

The sets were reported to be capable of detecting the splash of 6-inch and greater shell, the operator observing the difference in the range to the target and fall of shot on the "fine" range tube. The range discrimination of the set is, however, poor, and it was reported that the two breaks merged when the range difference was less than 600 metres. No information on fall of shot errors for line could be obtained from this set.

The power supply is at 380 volts 3 phase; 18 kw. being required. The set weighs about 12 tons and the cabin is rotated by a Ward Leonard electric drive giving maximum rates of 10°/sec. in bearing and 5°/sec. in elevation.

(c) Instruments in the Battery Observation Post.

The B.O.P. was built on top of the Battery Plotting Room and equipped with a 10.5 metre base stereoscopic rangefinder and a periscopic director. An exactly similar rangefinder was captured near Ghent in Belgium and a detailed report on it is at Appendix A.

Ranges and bearings obtained by continuous following on the stereoscopic rangefinder (the battery pivot) and director were passed to the adjacent plotting room by telephone.

Note: No German specimens of depression rangefinders were found in Denmark, but even if they possessed any it is doubtful if they would have been employed in the defences visited because of lack of height.

SECTION II.

(d) Instruments in the Battery Plotting Room.

The following instruments were provided in the Battery Plotting Room:-

(i) The Langbasis Kleingerat (L.B.K.G.)

This instrument was used to obtain battery pivot range and bearing when supplied with either range and bearing from one of the radar O.P's or bearings from any two of the optical or radar O.P's. It therefore combined the functions of long base cross-observation computer and displacement corrector. It was also used to compute target "future" bearing when time of flight was fed into it as a function of future range.

The following corrections to bearing were applied on this instrument:- Meteor corrections, drift, spotting corrections, and corrections for the rotation of the earth.

The photographs on Page 27 show the external linkages on the two longer sides of the main casing which reproduce the relative positions of observation posts and the battery pivot to a scale of 1 : 20000 or 1 : 40000, the larger scale being employed to obtain greater accuracy when firingz at the shorter ranges. The linkages can be quickly set up and oriented for any two O.P's. Settings are made to the nearest 10 metres or 1/16th degree, the maximum displacement on the Hanstead instrument being 274,520 metres. Target bearings from two O.P's or range and bearing from a single O.P. are hand set and battery pivot range and bearing obtained by simple triangulation.

Target battery pivot bearings obtained from the linkages are "followed up" on a dial and the operator's handwheel displaces "a pen" which produces a bearing plot on a paper moving at constant speed. Parallel lines are inscribed on a glass plate which is fitted over the plot and the bearing rate operator rotates the grid so that the lines are parallel to the bearing plot, he thus rotates his handwheel by an amount proportional to the rate of change of bearing.

Future target bearing (Bf) is assumed to be equal to present bearing (Bp) plus rate of change of bearing ($\dot{b}$) multiplied by time of flight (t). Time of flight is hand set into the instrument as a function of battery pivot range on a suitably graduated range drum. A mechanical multiplying device produces the product $\dot{b}t$ which is added to Bp on a differential to produce Bf.

The instrument appeared to employ no new principles. It was very solidly constructed, the displacement linkages being especially heavy. Despite the high standard of workmanship it was said that the instrument frequently went out of adjustment and required undue maintenance.

Notes on the tests carried out on the instrument indicate that an overall accuracy of about 1% of range was obtained under static conditions.

(ii) The Eumesser - Graphical Range Rate Calculator (G.R.R.C.)

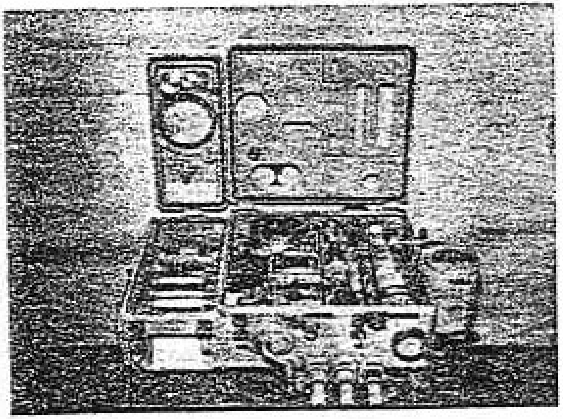
Present battery pivot range from either the L.B.K.G. or the 10.5 metre rangefinder were passed to the G.R.R.C. This instrument measures the range rate and so evaluates "future" battery pivot range. Facilities for the application of "spotting" and meteor corrections to range were incorporated.

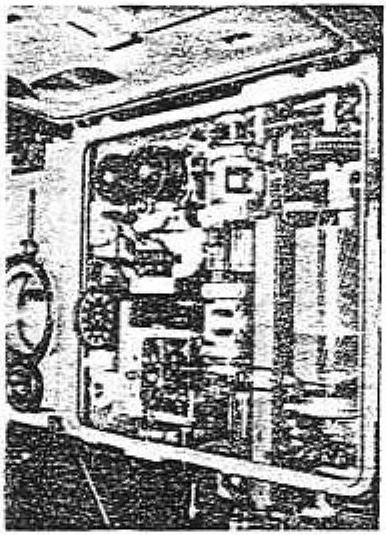
An operator continuously sets in present range (Rp) and the range rate ($\dot{r}$) is obtained by plotting in exactly the same manner as the bearing rate is obtained on the L.B.K.G. A drum x carries curves of the product $\dot{r}t$ plotted against t for various values of $\dot{r}$ and an operator matches a range dial and thereby causes a pointer to be displaced from the origin of the curves by an amount proportional to t. The drum is rotated so that the curve corresponding to the range rate obtained by plotting just touches the pointer. The drum is thus rotated for $\dot{r}t$.

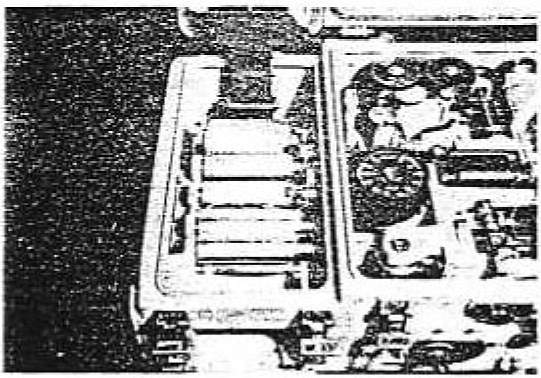
The value of future range (Rf) is obtained by adding Rp to $\dot{r}t$ in a differential. Differential gears are also used to permit corrections, alraady referred to, to be added to Rf.

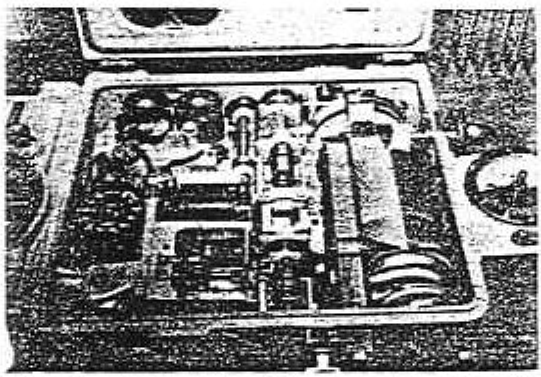
The instrument is compact and well made.

Future ranges and bearings were transmitted by selsyn to the gun emplacements from the G.R.R.C. and L.B.K.G. respectively.







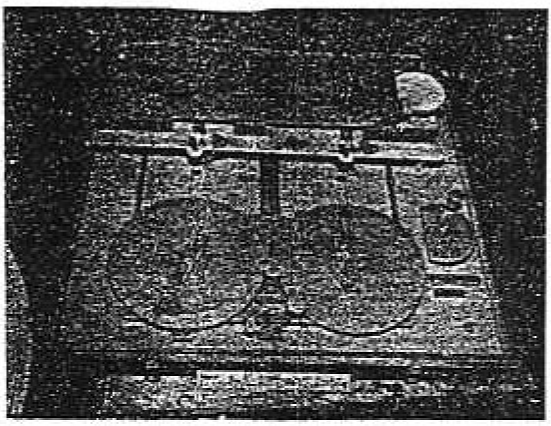


THE EUMESSER - GRAPHICAL RANGE RATE CALCULATOR.

(iii) Fall of Shot Correction Calculator (F.S.C.C.)

This encoder evolved "spotting" corrections to range and bearing whem fed with target bearings and fall of shot observations from two displaced O.P's. It could also be used to calculate travel corrections when target location and its course and speed are set.

The Fall of Shot Correction Calculator is dealt with in Military College of Science, Bury, No. MCSB/T/CA/6, Part II.

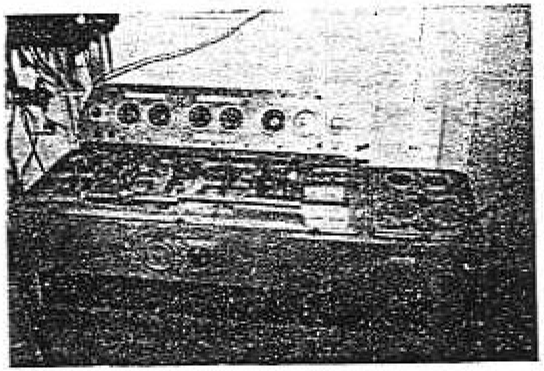


FALL OF SHOT CORRECTION CALCULATOR.

(iv) T.V. Rechentish C.39.

An instrument used to calculate range and bearing corrections for wind and abnormal ballistic conditions.

This instrument is dealt with in Military College of Science, Bury, No. MCSB/T/CA/6, Part I.



T.V. RECHENTISH C.39.

(e) Instruments on the Mounting.

Each mounting is fitted with a Seipa Empfanger and a Epa Empfanger. These are bearing and range receivers which also correct battery pivot future range and bearing to gun range and bearing.

Follow-the-pointer methods are used to lay the guns in bearing but read and set methods are used to lay the gun in elevation.

Full details of the Seipa Empfanger and Epa Empfanger are set out in Appendix B.

SECTION II.

(f) Appreciation.

Aircraft had been allocated to the battery for spotting until the Germans lost air supremacy and the Fortress Commander considered that radar ranges, optical bearings and aircraft observation of fall of shot would have given him all the basic data he required to obtain hits, even at long range. With this combination, which he regarded as the best, he claimed to have obtained 20% hits on a battleship type target at a range of 30,000 yards in practice series.

Having had to abandon spotting aircraft, they corrected range from radar fall of shot observations, throwing off for line to obtain precise range difference between target and the M.P.I. of a salvo when ranging, and corrected bearing by a system of bracketing.

The Germans obviously failed to develop radar to the stage where it re-oriented the entire Coast Artillery fire direction problem. For this reason the German fire control equipment and technique examined is of historical interest only. Against targets maintaining a donstant course and speed success might have been achieved in conditions where direct observations of the target and fall of shot were allowed, but the time lag in picking up the commencement or end of a turn must have been considerable and it is considered that except at short range, say, less than 17,000 yards, the battery would have been incapable of dealing effectively with targets taking evasive action. German Naval officers smiled significantly when we enquired as to the procedure adopted to combat snaking targets.

SECTION III.

THE "INVASION" AREA.

1. The System of Control.

To provide early warning 16 giant Wurzberg radar sets were deployed on the West Coast of Jutland, covering a coast line of 300 kilometres with a mean spacing of about 20 kilometres. This chain was employed in coast watching both in the A.A. and C.A. roles. None of the sets were used to provide fire control data.

All Wurzberg installations were connected by telephone and wireless to the central control room in ESBJERG. The main equipment in the control room consisted of a large scale plan plotting board which enabled the location of any sea or aerial target to be obtained from any two radar cross bearings. The plotting was of the most elementary type and the main point of interest is that the control of the A.A. and C.A. defences was to be vested in a single commander in the case of a joint sea and air attack.

As soon as a sea target was detected its location was passed to the Headquarters at AARHUS on the East coast. A complete record of all friendly shipping was kept at AARHUS and the decision as to whether the target was or was not to be engaged was made there.

If hostile, the location of the target was passed to the four regimental control rooms situated North and South of ESBJERG, the ISLAND of FANO and the East Coast. The allocation of targets to batteries was effected from the regimental H.Q., but target information was passed on from the central control room to the Regiments and from Regiments to batteries in the form of a map reference.

2. Unorthodox Use of Radar for Target Detection.

In addition to the chain of Wurzberg radar sets referred to in the previous sub-section, use was being made of a chain of five radar receiving stations for target detection. Two sets were provided for each station, the five stations being approximately 70 kilometres apart. One of each pair of sets operated on a wave band of 3 to 12 centimetres, the second on a wave band of 35 to 3000 centimetres. They consistedof highly directional receivers not associated with any particular transmitter, but making use of the re-radiation from the target of the radiation from any transmitter which was following it.

The absence of a "local" transmitter implies the direct measurement of bearing and elevation only, the position of a target being roughly obtained by cross observation from any two sets. The necessary plotting was carried out in the control room at ESBJERG.

One of the advantages of this system of detection lies in its comparative immunity from jamming, but it would, of course, be effected by spoofing devices.

The chances are that the provision of receivers without transmitters was an economy measure. Assuming the provision of transmitters to be limited, for a given power, greater aircraft detection range would be obtained by an increased number of displaced receivers, since the total path of radiation from the transmitter via the target to the displaced receivers would be shorter in certain circumstances. This increase in scope would not be appreciable againsy shipping.

3. Communications.

Communications between the higher Artillery Commands was by telephone, radio apparatus being provided as an alternative for use in the event of a breakdown in telephone communication.

Although many of the fire control instruments were equipped with selsyn receivers and transmitters, selsyn transmission was only used between the Battery Plotting Room and the four gun emplacements at HANSTEAD. With this exception, telephone was used for the transmission of fire control data within the Fortress and Battery perimeters.

It had been the German policy to bury the telephone cables to a depth of 3 metres, but they found that this was inadequate protection against heavy bombing attack and that the cables were difficult to repair and maintain when buried to this depth. The practice was accordingly adopted of burying telephone cables to a depth of nine inches and waving the lines, i.e., leaving plenty of slack between connecting points, wood pegs were left protruding to indicate the exact route. The Germans stated that this system had stood up well to bombing and shelling in France. This policy had not been universally implemented in Denmark, the telephone cables at Hanstead were still buried to a depth of 3 metres and in many of the batteries the telephone lines were run along the side of the slit trenches connecting the guns and control points.

4. The Super-heavy Battery at OXSBY (Two Twin 38-cm.)

(a) General.

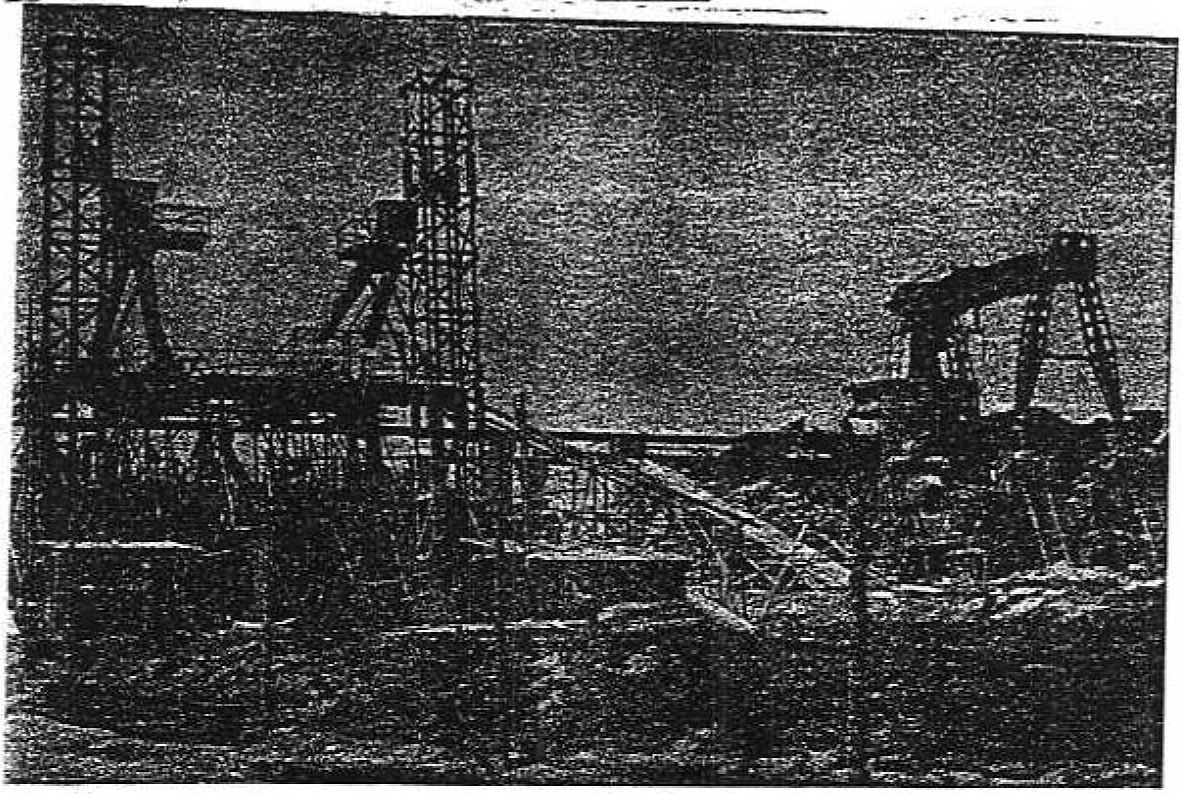
Copies of contracts indicate that the Todt organisation began work on this battery in July, 1944. Completion was anticipated by September, 1945. When work stopped in May, 1945, the concrete emplacements were about 80% complete and 175,000 kg. trestle cranes had been erected over each emplacement for the positioning of the mountings - which are on the site, rusting. It was reported to us that the guns and fire control instruments were in a railway siding at Guldager. The ammunition had not been issued.

Ten miles of special railway track had been laid to bring the material to the battery position and the installation of this battery undoubtedly called for a prodigious engineering effort.

An idea of the magnitude of the work can be obtained from the photograph on Page 36 which shews a single emplacement with the main twin turret frame underneath the trestle crane. The cranes are ideal for this type of work and we recommend that at least one of them be shipped to the U.K. Details are given in Appendix C.

The two emplacements were approximately 200 metres apart, low sited in sand dunes, and about 2000 metres from the beach. The guns would have had an unobstructed command over the water area.

No attempt had been made to camouflage the battery during the constructional stage, it would obviously be impracticable, but light A.A. guns near the emplacements were manned from the outset and it was proposed to instal H.A.A. batteries for local protection in due course.



CONSTRUCTION OF TWIN 38-cm. BATTERY AT OXSBY.

(b) The Emplacements.

The Naval design of mounting had been accepted for use in the Land Service without any major modification. When in battleships they were reported to have an armoured turret with 80 mm. of plate at the top and 35 mm. of plate as side protection. When used in fixed defences it was the policy to increase this thickness of armour in the ratio of 5 : 2

Figure 14 is an accurate representation of the concrete structure, the small inset giving an external view of the mounting as it would have appeared when complete.

Figures 15 and 16 are asymmetric views of the top and lower floors of the emplacement. Titles on these Figures indicate the purpose of each compartment.

The entire structure was reinforced concrete apart from the inner circumference and circular paths at the top of the gun pit, these were lined with 2-in.

GENERAL VIEW OF CONCRETE EMPLACEMENT.

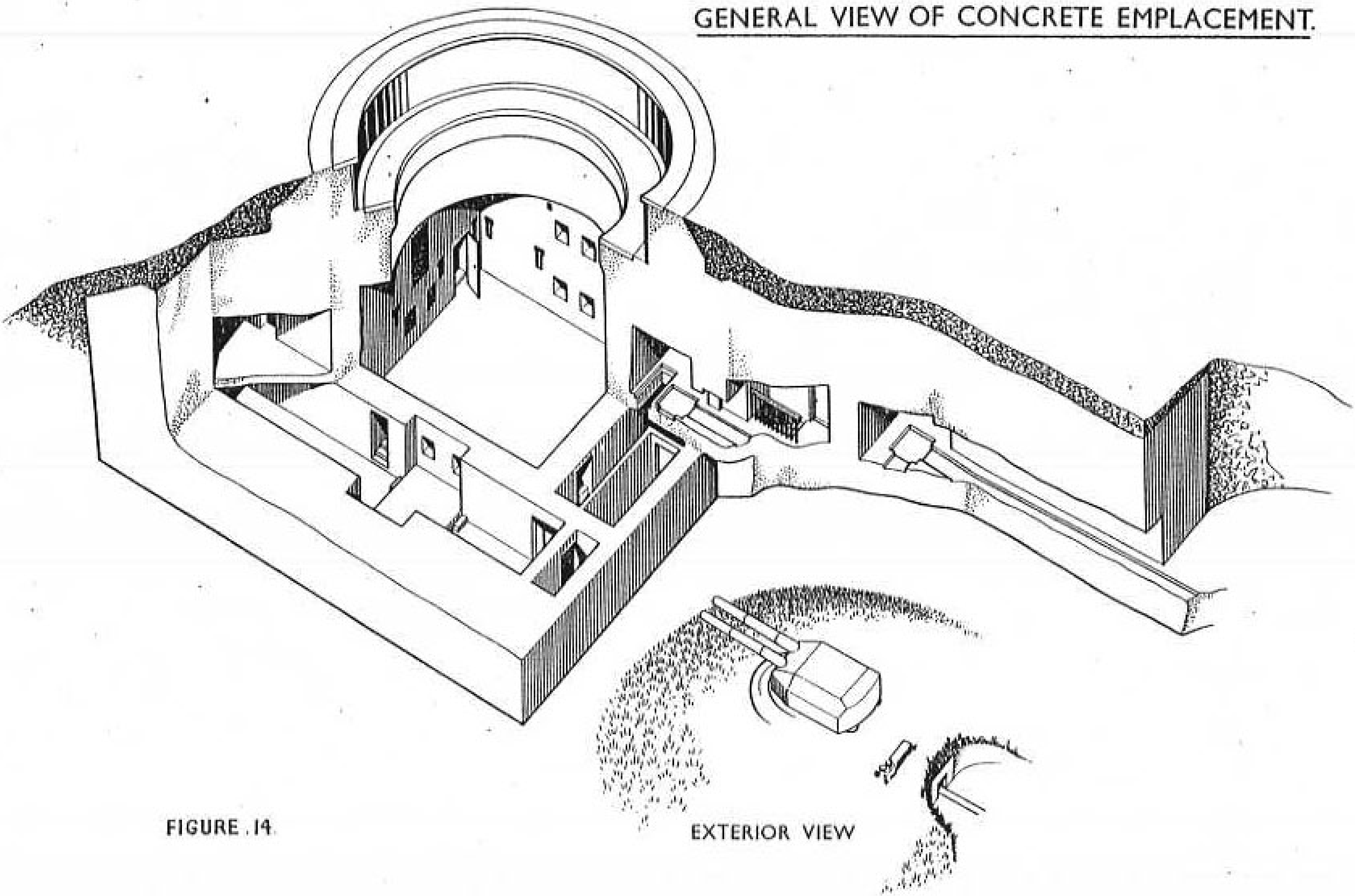


FIGURE .14.

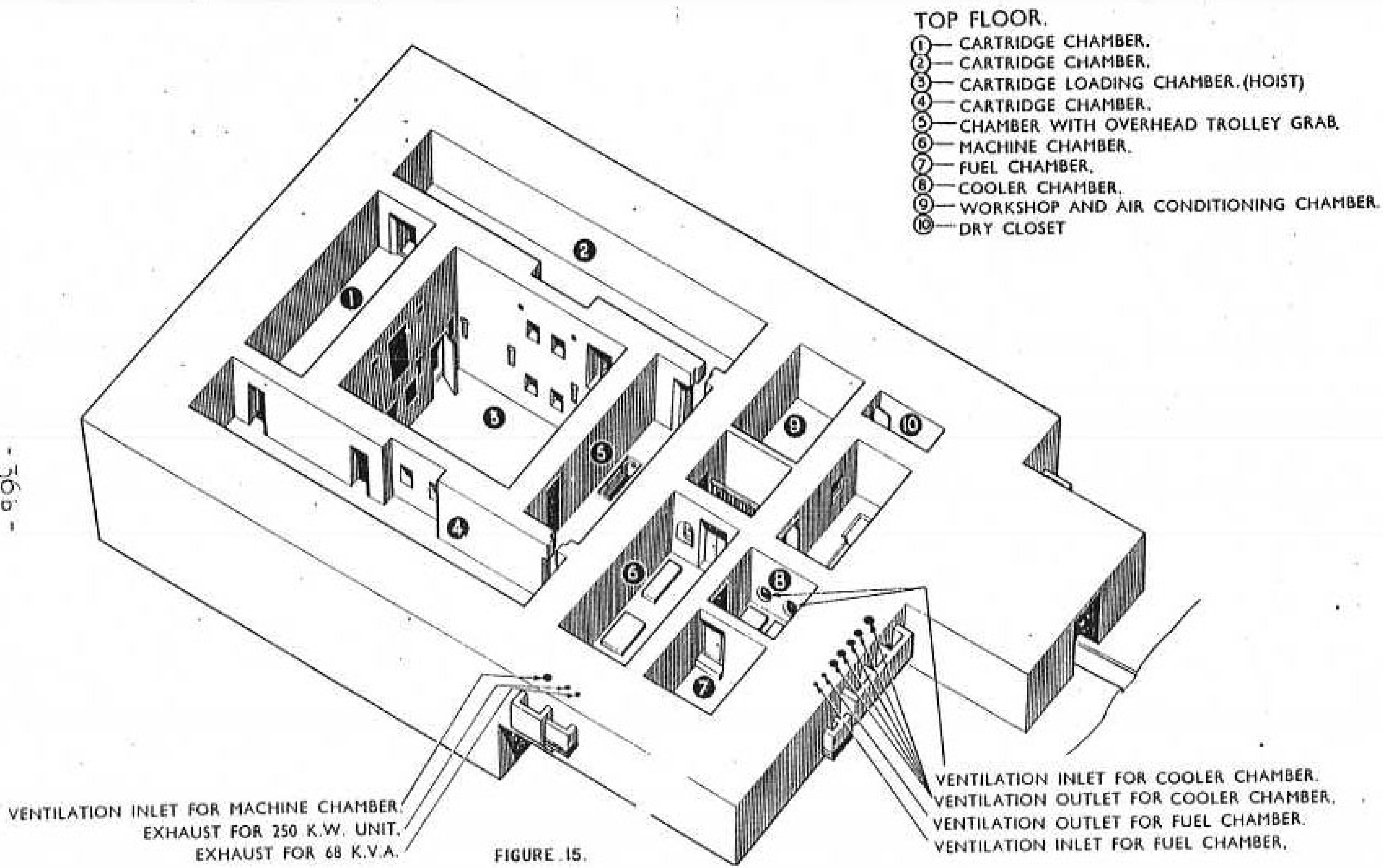

TOP FLOOR.
1 — CARTRIDGE CHAMBER.
2 — CARTRIDGE CHAMBER.
3 — CARTRIDGE LOADING CHAMBER. (HOIST)
4 — CARTRIDGE CHAMBER.
5 — CHAMBER WITH OVERHEAD TROLLEY GRAB.
6 — MACHINE CHAMBER.
7 — FUEL CHAMBER.
8 — COOLER CHAMBER.
9 — WORKSHOP AND AIR CONDITIONING CHAMBER.
10 — DRY CLOSET
VENTILATION INLET FOR MACHINE CHAMBER.
EXHAUST FOR 250 K.W. UNIT.
EXHAUST FOR 68 K.V.A.
VENTILATION INLET FOR COOLER CHAMBER.
VENTILATION OUTLET FOR COOLER CHAMBER.
VENTILATION OUTLET FOR FUEL CHAMBER.
VENTILATION INLET FOR FUEL CHAMBER.

FIGURE 15.

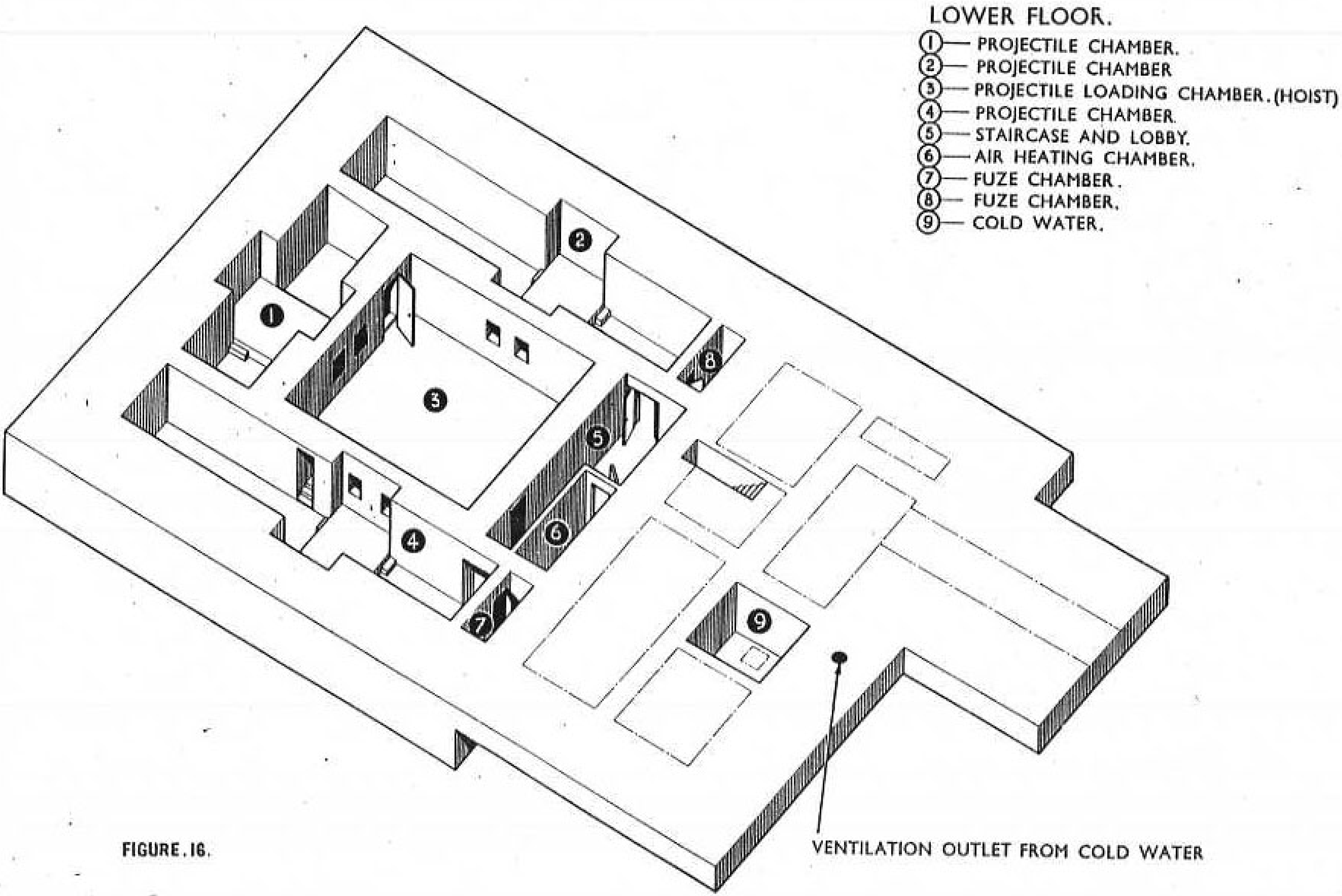

LOWER FLOOR.
1 — PROJECTILE CHAMBER.
2 — PROJECTILE CHAMBER
3 — PROJECTILE LOADING CHAMBER. (HOIST)
4 — PROJECTILE CHAMBER.
5 — STAIRCASE AND LOBBY.
6 — AIR HEATING CHAMBER.
7 — FUZE CHAMBER.
8 — FUZE CHAMBER.
9 — COLD WATER.
1
2
3
4
5
6
7
8
9
VENTILATION OUTLET FROM COLD WATER

FIGURE. 16.

GENERAL VIEW.

SECTIONED THROUGH TOP AND LOWER FLOORS.

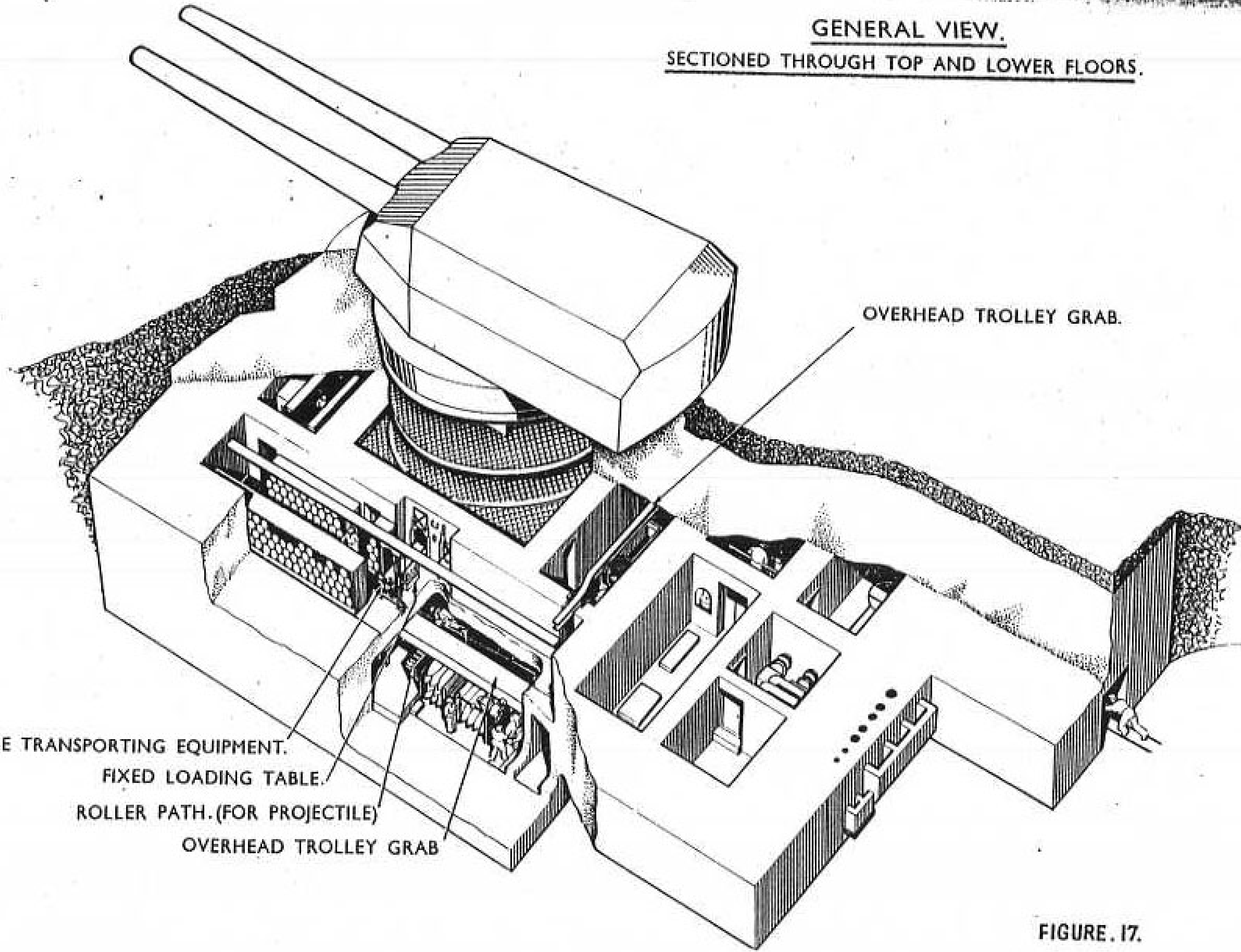
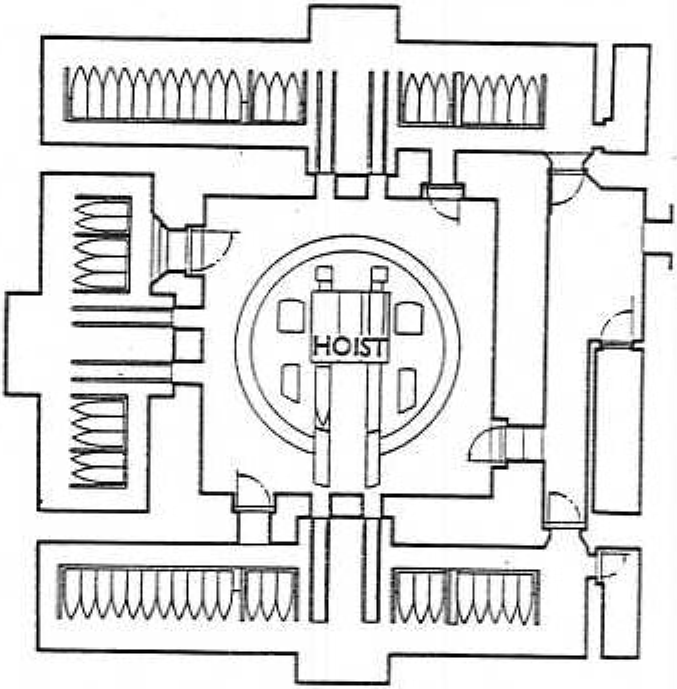
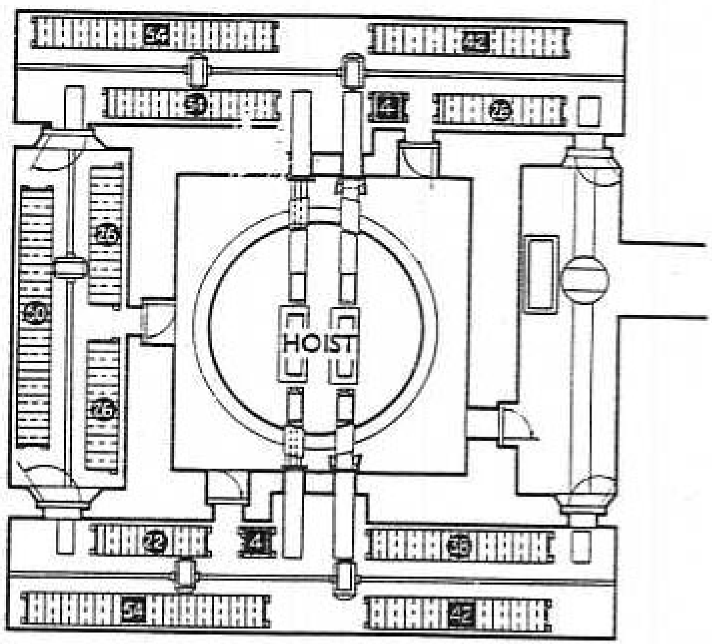


FIGURE. 17.



LOWER FLOOR

PROJECTILES



TOP FLOOR

MAIN CARTRIDGES ●

FORWARD CARTRIDGES ■

FIGURE. 18.

and 6-in. armour plate.

All Figures referred to in this sub-section are roughly to scale, the maximum thickness of the concrete roof being approximately 11 feet. It is estimated that the concrete roof and emplacement walls would have withstood a direct hit or near miss from a 4000-lb General Purpose bomb or a 9.2-inch A.P. shell, but they would not have withstood a direct hit from A.P. or rocket assisted bombs, or a near miss from a "Tall-boy".

The turret armour is probably the maximum the Naval engine power assessment will permit and not determined by the penetrative effect of a specific projectile or bomb. Having regard to the ~~xxxxxxxx xxxxxxxxxxxxxxx~~ size of the concrete structure as compared with that of the turret itself, a sensible balance appears to have been maintained in the overall scale of protection.

Despite the layers of plate at the top of the gun pit, the roller paths and overhanging portion of the turret are considered to be the most vulnerable part of the structure.

It is noticeable that the shell are lower than the cartridge chambers. This is rather surprising and probably governed by German Naval design considerations.

Figure 17 is a general view sectioned through the top and lower floors to show the methods of handling the ammunition. This should be studied in conjunction with Figure 18 which gives a plan of the ammunition storage system, hoists, etc.

(c) The Guns, Mountings and Ammunition.

(i) The guns and ammunition were to be the same as those supplied to the Hanstead 38-cm. battery.

Maximum elevation - 30° Traverse - 360°

Maximum range:-
A.P., S.A.P. and H.E. shell (800 kg.) 39,000 yards.
Light shell (495 kg.) 46,300 yards.

M.V. - 2700 and 3465 f.s. respectively.

The main power drives in elevation (hydraulic) and bearing (electric) gave maximum rates of 6° per second. The auxiliary drives in elevation and bearing were electric and gave maximum rates of 2° per second. The creep speed in elevation and bearing were 1.5 minutes per second.

(ii) Power Supply.

Main - 250 KW. 220v. D.C. generator.

Auxiliary, for lighting, ventilation, etc. - 68 K.V.A. 220v. A.C. generator.

(iii) Ammunition Hoists.

Main system hydraulic, capable of handling shell and charge simultaneously. Rate of fire - 2 rounds per minute per barrel.

Auxiliary system electric, shell and charge handled consecutively. Rate of fire - one round per minute per barrel.

As compared with the Hanstead Battery, the increase in fire power is considerable.

(d) Fire Direction System.

A study of the drawings and the interrogation of the Engineer concerned with the installation indicate that the fire direction system was to be very similar to that installed at the Hanstead Battery, the only noteworthy difference being that a radar set was to be allocated to each turret and sited within 200 yards of it, in order to give range and fall of shot corrections.

SECTION III.

5. German Medium Transportable Coast Artillery.

(a) One of the most interesting Batteries visited was that at BLAAVANDS KRO since it portrayed the German attempt to employ a standard medium Field Army Artillery equipment of modern design in a mobile Coast Artillery role. Only one such battery was found in Denmark and it consisted of four 15-cm. K.39 field guns and carriages mounted on specially designed Coast Artillery firing platforms.

(b) The Gun (Figure 19).

(i) Details.

Bore.	5.87 inches.
Total length.	55 cals. (27.07 ft.)
Length of rifling.	43.4 cals. (21.37 ft.)
Rifling twist:-	
Initial.	4° 16' (1 in 42 cals.)
Final.	6° (1 in 30 cals.)
Chamber:- Length.	4.14 ft.
Capacity.	1574.4 cu. ins.
Weight of projectile.	99.2 lbs.
Muzzle Velocity.	2920 f.s.
Muzzle energy.	5863 ft. tons.
Charge weight.	33.95 lbs.
Range (maximum).	15½ miles (approx.)
Weight:-	
Gun with B.M.	4.84 tons.
Breech mech.	341.7 lbs.
Inner "A" tube.	2.15 tons.

(ii) Short Description.

The figures in brackets refer to Figure 19.

The gun assembly is of a normal type. The rear cylindrical shoulder of the inner A tube is housed in the jacket. Above and below the middle vertical plane of this shoulder there are grooves for the fitting pins (9).

A slightly tapered portion is attached lengthwise on the jacket to the collar of the inner A tube. Following on this up to the muzzle there is a strongly tapered portion of the inner A tube. At the rear of the inner A tube there is a projection for cartridge case and extractors.

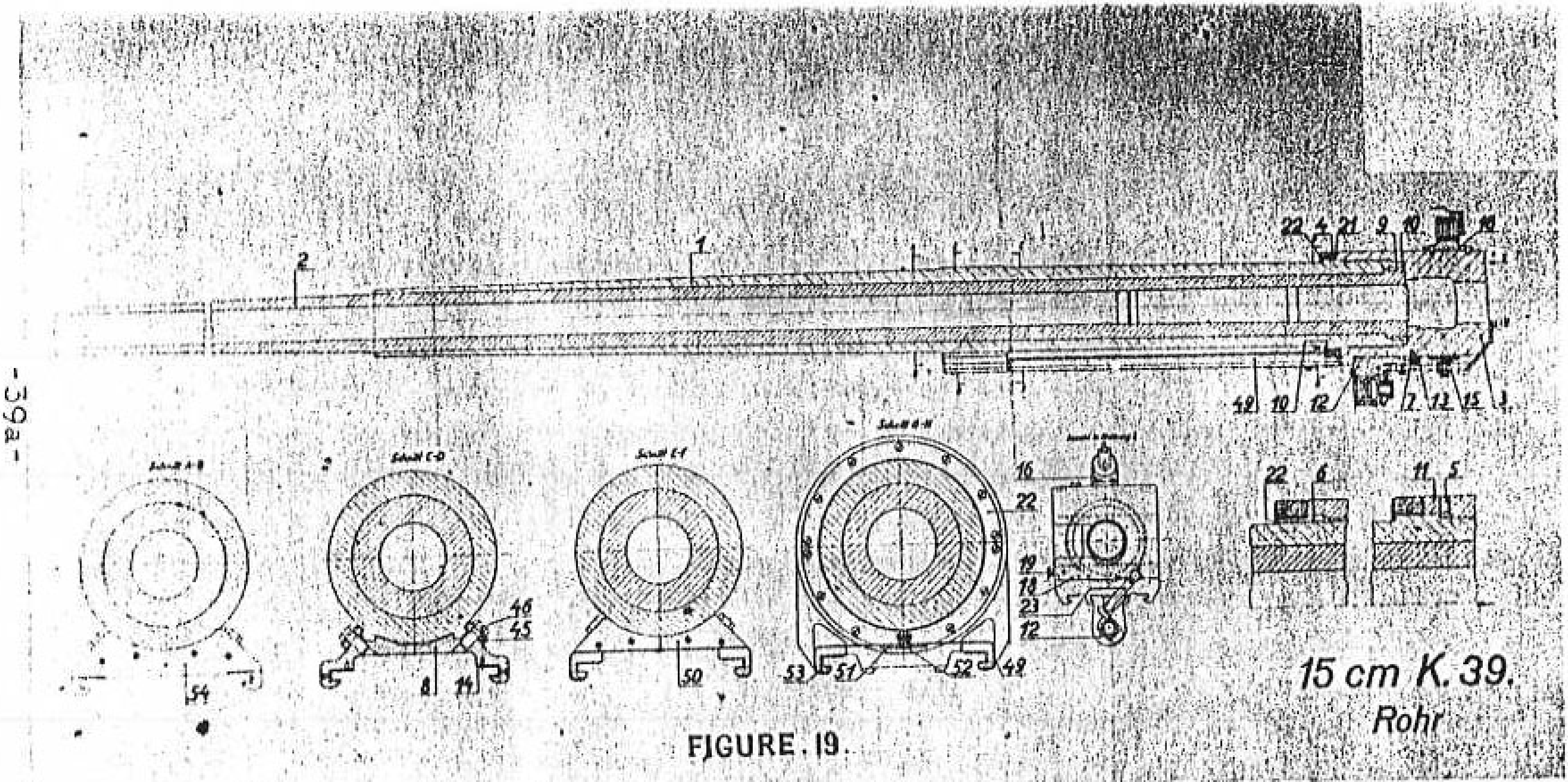

15 cm K. 39.
Rohr
22
4
21
9
10
1
2
48
12
7
13
15
16
19
18
23
6
11
5
46
45
8
14
50
53
51
52
54

FIGURE. 19.

SECTION III.

The bore of the inner A tube consists of a chamber and rifled portion. The latter has 48 grooves and is increasing twist.

The jacket is provided with a ring groove for inserting a graphite cord (10), at the rear centre surface, in front of the thread for the thrust collar and at the forward end of the bore. This graphite cord prevents the penetration of dampness.

The threads of the breech ring and jacket are pressed against each other by means of the guide ring (4) screwed on to the jacket (1). The guide ring is prevented from rotating by means of the safety ring (21), which is driven into the three upper of the eight interruptions of the guide ring and into the three slopes on the breech ring. The guide ring is provided with eight holes for the crank pin key. The two piece clamp ring (22) is placed on the forward frontal surface of the guide ring. This clamp ring presses the graphite asbestos cord into its groove.

Breech mechanism. The breech mechanism is a rectangular wedge crank lever type. It has a rebound striker firing mechanism, which is effected by means of a trigger piece seated in the right side of the breech block.

(c) The Carriage. (Figure 20).

(i) Details.

Elevation, trail arms spread.	$-4°$ to $+45°$
Traverse, trail arms spread.	$-30°$ to $+30°$
Traverse, trail arms locked.	$-3°$ to $+3°$
Width of track.	6.89 ft.
Length (centre of wheel to centre of trail spade).	16.47 ft.
Length, locked.	18.64 ft.
Length of carriage, trail spread, in firing position, including gun.	40.36 ft.
Breadth of carriage, spread.	27.56 ft.
Recoil - Normal.	57.09 ins.
Maximum.	58.27 ins.

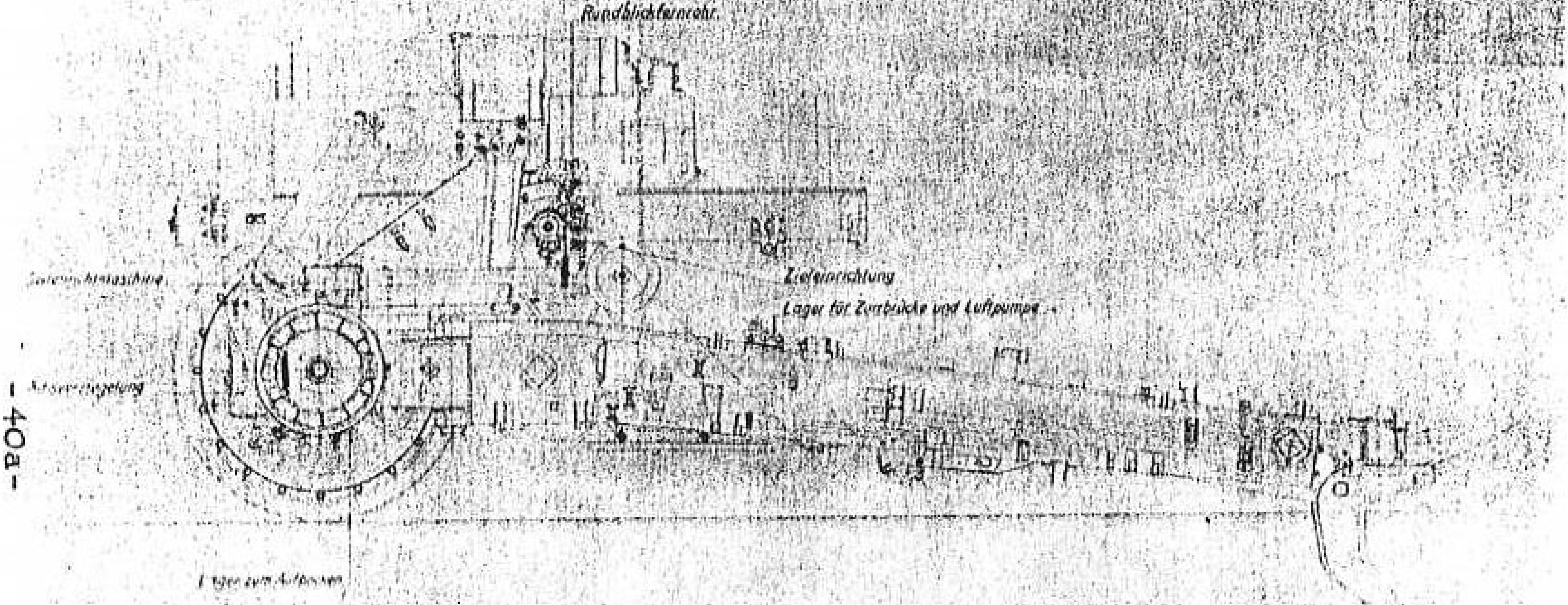


FIGURE. 20.

15 cm K. 39.
(von links)

(ii) Short Description.

This is a gun recoil split trail carriage with gun brake, recuperator, compensator and pointer type sighting gear. The trail arms, which have a 30° spread, are connected to the saddle support, around the vertical journal of which the saddle mounting is swivelled, and are locked in the spread position by means of a strut with the saddle support. The traversing gear, situated on the left wall of the saddle mounting, can give the gun a 30° traverse to the right and left. The cradle is seated in the trunnion bearings of the saddle mounting with the gun, gun brake and recuperator. The recoil is not variable and the forward moment of the gun is taken up by the compensator. The gun is elevated by means of an elevating gear, the coarse drive of which is arranged on the right trail arm, while the fine drive is situated in the casing of the general drive for elevating and traversing gear on the left side of the mounting.

When firing with locked trail arms the field of traverse amounts to 6°, and the mounting, when axle suspension has been disengaged, rests on the wheels at the front and on the trail spades or ice spades at the back situated on the ends of the trail arms. The carriage has a brake, which can be worked by compressed air and by hand.

For firing, the axle, which is pivoted around a bolt in a rocking bar, is secured above and below after the gun has been mounted, by a lock which is housed in a casing at front on the saddle support, so that it offers no more resistance to the lateral crossing of the axle. For travelling the axle is unlocked.

(d) The Coast Artillery Firing Platform.

Figure 21 is a sketch of the complete firing platform on its tractor drawn transporter. The total weight of the transporter as illustrated is approximately 16 tons, the platform itself weighing approximately 6 tons.

The transporter carries all the gear required to adapt the Field Army equipment for use in the Coast Artillery role. The platform can be installed quickly and withdrawn complete, thus allowing the

MOBILE PLATFORM AND TRANSPORTER

15 cm. K 39 FIELD CARRIAGE IN C.A. ROLL.

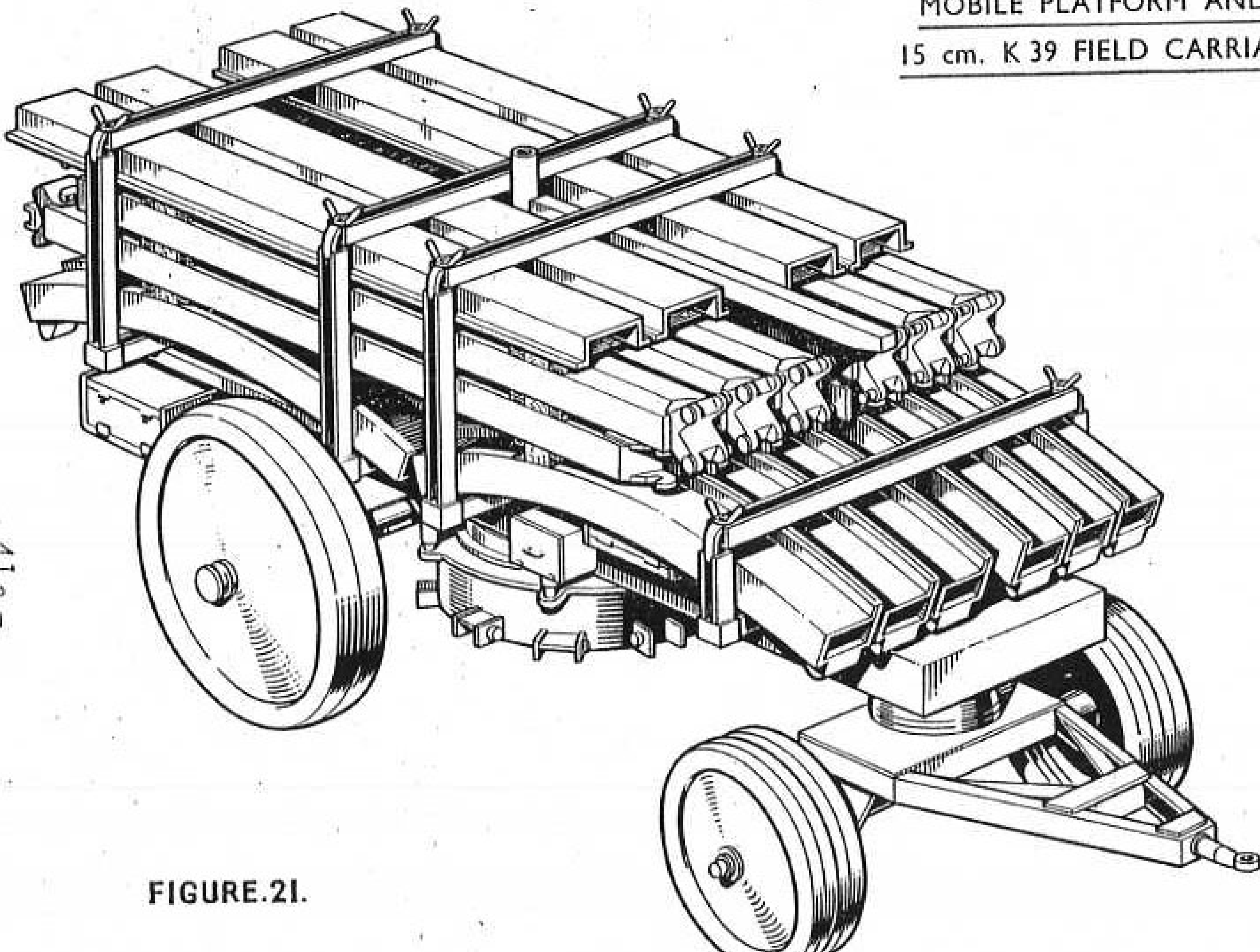


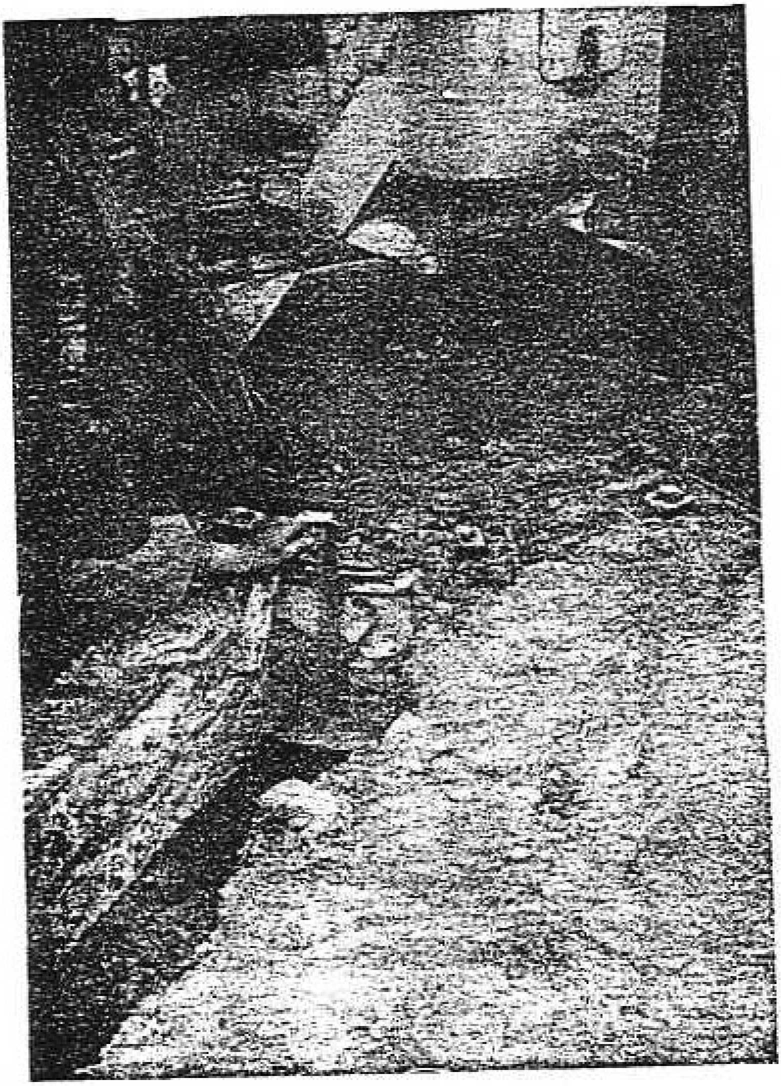
FIGURE.21.

parent equipment to revert to its Field Artillery role when required; a tactical asset.

The main components of the firing platform are:-

(i) A Central Turntable.

This takes the full weight of the gun and carriage when the latter is jacked up off its wheels.



15-cm. K.39 EQUIPMENT - FIRING PLATFORM.

SECTION III.

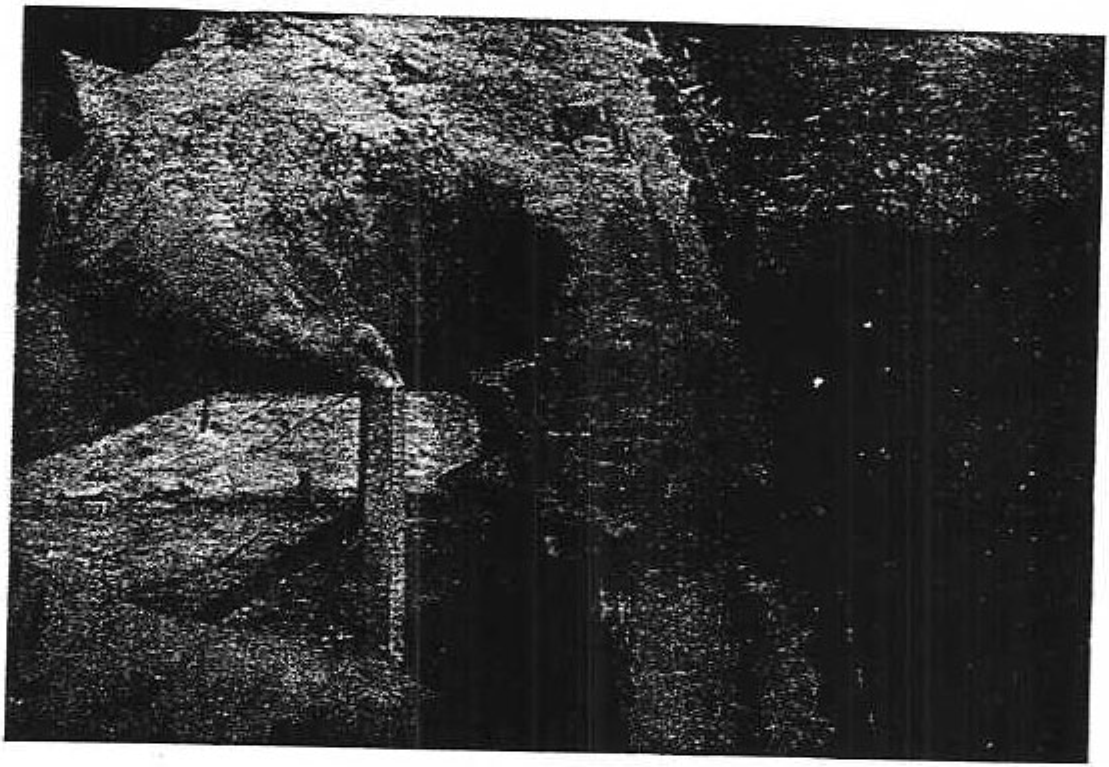
The photograph on Page 42 shows the turntable and the struts rigidly connecting the movi part of the turntable to the underside of the carriage.

(ii) Twelve Outriggers (radial arms).

These are connected to the static part of the turntable as shewn on photograph on Page 42.

(iii) Twelve Arcpieces.

These form the circumferential roller path of the firing platform and are pinned to the outriggers as per photograph (page 43).



15-cm. K.39 EQUIPMENT - FIRING PLATFORM.

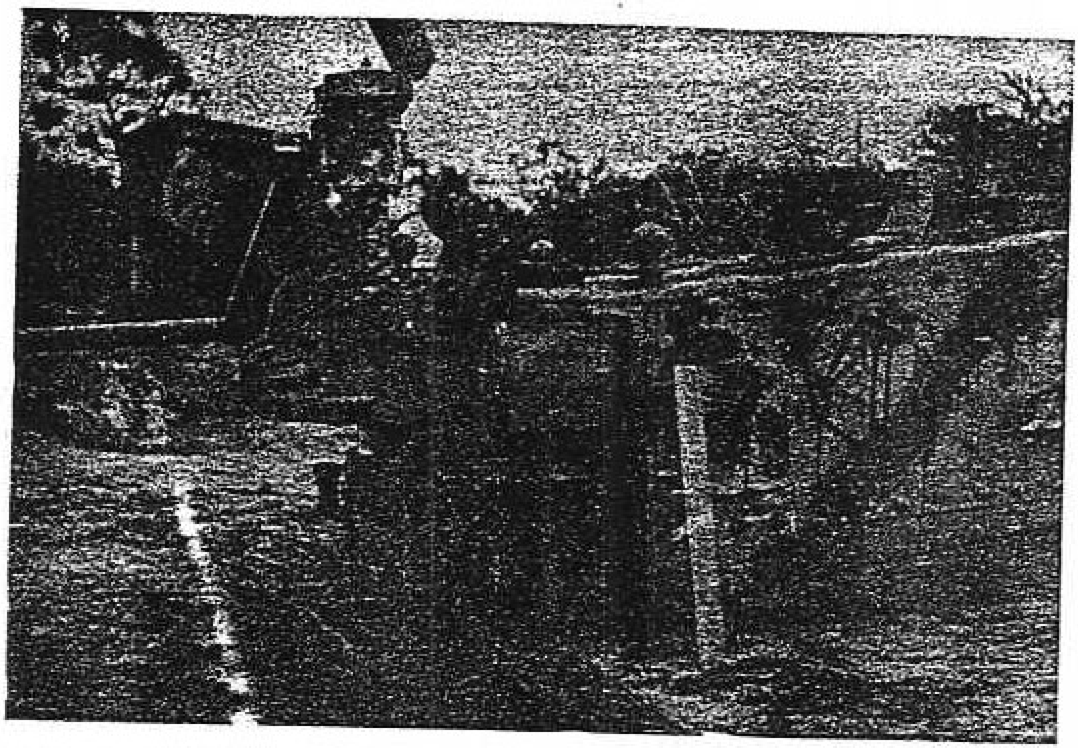
(iv) A Bogie.

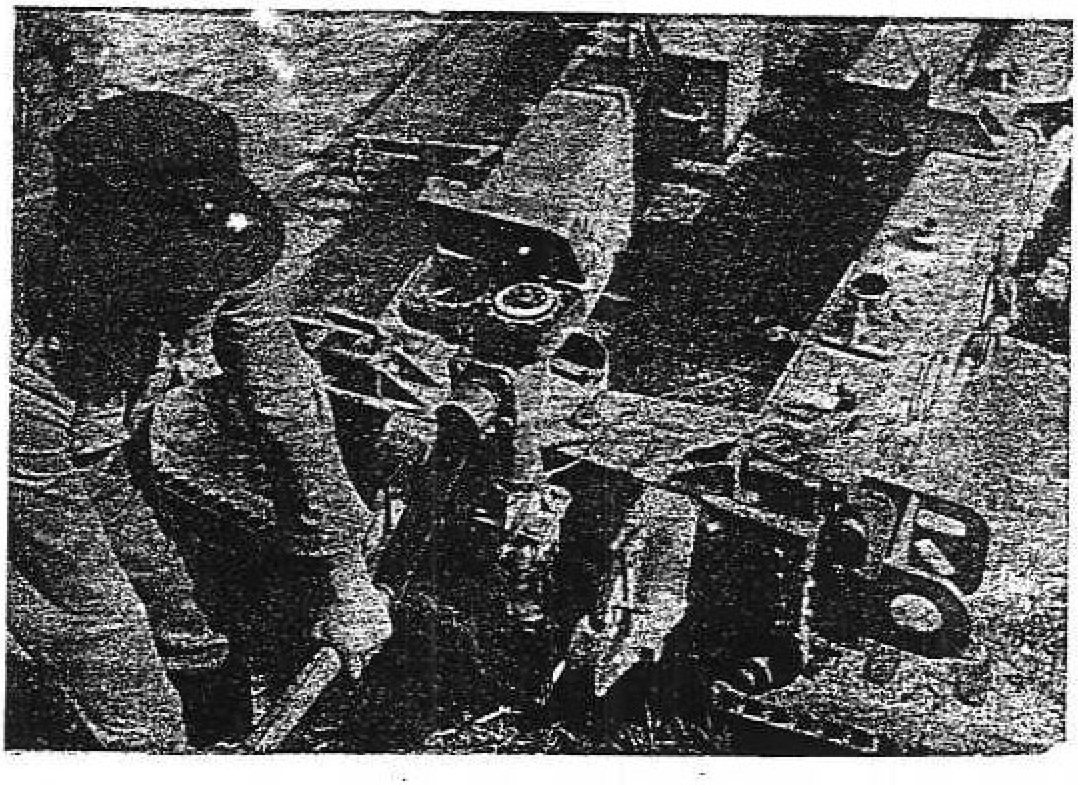
The two trails are brought together and the bogie replaces the two spades normally used in the Field Artillery role. A pinion in the bogie engages in the suitably machined arc pieces (see photograph on Page 43). A mechanical two-speed bearing dial is geared to the sprocket drive and the carriage can be traversed through 360 degrees and laid accurately by the pseudo rack and pinion method. The photographs on Page 45 shew the complete end of the trail assembly. The dimensions can be roughly gauged from the 40-cm. rule.

The platform is well designed, very careful attention having been paid to the ease and rapidity of getting the weapon into action. A complete equipment has been recovered for a more detailed examination at the Royal Arsenal, Woolwich.

The platforms at BLAAVANDS KRO were emplaced in sand and reported to give a high degree of stability, there being no significant movement after four "bedding down" full charge rounds had been fired.

SECTION III.





15-cm. K.[illegible] EQUIPMENT - FIRING PLATFORM.

SECTION III.

) The Fire Direction System.

(i) The battery was provided with a Long Basis Gerat (L.B.G.) installed in a very small plotting room next to the Battery Observation Post. Samples of this instrument were captured at Cherbourg and have been reported on in Military College of Science, Bury, Report No. MCSB/T/CA/6 and in the American E.T.O. Ordnance Technical Intelligence Report No. 100, dated 27th December, 1944. This instrument received target bearings as observed from two flank O.P's and by means of a system of cross observation plotting evolved battery pivot "present" ranges and bearings. No very great accuracy could be obtained from it, but it is noteworthy that it can be quickly set up for any siting conditions and is suitable for use when it is required to link mobile batteries with a Fortress system of long base cross observation.

(ii) The short base monostatic rangefinder provided as the battery optical position finder contained no features of technical or user interest. It was sited close to the B.O.P. in the open with no protection.

(iii) "Present" target data could thus be obtained from the battery rangefinder by day and possibly from the L.B.G. when smoke screens were laid in front of the battery. No further instruments were found and the remainder of the gunnery data was calculated during an action or obtained from previously prepared charts, drums, boards and slide rules. Inlets in wood frames indicate that stop watches may have been used to obtain travel corrections from rangefinder rates. For long range engagements and, probably, all shooting by night, the area commanded by the battery had been divided up into 250 metre squares each of which was numbered. Gun firing data had been calculated for each square and recorded on rollers. Thus, radar data passed through the Regimental Headquarters or optical data from the L.B.G. was plotted, a square accordingly selected as the most probable future position of the target and a barrage ordered down on that particular square. This was common German practice for medium batteries. Altogether the B.O.P. had a general Heath Robinson appearance of a bookmaker's control room on Derby day!

(iv) "Future" range and bearing was transmitted from the B.O.P. to the gun emplacements by telephone and these data were then corrected for the individual gun displacements from the battery pivot and set on the gun range indicator plates - small scale editions of the "super-heavy" elevation laying gear - and mechanical bearing dials.

(v) Dial sights and direction sights were used for direct laying, special telescopes being provided.

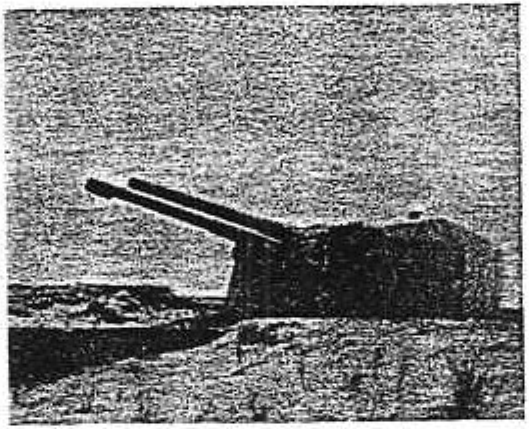
(f) General.

The siting of the guns was very ill conceived and they had very restricted arcs for close defence. The emplacements were completely open, no attempt having been made to dig in or provide even blast walls, but the battery perimeter was well wired in and very heavily protected by mines.

SECTION III.

The "Fano" Medium Battery (Two Twin 15-cm.)

(a) The main armament on the Island of Fano consisted of four 15-cm. Q.F. guns on two "twin" Naval mountings. The two equipments had been withdrawn complete from the "Gneisenau" and installed in a Coast Artillery role without any major modification. The two mountings were approximately 150 yards apart and about 50 feet above sea level. The guns had a maximum depression of 7° and a maximum elevation of 40°; this corresponds to a maximum range of approximately 25,500 yards with top charge. Each equipment had an arc of fire of 350° with a clear command over the water area and it would have been necessary to neutralise this battery to gain access to the port of Esbjerg.



(b) The above is a photograph of one of the turrets. The front plate of the turret is 6 inches thick, top plates $2\frac{3}{8}$ inches, side and back plates $1\frac{3}{4}$ inches. In general principle the emplacements are similar to those designed for the 38-cm. "twins" at Oxsby.

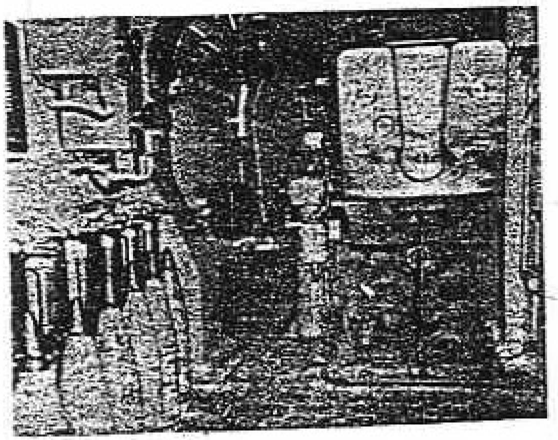
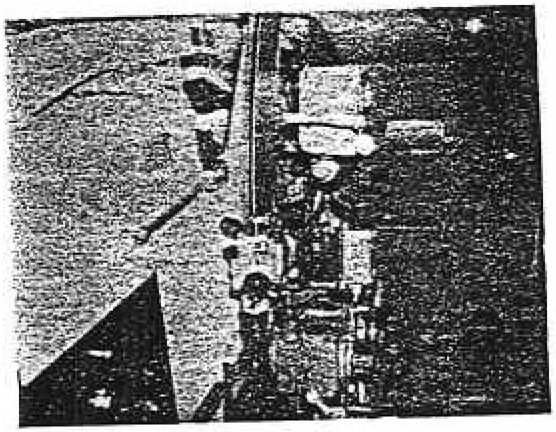
(c) The 15-cm. SK C/28 Guns - Main Characteristics.

Weight of gun with B.M.	8.96 tons.
No. of grooves.	44.
Depth of grooves.	.069 inches.
Breadth of grooves.	.242 inches.
Breadth of lands.	.177 inches.

Initial twist	= 1 turn in 50 cals.	(cubic para-(bolic turn-(ing point.	1 turn in 24.458 ft.
Final twist	= 1 turn in 30 cals.	(19.685 ins. (in front of (muzzle.	1 turn in 14.675 ft.

Length of rifling.	21.614 ft.
Length from shell base to commencement of rifling.	4.029 ft.
Length of bore.	25.643 ft.

(d) The breech block is of the drop block type, manually operated. Ejection of the spent cartridge case is semi-automatic and the loading number, who wears an asbestos glove, was said to catch the case and throw it aside or through the back door.

15-cm. SK C/28 Equipment.
Internal views of turret from left and right rear.

No air blast was fitted, but the defuming apparatus was excellently conceived. A suction fan extracts the propellant fumes through a duct immediately over the breech block, the trunking runs along the top of the gun towards the trunnions and links with the trunking on the non-elevating part of the mounting through a self adjusting shitter. At maximum rate the gun elevates through 30° in 4 - 5 seconds; thus, with a fixed loading angle, the rate of fire is not likely to be greater than from 5 to 8 rounds per gun per minute, although a 6 seconds loading interval is said to have been achieved on the dummy loader.

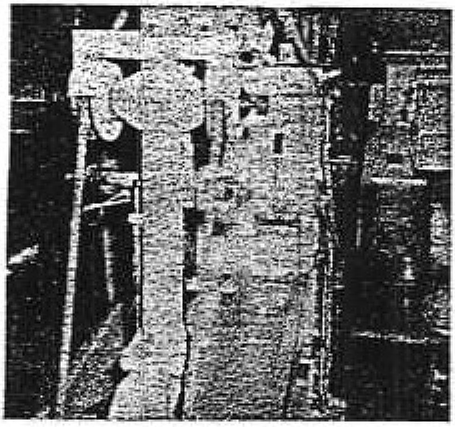
(e) Direct Measurement of Muzzle Velocity.

There were two screw-plugged 1-inch diameter holes in the top of the barrel, approximately ~~3~~ 3 inches and 23½ inches from the muzzle. Although not fitted, these holes were prepared to receive plugs carrying a magnetic core, the dome end of which protruded slightly so as to make contact with the driving band of the shell during its passage along the bore. The core was energised as an electro magnet by means of a battery excited coil. A second coil, wound round the first, was used to register small differences in the magnetic flux caused by the passing shell. This small impulse was fed through a valve amplifier to a cathode ray oscillograph, where it was registered on a film drum about one metre in circumference rotating at about 6000 r.p.m. With an M.V. of 1000 m.s. this would give a measuring distance on the drum of a tenth of that between the two plugs. The Germans claim that it is easy to see the point of passing of the driving band on the impulse, this part of the impulse being used as a datum point for calculations.

The accuracy achieved is not known, the velocity evolved would, however, be the mean between the two points of "contact" and the true M.V. would still have to be obtained by extrapolation.

This work is understood to have been dealt with by Dr. Baraneck, head of the Electronic Department of Rheinmetall-Borsig.

(f) The magazines were about 17 feet below ground level, the cartridge and shell chambers leading off the gun pit as at Oxsby. The vertical ammunition hoist delivers two shell in the top trays and two cartridges in the lower trays, simultaneously, to a position midway between and to the rear of the two guns (see photograph on Page 51).



15-cm. SK C/28 TWIN EQUIPMENT - AMMUNITION HOIST.

The shell and cartridges are then man-handled and rammed by hand.

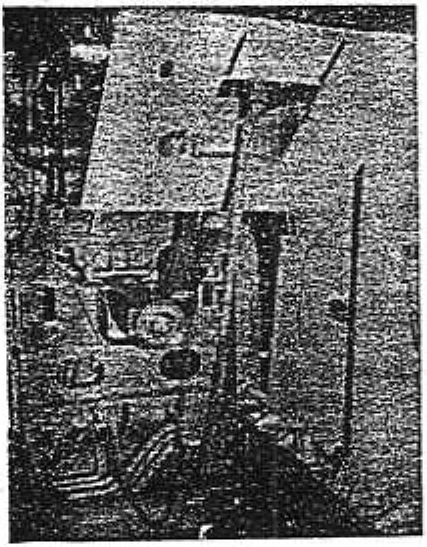
A small quantity of ready-use shell and cartridges were stacked on each side of the turret as shewn in the photograph on Page 49.

(g) The guns are elevated by hydraulic pressure with alternative hand control. A plunger with rack teeth on the underside causes a pinion to revolve, this meshes with an elevating arc attached to the cradle. The two guns can be elevated independently by means of handwheels on each side of the mounting, but the control wheel on the right is used when it is required to elevate both guns together. (See photograph on Page 52).

(h) The maximum rate of traverse in power is about 8 degrees per second and the traversing handwheel is conveniently situated with regard to the binocular direction sight on the left side of the mounting. The Case III laying gear is the same as that on the 38-cm. Hanstead mountings.

SECTION III.

(i) The fire direction system followed the general principles employed at the super-heavy batteries, the battery monostatic rangefinder having a 6-metre base.



15-cm. SK C/28 TWIN EQUIPMENT.
REAR VIEW OF ELEVATING ARC AND BREECH RING.

SECTION III.

7. SEATARGET THERMAL LOCATION APPARATUS.

The DONAUGERAT.

The Donaugerat consists of a 60-cm. parabolic reflector mounted in a barrel which can be elevated and traversed. When the barrel is directed towards a source of heat the radiation is concentrated on one of two bolometer strips at the focal point of the reflector. These heat sensitive elements form two arms of an A.C. bridge which is followed by an amplifier whose frequency response is broadly selective with respect to the frequency of the bridge supply voltage.

The bridge is balanced to give an amplifier input voltage as near zero as possible when the radiation falling on the two strips is the same. The movement of a target image across the two bolometer strips causes a 4000 cycle per second signal to be passed from the bridge to the amplifier. On the signal thus obtained an additional modulation is impressed by mechanically chopping the incident radiation at an approximate frequency of 16 cycles per second.

The amplifier thus receives an input 4000 c/s "carrier" frequency modulated at approximately 16 c/s; a signal whose phase is determined by the bolometer strip upon which the image of the target is situated.

This bridge amplifier is followed by a detector which removes the "carrier" from the modulated signal and indicates the relative phase of the signal with respect to the bridge supply voltage. A low frequency amplifier follows the phase sensitive detector and provides additional amplification at modulation frequency. This is followed by a second detector which yields an output current whose direction is governed by the direction of motion of the target.

The output is passed to a display unit which consists of a centre zero moving mirror galvanometer reflecting on to a fluorescent drum which is rotated by a clockwork motor.

Five "Donau" sets were found in Esbjerg, they were new and intended for installation on the Island of Fano, approximately 5000 yards apart, as the basic directors in a horizontal base system of position finding.

SECTION III.

In operation the barrels automatically traverse a specified arc at a uniform rate of 90 degrees a minute, the number of sets on the "look-out" being governed by the height above sea level and the range zones it is required to cover. An observer watches the fluorescent drum which has a straight line traced on it in normal conditions. Whem a target is passed the radiation causes the galvanometer to "kick", and hence the trace shews a break. Hand control is then ordered and the bolometer head is made to oscillate by means of an eccentric drive. The observer thereafter maintains the symmetry of the oscillating trace about the zero line by controlling the rate of traverse of the barrel, and thereby follows the target. The bearing to the target is read from a vernier mounted on the tripod supporting the barrel and passed by telephone to a central control room. The maximum inaccuracy of the bearing so obtained is of the order of 5 minutes.

The central set was to operate as the master, two of the remaining four sets being ordered to take bearings on the selected target, approximate bearings being passed to them for "putting-on" purposes. A system of elementary cross observation plotting was to be used to fix the position of the target, the bearing from the master set being used to verify that the two working sets were following the same target.

The Germans stated that this equipment when under trial at Swinemunde had detected a medium size ship at 15 km. range in good atmospheric conditions and that firing trials against a towed target, consisting of a lighted stove, at 12 km. range, had resulted in 40% hits. The target had, however, maintained a constant course and speed.

The advantages and disadvantages of this system as compared with radar as a means of orthodox position finding are well known, and it is not considered that there is any justification for reviewing the conclusions reached prior to the examination of the German equipment. The "Donau" apparatus is, in fact, much more complicated than the "Arran" experimental apparatus developed by the Admiralty Research Laboratory and subject to trials at Malta and Gibraltar, without being quite as accurate. The development of auto-following thermal detection gear and the possibility of its application to "homing" anti-ship projectiles is, however, obvious.

SECTION III.

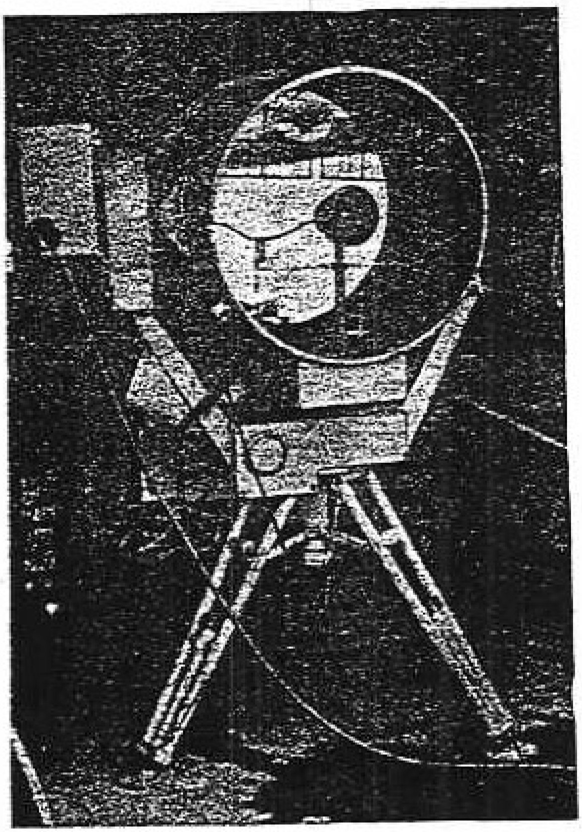
Relevant literature is:-

Admiralty Research Laboratory Reports ARL/N1/E.530 and ARL/N2/E.530.

U.S. Army Signal Corps Intelligence Report I.F.R.-1, dated 6th July, 1945 - Interrogation of Drs. Gaetner and Brenning on Development and Military use of infra-red equipments.

German handbook "Beschreibung Fur Gerat Donau 60".

Complete sets of equipment are available in the U.K. for trials, if required.



DONAUGERAT.
MIRROR AND BOLOMETER ASSEMBLY.

SECTION III.

8. A.A. Shooting by Coast Artillery Batteries.

We obtained a copy of the High Command instructions to Army Coastal Batteries, dated 1st November, 1944, to govern fire for defence against air attack on their own position. Only formations (5 or more planes) approaching their own position were to be fired at.

The various units appeared to have formed their own rudimentary methods of A.A. fire in the light of the equipment available. At Hanstead, for example, (38-cm., 67° maximum elevation) they plotted the formation from radar observations, selected a "future" position on the probable course, obtained the appropriate Q.E., fuze setting and bearing, using graphical Range Tables, and then fired on "dead time". Lesser calibre batteries used constant fuze settings and even more rudimentary methods of obtaining and laying the gun in bearing and elevation. The instructions can have been little more than a belated attempt to stiffen morale.

9. Medium and Light Batteries.

(a) General.

Although each different type of battery was visited, we have only considered it useful to give a separate report on the 38-cm. and 15-cm. equipments. Judged by British standards the remaining weapons were completely obsolete and the only interest in them lies in the scale of protection, their fire direction systems and gunnery methods. The fire control layouts and procedure had been standardised, these aspects can therefore be dealt with as a whole, irrespective of the actual calibre of the battery.

(b) Protection.

The protection afforded the emplacements varied considerably and had obviously been dealt with on an "ad hoc" basis in the light of the equipment available. Some mountings were in armoured cupolas, the thickness of plate probably being sufficient to withstand 20-mm aircraft cannon fire and shell and bomb splinters. Others were on concrete holdfasts in open emplacements, the gun pit floor being as far below ground level as the maximum depression required from the gun and the configuration of the ground would allow.

SECTION III.

One of the most interesting examples of concrete casemated guns was the 12.2-cm. Russian Field gun and carriage. These weapons are capable of 90° traverse and they were sited to the flanks of likely landing beaches so that they covered the beach on the extreme of their 90° arc of fire. The walls and roof of their concrete gun houses were from four to six feet thick and when not required for action the complete gun and carriage was withdrawn inside the gun house and the front aperture closed by a sliding armoured panel 3 inches thick. When required for action, wedges were placed behind the wheels and the two spades in the split trail replaced by blocks 3 feet long. These blocks had a steel "tongue" 3 inches deep and 1½ inches wide running their full length which engaged in suitably grooved rails grouted into the concrete floor. The forward shape of the gun house was as though the gun and carriage itself had been used for a mould and the concrete poured round it. These guns would have been very difficult to knock out.

(c) All weapons were equipped with a tangent sight, a range/elevation indicator plate, a direction sight and a bearing arc; most of the gear being crude. They were therefore equipped for direct and indirect laying (Case I, II or III), but the batteries were not equipped with radar or other means of indirect firing, except on the "square 5" principle referred to in the Sub-section on the 15-cm. K.39 battery.

(d) As means of rangefinding one or more of the following alternatives were provided:-

(i) A monostatic rangefinder, 4 to 6 metre base.

(ii) A short base system of cross observation. This consisted of an inner O.P., either within the B.O.P. or in its immediate vicinity, and an outer O.P. displaced from the B.O.P. by an amount not less than 5% of the maximum range of the guns. Elementary triangulation on a Field Plotter was used to fix target position, synchronous bearings being taken every minute. At least four "fixes" were said to be required to obtain target travel corrections.

(iii) A clinometer on a scissors telescope or an azimuth disc. This gear was made locally when the battery was not less than 40 metres above sea level, depression angle of sight from the known height being used to obtain range. Having measured D.S.L. the corresponding range was extracted from a previously prepared table or calculated from the usual formula.

(e) Meteor corrections were calculated arithmetically, or estimated, and fed to the guns as an initial correction to range and bearing.

(f) Travel corrections were obtained from:-

(i) Rangefinder rates recorded against a stop watch.

(ii) A rate clock.

(iii) A previously prepared table or slide rule.

(ii) and (iii) depended upon the G.P.O's estimation of target inclination and speed and the estimated or measured range.

(g) Method of Direct Firing.

There are very great differences between the British and German methods of direct firing. This is primarily due to the British policy of obtaining "present" range and bearing continuously and transmitting these data throughout the fire direction system as a continuous flow. It is only when present German equipment and methods are examined that one appreciates to the full the outstanding contributions to British gunnery of Watkin and other pioneers who were responsible for the design of the automatic sight, the depression rangefinder, etc. Apart from direct laying for line with the gun sighting gear, German firing data is based on an initial range and bearing, and cumulative corrections for target travel.

The first object in German methods of direct firing is to apply bearing corrections to bring the salvos into the line of observation from the control post to the target and keep them there. Rounds falling out for line were not observed for range unless falling amongst a formation of targets. Salvos were repeated at the same range when range of observation of fall of shot was at all doubtful.

When the range was increasing (a receding target), salvos which fell over the target were defined by the Germans as falling on the favourable side of the target and salvos which fell short were on the unfavourable side. With a decreasing range (an approaching target) it was the opposite, i.e., short salvos were favourable, "overs" were unfavourable. This distinction was fundamental in all German rules of ranging at "battle ranges".

The target was bracketed for range, range being continuously adjusted for target travel during the firing of the ranging salvos. The choice of ranging bracket (200m., 400 m. or 800m.) was governed by the distance travelled by the target during the loading interval, the accuracy of rangefinding and the ease of observation. After crossing from the "favourable" to the "unfavourable" side of the target with a small range bracket, fire for effect at maximum rate was ordered down on the "favourable" side. Range was no longer adjusted for travel and the target was thereby called upon to run through the barrage. (Note: In certain circumstances, e.g., small range rate and rapid rate of fire, the target xx "was approached on a narrow front" at fire for effect, i.e., small range corrections were applied in the direction of the target).. When salvos were again observed on the "unfavourable" side of the target, range travel corrections were applied to carry the salvos back on to the "favourable" side.

With accurate range support "in a battle emergency, e.g., approaching E-boats and landing craft", the ranging salvos were dispensed with and fire for effect taken up as soon as a salvo was observed on the favourable side.

The detailed instructions contained in German Training Manuals are merely elaborations of the remarks outlined above.

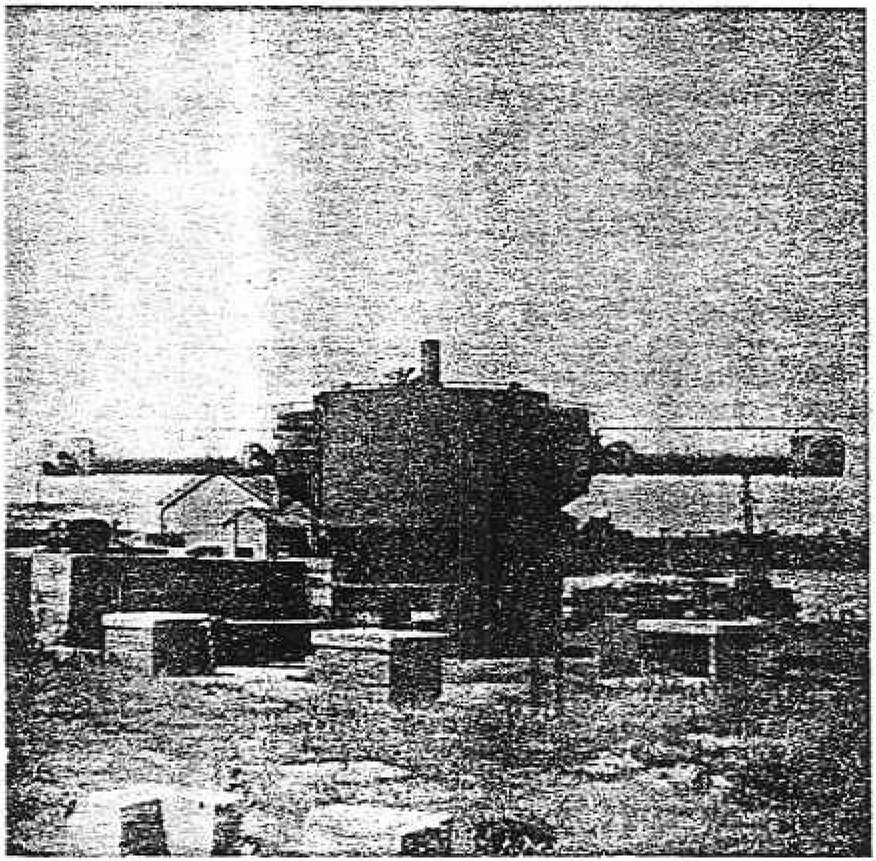
Providing that the rate of fire is high enough to prevent the targets "running through the raindrops", the German doctrine of "favourable" and "unfavourable" sides of the target means that if the salvos are kept in for line and the enemy is opening or closing the range with a set objective, range and, therefore, hits, will be obtained sooner or later. There is nothing in this system, however, to recommend any change in the British practice of going in for a quick kill and regarding only those rounds which fall in between the two sides of the target as favourable.

(h) Searchlights.

150-cm. A.A. searchlights were provided for night firing. The scale was certainly less than one per gun and the Germans did not contemplate distributing the fire of their batteries except in the most exceptional circumstances.

APPENDIX A.

GERMAN 10.5-metre BASE MONOSTATIC RANGEFINDER.



Appendix A.

German 10.5-metre Base Monostatic Rangefinder.

Note. We are indebted to the Admiralty Research Laboratory for permission to include in this Appendix the ~~laboratory~~ information contained in their report A.R.L./N.3/66.71, dated 12.7.45.

This instrument is now being subject to a more detailed examination, including performance trials, and establishments who would like further information on it and who are not included in the normal A.R.L. distribution are asked to notify Supt., A.R.L., accordingly.

1. General.

The instrument is transported in two parts:-

(a) The rangefinder tube which is approximately 37 feet long and two feet in diameter and weighs 12 tons.

(b) The rangefinder turret which is approximately 10 feet square and 8 feet 6 inches high and weighs 38 tons.

The sides of the turret consist of steel plate approximately 6-cm. thick. The thickness of the centre of the top plate is about 15 centimetres and it tapers radially to a minimum of 6 centimetres.

The rangefinder is sunk to ground level to give increased protection, access to the turret is from beneath. The degree of protection afforded is much greater than that given to British horizontal base rangefinders and the German instruments are much the less conspicuous when installed.

2. General Description.

The rangefinder tube contains four instruments:-

(1) A stereoscopic rangefinder of 10.5-m. base.

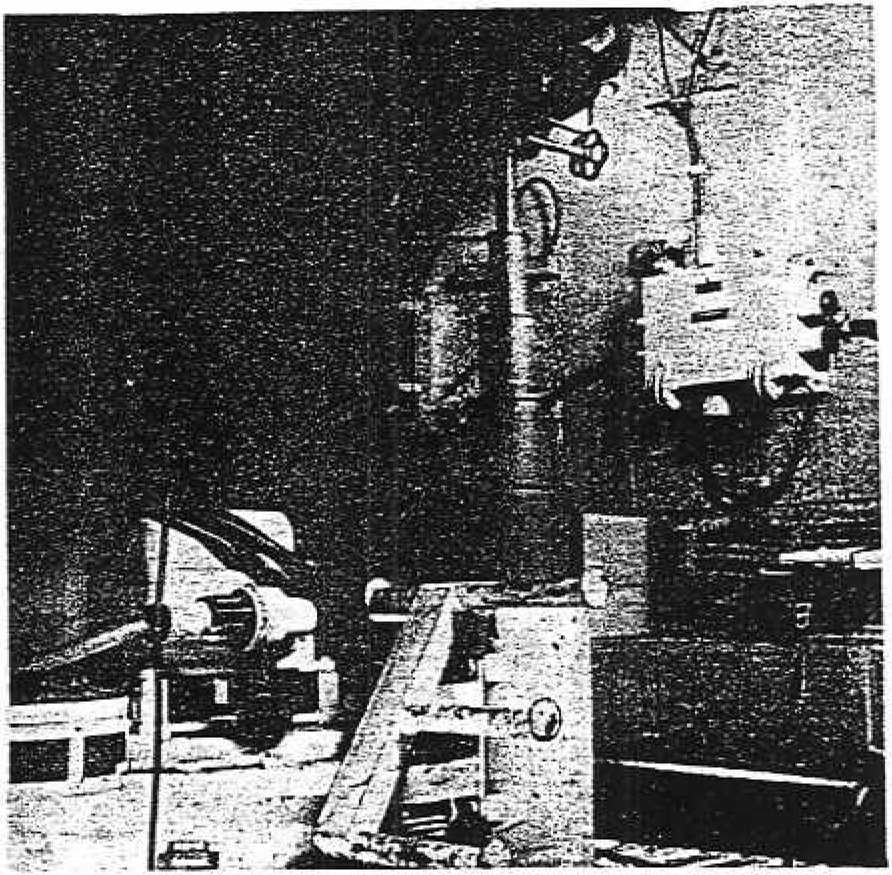
(2) A stereoscopic spotting telescope of 11-m. base.

(3) A stereoscopic laying telescope of 6-m. base.

(4) A stereoscopic training telescope of 6-m. base.

The eyepieces of these four instruments are arranged so that the range-taker and spotter sit on one side of the main tube, and the layer and trainer on the other. The four observers sit on motor cycle type saddles mounted on spring loaded telescopic pillars. These seats, shewn in Figure 1, allow the observers to observe in comfort at any elevation within ± 30 degrees of the horizontal by a slight change in pressure of the feet.

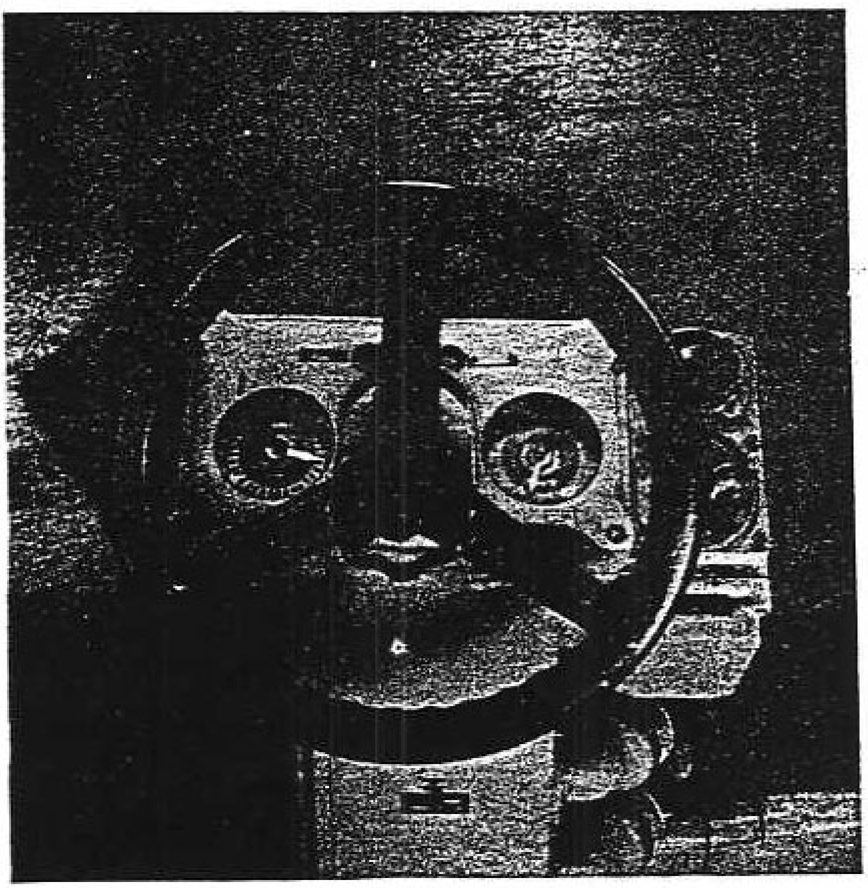
Figure 1.



The turret is normally hand operated, the trackers' handwheels being situated beneath the range-finder. The elevation handwheel is duplicated on the range-takers side of the instrument and the training handwheel is duplicated on a separate mounting, see Figure 2, which is situated beneath an aperture in the roof armour. This wheel is used in conjunction with a periscope for getting on to the target, a mechanical traverse of fixed gear ratio being used for slewing. The traverse motor and clutch lever can be seen in Figure 3.

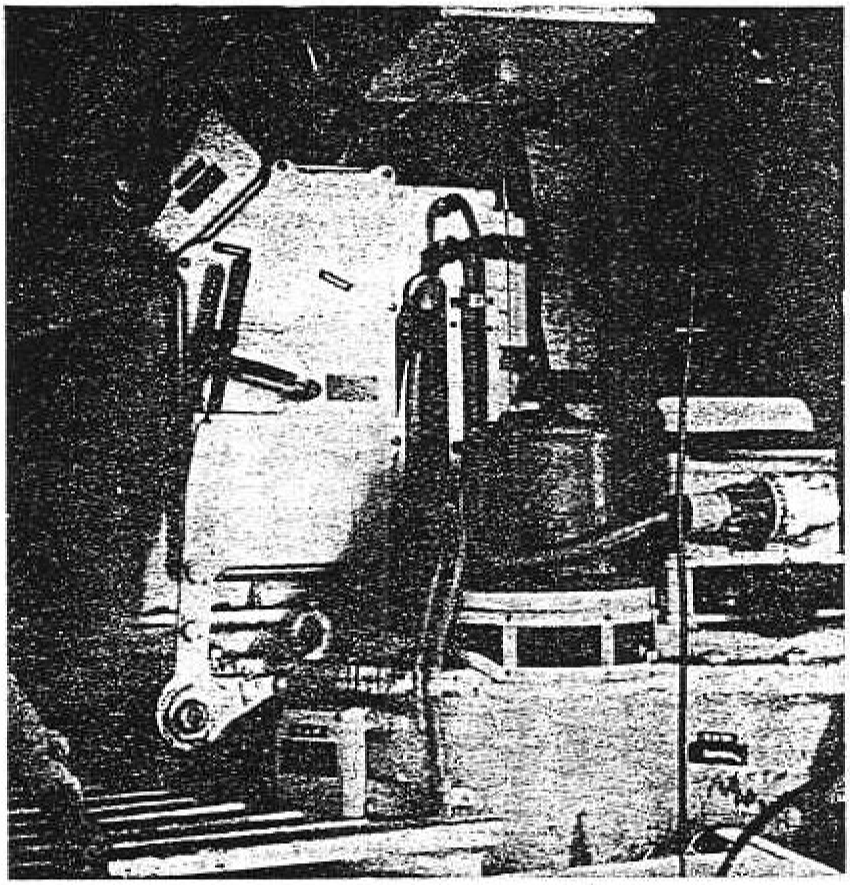
Heat insulation for the turret is obtained by fitting metal foil between the armour and the galvanised sheeting which forms the inner walls. Ventilation is provided by a fan which draws air in from beneath the turret. There are heater elements behind each pair of seats, and illumination is provided by lamps in the four corners of the turret.

Figure 2.



APPENDIX A.

Figure 3.

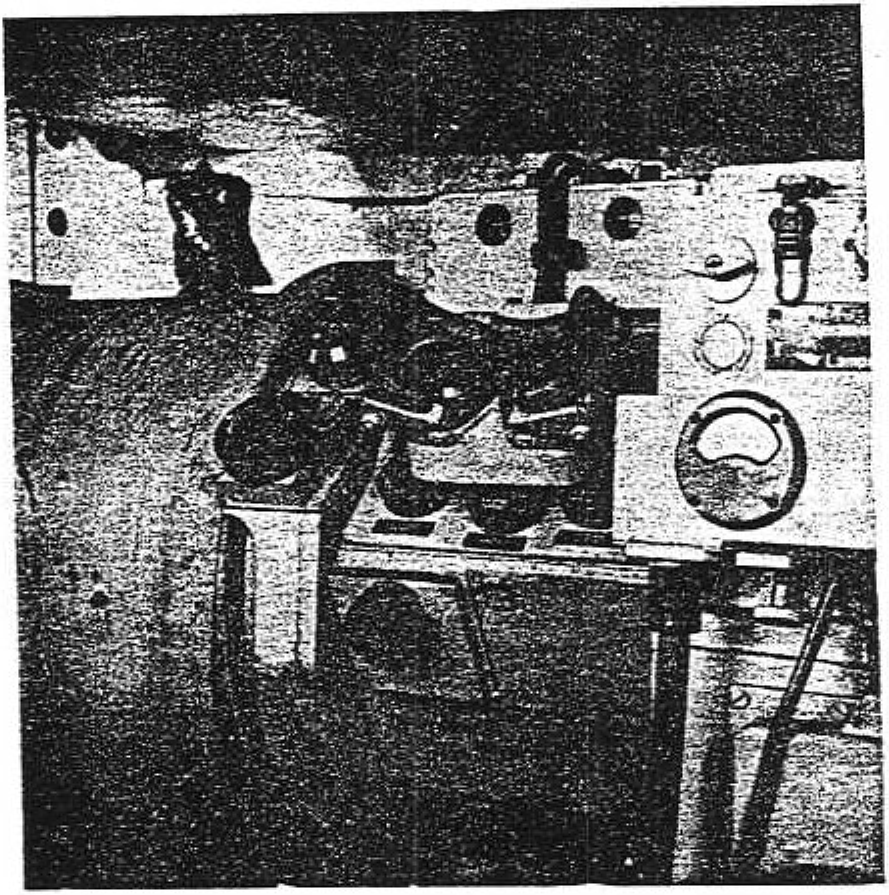


3. Description of Rangefinder.

The rangefinder works on the stereoscopic principle and has projected graticules similar to the German Army rangefinder type Em. 4m.R.40. The four magnifications provided, x 18, x 25, x 36 and x 50, are controlled by a head situated below the left hand eyepiece, see Figure 4. The head in the centre of the facepiece controls the facepiece filters, neutral or red, and the one on the right turns the images in the eyepieces right for left to give pseudoscopic vision. By turning this head further the images and graticules are turned through 90°, thus allowing height of image adjustment to be made stereoscopically. The two heads on top of the rangefinder above the eyepieces are used for height of image adjustment. Of the two heads to the left of the eyepiece panel, the upper is for fine elevation and the lower for control of neutral and red filters at the end windows.

APPENDIX A.

Figure 4.

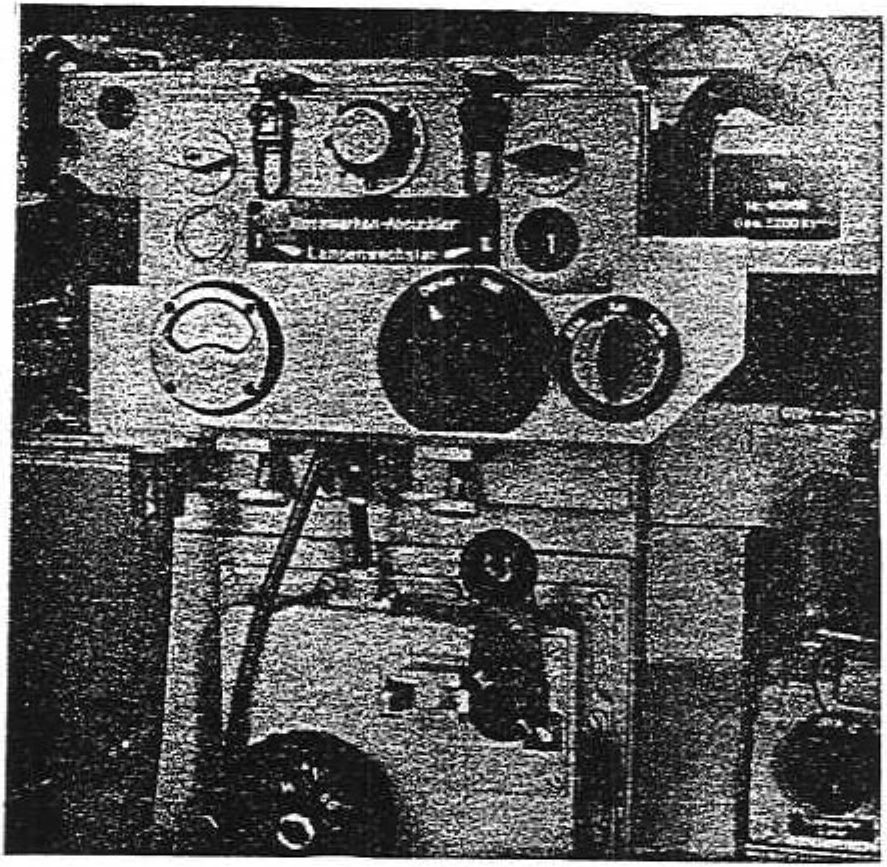


No. 3 of these neutral filters is of suitable density for ranging on the sun. The head below the facepiece puts a solid line graticule into the field, this graticule having three vertical lines extending the full diameter of the field. The rangefinder objectives are 8.0-mm. diameter.

Further controls for the range-taker are on the central panel shewn in Figure 5. At the bottom of this panel is the working head, and above this and to the right, the Ortho-pseudo control lever. This control reverses the projection system of the graticules and turns the facepiece pseudo head. To reverse the projection system involves the use of a separate graticule collimator and it is for this system that the second height of image head is provided. When this control is

APPENDIX A.

Figure 5.

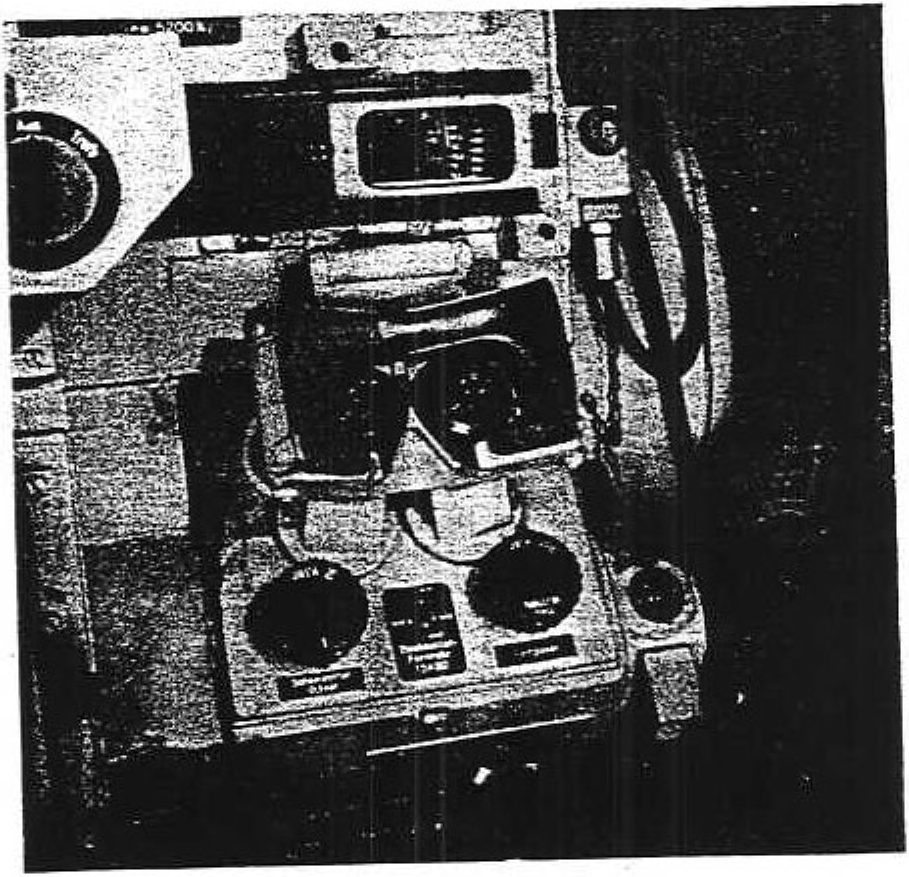


in the pseudo position the working head drives the range prisms in such a way that the average of one ortho and one pseudo reading is set into the scale as a scale adjustment. There is no scale adjustment head on this instrument as with the projected graticule system it is not necessary, and it is thought likely that the correction put in by this pseudo control would be chiefly for personal error.

The upper part of the central panel is for graticule illumination. The lower part of this is a detachable box containing a switch, a rheostat and a voltmeter. Above this are two diamond shaped knobs which rotate the projection lamp holders to bring in spare lamps when those in use burn out; the left hand knob is for the ortho system and the right the pseudo system. Between these knobs is the graticule brightness control, this head turning a variable density filter past the light aperture. The top cover of the central panel can be removed to replace bulbs.

To the left of the central panel is the spotting telescope, see Figure 6. Above the facepiece can be seen the range scale which is graduated from 3,000 metres to 100,000 metres and has an infinity scale of ± 10 divisions, on which 1 division = 0.28 seconds, i.e., 10 seconds in the image space when using the 36 magnification.

Figure 6.



APPENDIX A.

The stereoscopic spotting telescope has a magnification of 15, an aperture of 80 mm. and a base of 11 m. It has a graticule in one eyepiece which is in the form of a cross made up of nine horizontal and nine vertical marks, the extreme dot in each case being marked $\frac{16}{16}$.

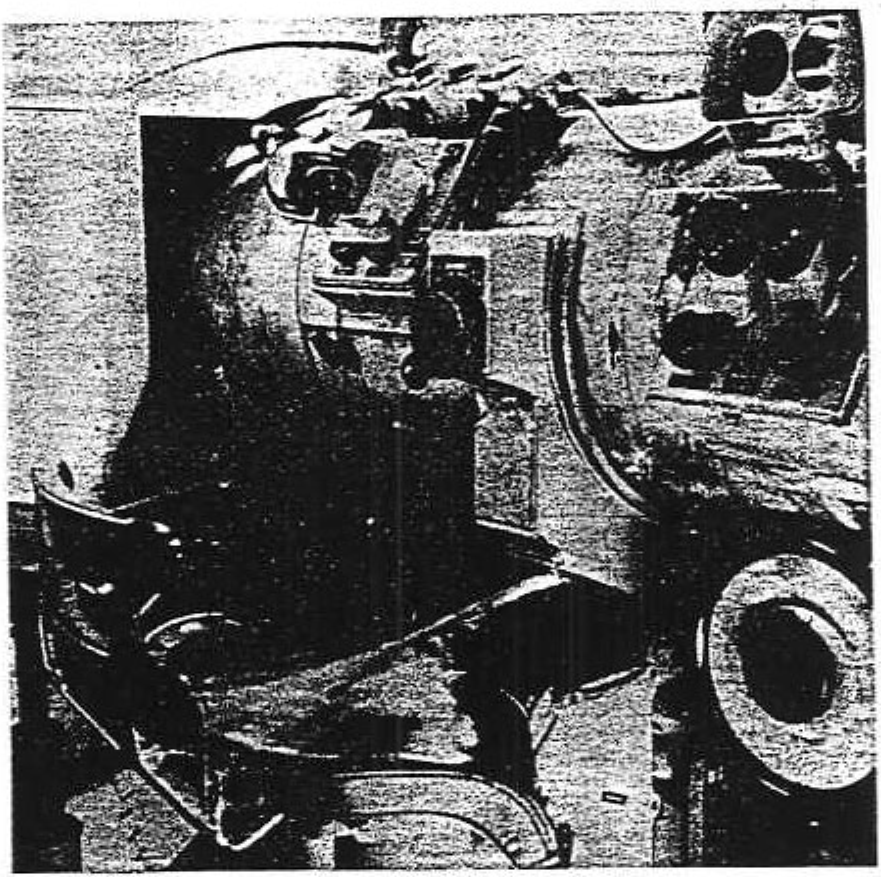
The units are sixteenths of a degree, the graticule covering two degrees. The two heads on the facepiece operate filter rings. To the right of these heads is a dial coupled to the working head and also adjustable by a knob at the side. This dial is used for measuring personal bias of the rangetaker, and, possibly, for training. Incorporated in the instrument is a novel and ingenious device for correctly setting the distance between the eyepieces of the rangefinder to suit the inter-ocular separation of the eyes of the observer. Below the facepiece are the valves for desiccating or gas filling and lower still and to the right is an elevation lock.

The layers and trainers telescopes, see Figure 7, are identical, having a magnification of x 15, an aperture of 60 mm. and a base length of 6 metres. Each has a graticule in one eyepiece and two filter heads. Between these two facepieces are two small handwheels which are used to cover the end windows.

The eyepieces of the four optical systems all appear to be of the same design and are fixed to the rhomboid prism boxes which stand above the face plate. The apparent field of view of the eyepieces appears to be in the region of 60°. Focus is obtained by screwing the eyepiece in or out and the inter-ocular distance is adjusted by moving a lever, attached to the right hand prism box, across the I.O.D. scale. There is no method of locking the I.O.D. The real field of view for the trackers and spotting telescopes is 4° and for the rangetaker 2° at x 18 and x 25, 1° 38' at x 36 and 1° 13' at x 50 magnification.

APPENDIX A.

Figure 7.



The standard of workmanship of both the turret and the rangefinder is very high. It is noticeable that many parts are standardised for both Army and Naval instruments.

APPENDIX B.

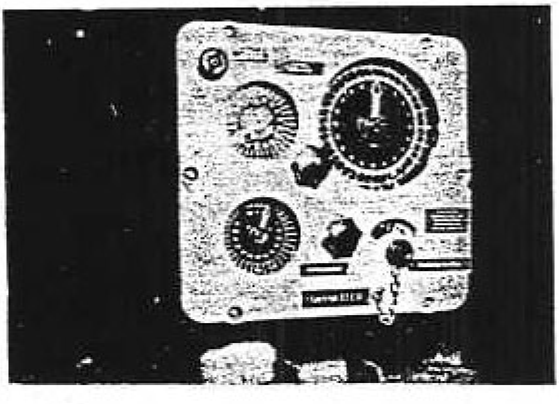
GERMAN COAST ARTILLERY BEARING AND RANGE RECEIVERS, INCORPORATING DISPLACEMENT CORRECTION GEAR.

Figure 1B.

The Seiba-Empfanger, S 2. (Bearing Receiver).

Figure 2B.

The Epa-Empfanger, S 2. (Range Receiver).



1. General.

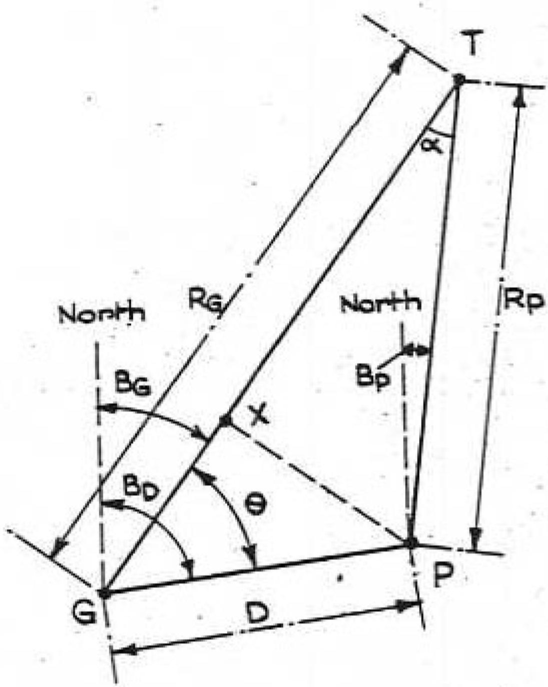
The above photographs show the bearing and range receivers which are used on German Super-heavy and specialised Medium Coast Artillery mountings for indirect laying. They receive battery pivot "future" bearing and range by a selsyn type of transmission.

The Epa-Empfanger corrects the input data for the displacement of the gun from the battery pivot, corrected range being shewn on a two-speed dial, whence it can be set on the gun.

On the Seipa-Empfanger the bearing displacement correction is computed and applied to the gearing between the gun traversing gear and the mechanical pointer matching the bearing selsyn input pointer. "Folow-the-pointer" methods are therefore used to lay the gun for line.

2. Principles.

Figure 3B.



APPENDIX B.

In Figure 3B T represents the target.

G represents the gun.

P represents the battery pivot.

B_G, B_P are bearings of T from G and P) respectively.

R , R are ranges of T from G and P)

D is the displacement GP.

B_D is the bearing of P from G.

PX is drawn perpendicular to GT.

is the bearing correction, $B_G - B_P$.

θ is $B_D - B_G$.

The input data to the correctors are B_P and R_P, and the required output data are α and R_G.

$$\sin \quad = \frac{XP}{PT}$$

$$= \frac{D \sin \theta}{R_P}$$

Or, since α is small,

$$\alpha = \frac{D \sin \theta}{R_P} \text{ approx. (Equation 1)}$$

$$R_G = TX + GX$$

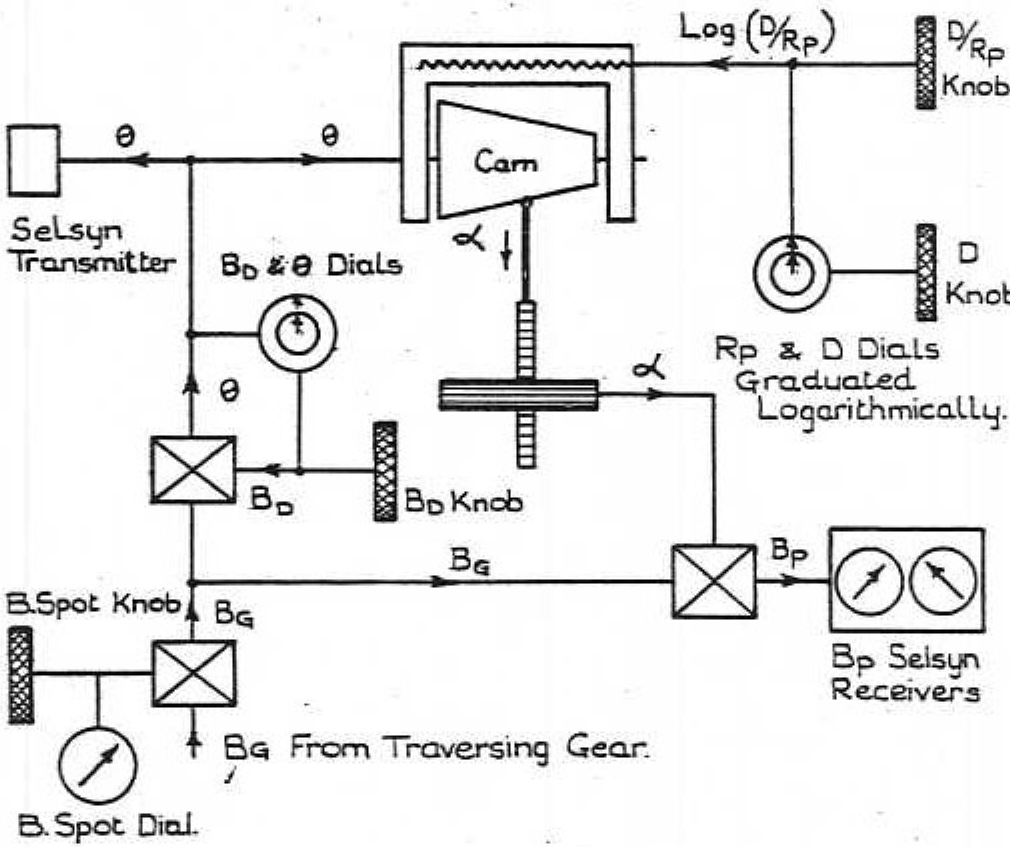
$$= R_P \cos \alpha + D \cos \theta$$

Or, since is small,

$$R_G = R_P + D \cos \theta \text{ approx. (Equation 2)}$$

3. <u>The Bearing Correction Mechanism</u> (Figure 4B).

<u>Figure 4B</u>.



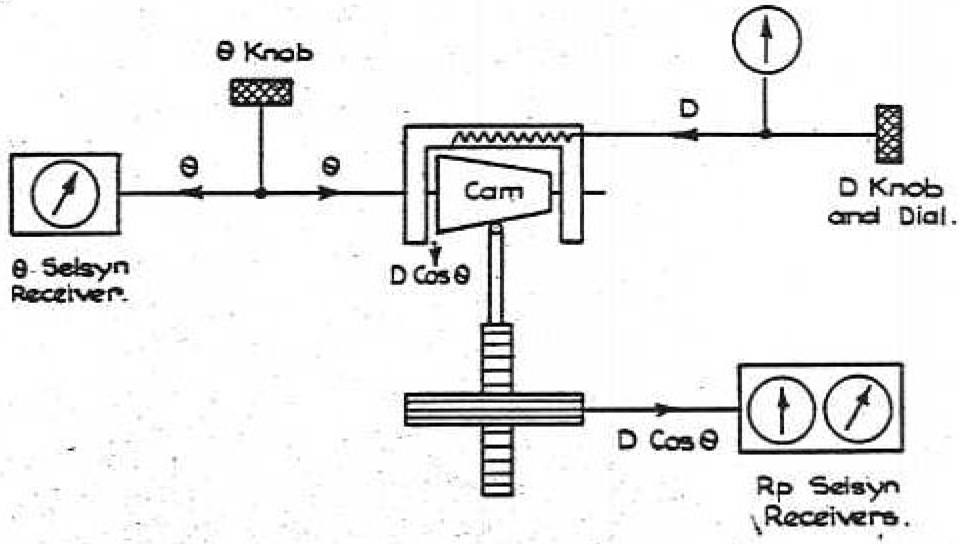
The bearing correction ( ) is obtained from a three-dimensional cam rotated for θ and translated for $\log \left(\frac{D}{R_P}\right)$, thereby solving Equation 1. is then subtracted by differential from B_G obtained by direct drive from the traversing gear, thus giving B_P to the mechanical pointers on the selsyn receivers.

θ is obtained by subtracting B_G from B_D at a differential. In addition to turning the cam, the output shaft of this differential rotates a selsyn transmitter which transmits bearing (θ) to the range receiver correctional gear.

Log $\left\{\frac{D}{R_P}\right\}$ is set by hand by matching a pointer against the range R_P on a logarithmic scale of ranges which has been set for D on a logarithmic scale of displacements. A selsyn receiver for R_P is fitted to this scale.

4. Range Correction Mechanism (Figure 5B).

Figure 5B.



The range correction D cos θ is obtained from a three-dimensional cam turned for θ and translated for D. θ is set in by an operator who "follows up" the bearing input from the mechanism referred to in para. 3, above.

The output of the cam (D cos θ) is caused to rotate fine and course dials in front of which selsyn receiver pointers turn for R_P; the dial readings thus give R_G. Fixed scales also give the readings of D cos θ.

5. Accuracy and Scope.

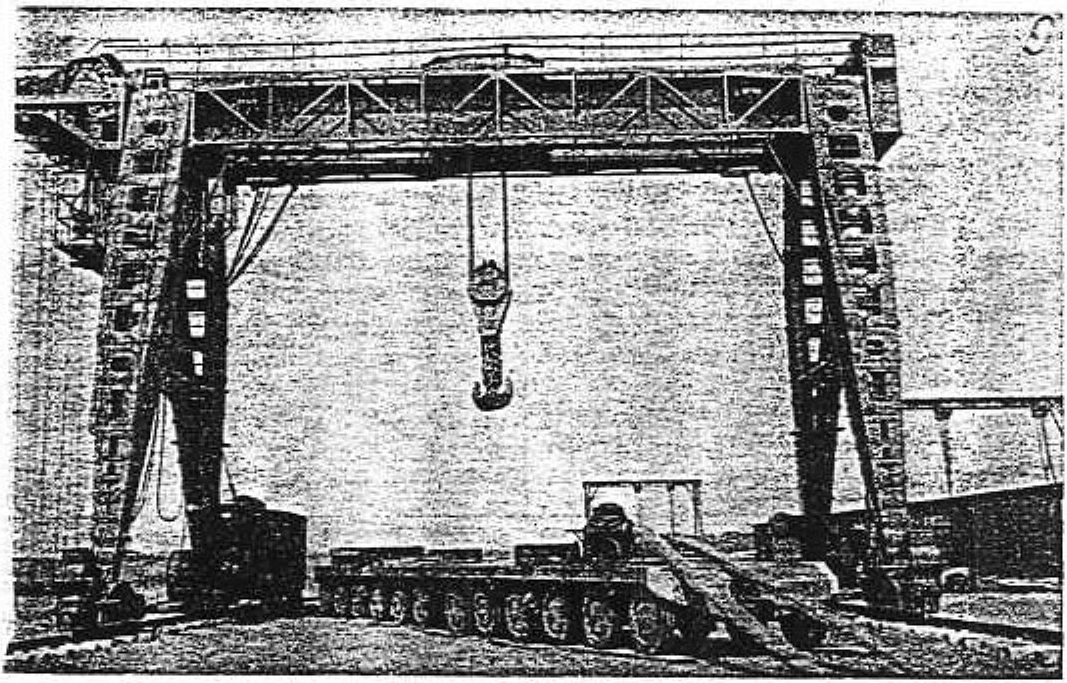
The two receivers cater for displacements up to 600 metres and a maximum range of 72,000 metres. The high speed/low speed ratios on both the range and bearing dials are 1 : 36, i.e., range 2,000 metres : 72,000 metres; bearing 10^{o} : 360^{o}.

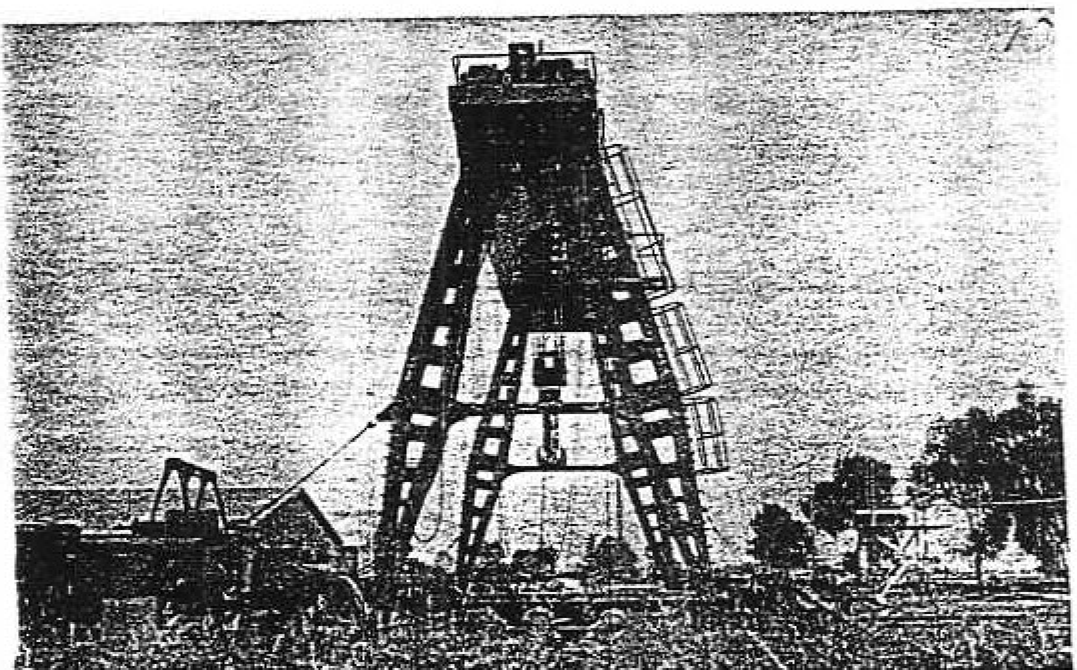
It was laid down that in not more than 10% of the readings in static tests should the error in gun range displacement correction exceed 15 metres and that in no case should the error be greater than 45 metres. This rule applied for displacement settings of 40, 200, 300 and 400 metres.

The average permissible error in bearing was of the order of 6 minutes, with a maximum of 15 minutes at very short range with large displacements.

APPENDIX C.

THE ARDELT-MONTAGE TRESTLE CRANE.





APPENDIX C.

1. The above are photographs of the fully assembled Ardelt-Montage Trestle Crane. These mobile cranes have a maximum load capacity of 175 tons (metric) and a maximum span width of 14 metres and were used by the Todt organisation for the erection of super-heavy Coast Artillery equipments.

2. Transport.

The following wagons were used for the rail transport of a completely dismantled crane:-

(a) A 42-ton wagon carrying the crane girder.

(b) A 15-ton open slat-side wagon carrying the power plant and the cabin.

(c) Two 38-ton wagons with an 18 metre loading length carrying (i) the crane pillars and the 7-ton load derrick used for the erection of the crane, and (ii) the operating machinery.

(d) A 35-ton wagon, 15 metre loading length, carrying the rails on which the crane runs.

For road transport, a special 12-axle road wagon was provided. This wagon has a central turntable housing a hydraulic jack and the complete crane girder can be loaded on it.

3. Description of the Crane.

(a) Hoist Gear.

The hoist gear is built into the projecting part of the girder and contains a gear box with which the heaviest load (175 tons) can be lifted at a rate of 0.75 metres per minute. A lighter load of 25 tons can be lifted at a rate of 5 metres per minute. The drive for the spur geared hoist comes from an electric motor which is controlled from the cabin by a special control cylinder.

A hoist brake is provided, this can be controlled by hand or made to hold the load through an electrical cut-out.

All loads are taken on an 8-strand pulley tackle, the double hook can turn freely in its thrust block and the pulleys and swivel are fitted with roller bearings. Movable pins can be set to restrict the extreme position of movement of the hook; the hoist motor stops on reaching the set limits.

A hand lever in the cabin is used to switch from "power" operation to "manual", thereby disengaging a friction clutch and engaging the appropriate "manual" coupling in the hoist gear. The hand-gear has only one speed.

(b) Trolley Limits Mechanism.

The travelling gear is housed in the projecting part of the girder. This permits lateral movement of the four wheel trolley supporting the pulley block. The drive is normally from an electric motor which activates the traversing chain through a gear train. A magnetic brake which takes effect on switching off current in the cabin limits the travel of the trolley. Hand-gear is provided as an alternative to power operation.

(c) Crane Travelling Mechanism.

The crane is supported on 16 wheels, two pairs being fitted to each of the four feet. The feet of the four pillars are designed so as to give a uniform travelling motion even on a badly laid railway. The crane legs are also designed to permit movement of the pivot in the axis of traverse, thereby allowing movement of the crane over a slightly curved rail. A gear box is built into each of the feet and each therefore contains a separate drive. A system of central control of the power plant ensures that the four legs move at the same speed. The travelling gear is operated by an irreversible worm drive immersed in oil. For precise halting an electro magnetic stop brake is operated from the control cabin.

The travelling gear has a manual drive gear in addition to the electric drive and all travelling bogies have roller bearings. Each foot is provided with a rail clamp for use in bad weather.

APPENDIX C.

4. Performance of Crane.

(a) Hand operation.

The figures given hold only for short duration.

	Weight. Tons.	Speed. metre/min.	Men required.
Hoist:	175	.02	8
Lower:	175	.06	8
Trolley traverse:		.3	4
Travelling:		1.2	4
Erecting (time about 3 hours)			8

(b) Electric operation.

Current strength: 380 volts 50 cycles.

Hoist:	175 tons.	Speed:	.75 m/min.	HP: 24.
"	175 "	"	0.075 "	" 24.
"	25 "	"	5.0 "	" 24.
"	25 "	"	0.5 "	" 24.

The low gear (1 : 10) is only used for taking the strain of the load

Trolley traverse:	Speed: 3.5 m/min.	HP:	7.
Travelling:	" 13.0 "	"	4 x 9.
Erecting: (time 40 mins.)	.47 "	"	2 x 11.

(c) Greatest wheel loads (each side).

Crane without load:	5 tons each wheel.
Crane with load central:	15 tons each wheel.
Crane with load traversed one end:	23 tons each wheel.