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ENEMY WEAPONS

PART IV.—GERMAN INFANTRY, HEAVY AA AND DIVISIONAL ARTILLERY

1943

Prepared under the direction of
The Chief of the Imperial General Staff.

THE WAR OFFICE,
February, 1943.

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CONTENTS

APPENDICES

To face page 1

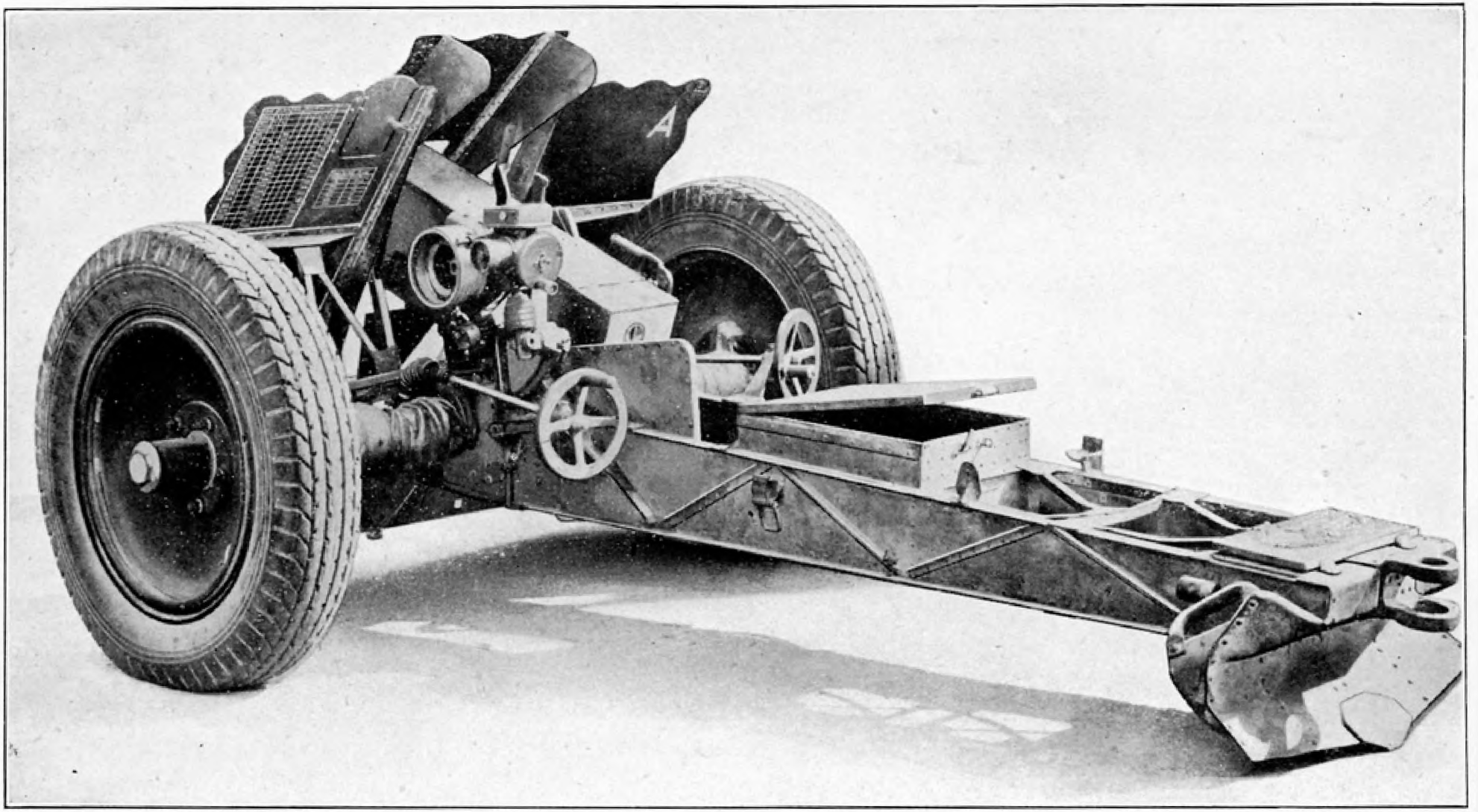


FIG. 1.—7·5 CM. (2·95 IN.) LIGHT INFANTRY HOWITZER (7·5 CM. I.I.G. 18)

ENEMY WEAPONS

PART IV.—GERMAN INFANTRY, HEAVY A.A. AND DIVISIONAL ARTILLERY

I. 7·5 cm. (2·95 in.) Infantry Howitzer (7·5 cm. 1. I.G. 18) (*See* Figs. 1–8)

1. General particulars

The 7·5 cm. infantry howitzer was introduced in 1933 or 1934 as an infantry close support weapon. There are two versions—one on artillery wheels and the other on pneumatic tyred disc wheels. The former is also used by airborne troops. The 7·5 cm. Mountain Infantry Howitzer, 7·5 cm. 1. Geb. I.G. 18, is of similar design and has a similar performance, but is not fitted with a shield.

The gun is drawn by six horses, or by a motor vehicle; alternatively it can be split into six loads (maximum 165 lb.) for pack transport.

A range table for use with the 12 lb. H.E. shell is at Appendix D.

2. Data

i. *Ballistic characteristics*

(*a*) 13·2 *lb. H.E. shell with percussion fuze A.Z. 23.*

LOWER REGISTER

Charge	Max. range yds.	M.V. f.s.	50 per cent. zone (yds.)		Time of flight secs.	Weight of charge oz.
			Length	Breadth		
I	875	302	46	2	11·4	0·547
II	1200	359	49	2	13·9	0·776
III	1640	431	50	2	15·8	1·092
IV	2560	548	55·5	3·5	21·9	1·675
V	3780	690	71	4·5	26·6	2·520
UPPER REGISTER						
I	875	302	47	2	13·7	
II	1200	359	50	2	16·1	
III	1640	431	52	3·5	20·2	
IV	2560	548	59	3·5	23·6	
V	3780	690	73	5·5	29·2	

Note.—Splinter effect is 65 ft. laterally, 19-32 ft. forwards and 10-16 ft. backwards.

(*b*) 12 *lb. H.E. shell with percussion fuze A.Z. 23 n.A.*

LOWER REGISTER

Charge	Max. range yds.	M.V. f.s.	50 per cent. zone (yds.)		Time of flight secs.
			Length	Breadth	
I	930	310	32	2	12
II	1260	368	35	3	13·8
III	1750	440	41	4	17·5
IV	2680	565	45	5	20·7
V	3880	730	49	6	25·6
UPPER REGISTER					
I	930	310	33	2	14·4
II	1260	368	37	3	16·9
III	1750	440	42	4	18·9
IV	2680	565	47	6	24·2
V	3880	730	50	7	29·2

Note.—Splinter effect is 66 ft. laterally, 20-33 ft. forwards and 10-16 ft. backwards.

A 1 and P fuze, the Dopp. Z.S./60 Geb., is used with the mountain version of the gun, as well as the A.Z. 23 n.A.

ii. *The gun and carriage*

Theoretical rate of fire	...	15-20 r.p.m.	Maximum depression	...	10°
Practical rate of fire	...	5-10 r.p.m.	Maximum traverse	...	12°
Length of barrel ...	...	10 cals.	Height of trunnions	...	2 ft. 1½ in.
Weight in action ...	...	880 lb.	Diameter of wheels	...	2 ft. 7½ in.
Maximum elevation	...	73°			

iii. *Ammunition*

The ammunition is separate, the cartridge case being either 6341 (brass) or 6341 St (steel). The following types are used :—

(*a*) H.E. shell 7·5 cm. Igr.18, with fuze A.Z. 23. Weight 13·2 lb.

(*b*) H.E. shell 7·5 cm. Igr.18, with fuze A.Z. 23 n.A. Weight 12 lb. The fuze can be set to instantaneous (" o.V "), or to 0·15 secs. delay (" m.V "). This shell is not provided for the 7·5 cm. 1.Geb. I.G.18.

(*c*) H.E. shell 7·5 cm. Igr.18 Al., with fuze A.Z. 23 n.A. Weight 12 lb. This shell is provided for both guns. When fired by the 7·5 cm. 1.Geb. I.G.18, a T and P fuze, the Dopp. Z.S/60 Geb.. can also be used. The letters " Al " are understood to indicate inclusion of a granular aluminium flash composition in the filling.

(*d*) A hollow charge shell, the 7·5 cm. Igr.38, with fuze A.Z.38, weight 10·6 lb. It is fired with Charge V. This shell has been introduced primarily for anti-tank purposes, but in emergency can be used against personnel, etc. Penetration is approximately 55 mm. (2·17 in.) at normal, and 45 mm. (1·77 in.) at 30 degrees.

(*e*) There are also two types of practice shell, 7·5 cm. Igr (Übb) and 7·5 cm. Igr (Üb.Al.).

Ammunition is carried in baskets holding three rounds, or in a more recently introduced metal container, which also holds three rounds.

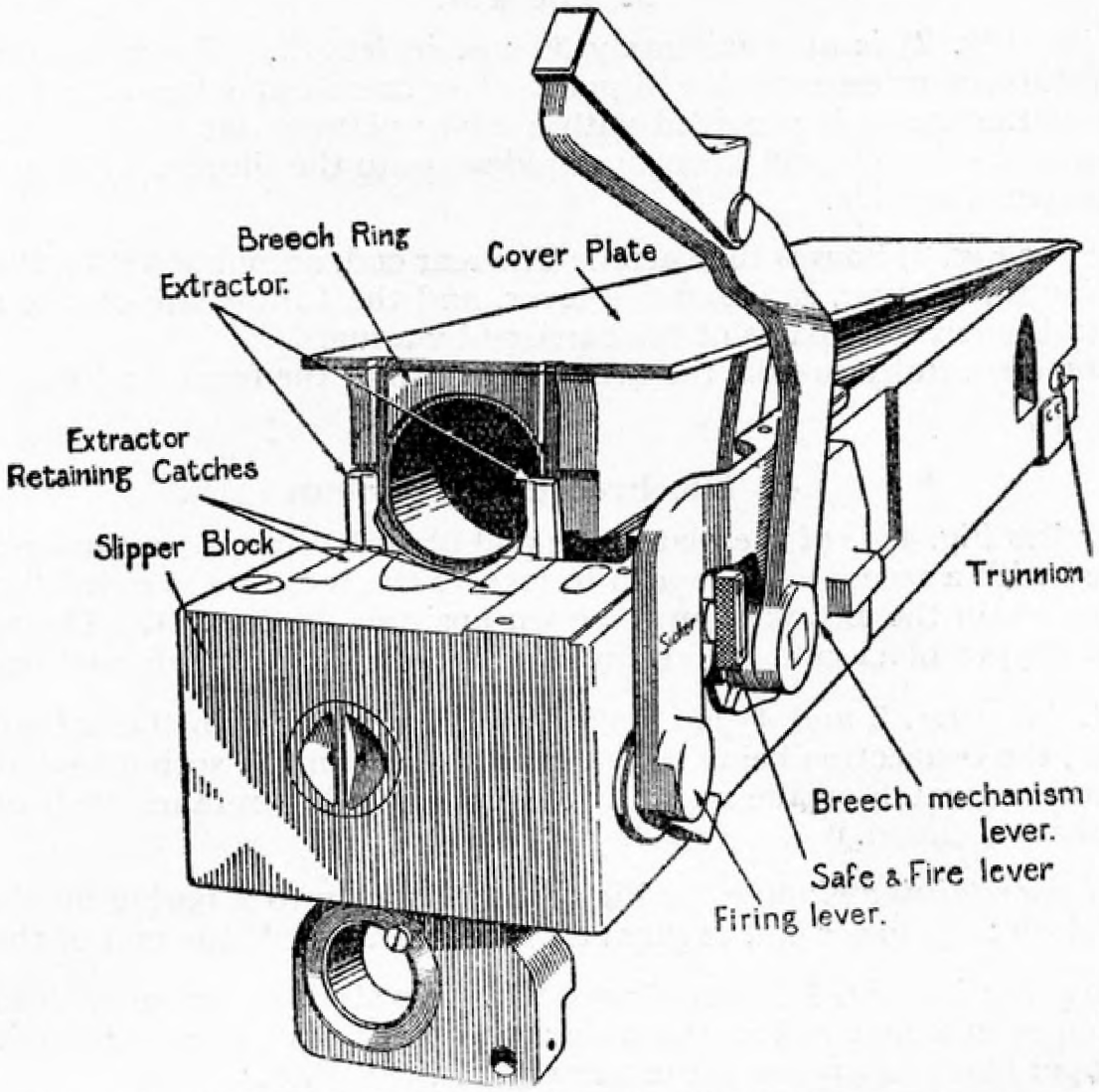


FIG. 2.—7·5 CM. (2·95 IN.) LIGHT INFANTRY HOWITZER (7·5 CM. 1.I.G.18)—
BREECH RING AND SLIPPER BLOCK (OPEN POSITION)

3. The gun

i. *The barrel* (*see* Fig. 2) is approximately 30 ins. in length. The muzzle end is formed with trunnions, which rotate in recesses in the slipper. The breech end has a rectangular breech ring. The upper surface of the barrel is provided with a cover plate as far as the trunnions. A guide is formed on each side of the breech ring to engage guideways in the slipper, while a longitudinal groove in the right side receives the slide.

ii. *The slipper* (*see* Fig. 3) houses the barrel. The rear end, accommodating the firing mechanism, is a solid block. The firing lever, safe and fire lever, and the L.B.M. are on the right of this block, which is attached to the recoiling parts of the carriage by a lug.

The block is bored centrally to take the firing hole bush at the front, and the striker, main spring and cover at the rear.

4. The breech mechanism

i. *The extractor* (*see* Fig. 4) is of the plate type and fits into a recess in the rear face of the breech ring. It is prepared with a recess on each arm to receive the toes on the extractor retaining catches, which are shaped to retain the extractor in the open position (*see* Fig. 4). The retaining catches fit into recesses in the slipper block and are secured by the shaft of the safe and fire lever.

ii. *The L.B.M.* (*see* Figs. 3 and 4) is cranked and connected with the actuating link by a boss or stud on the latter, the connection being secured by a taper pin. A spring-loaded catch is provided, which engages a retaining catch on the right of the slipper, and so retains the lever in position when the breech mechanism is closed.

iii. *The firing lever retaining plunger* (*see* Figs. 3 and 5) fits into a boring on the left of the upper face of the slipper block ; its lower end engages a cannelure towards the end of the firing lever shaft.

iv. *The actuating link* (*see* Fig. 4) is bar-shaped with two studs on opposite sides, one at either end. The inner stud engages in a hole cut in the slide ; the outer stud passes through a hole cut in the right side of the slipper block to engage in the rear end of the L.B.M.

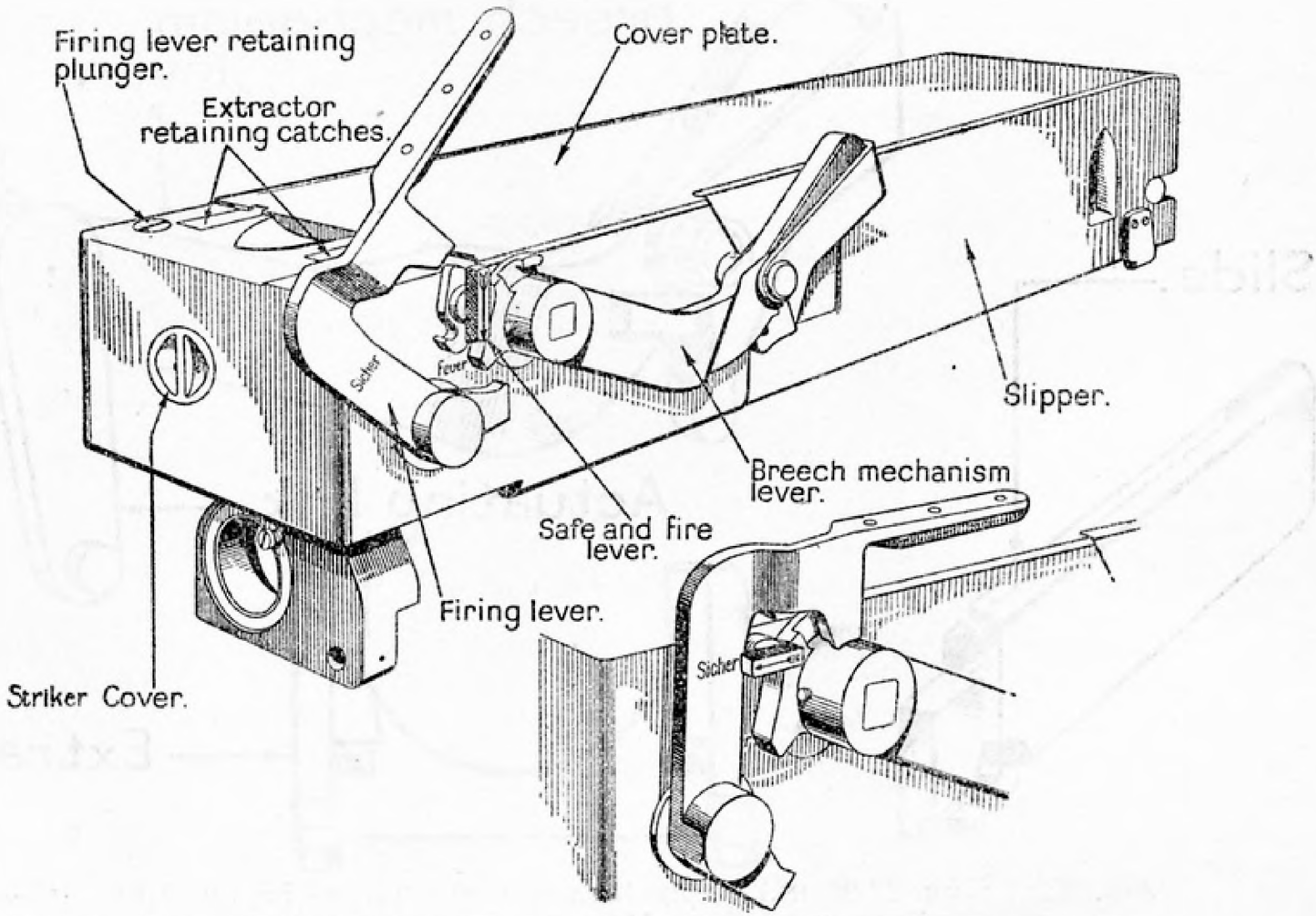


FIG. 3.—7·5 CM. (2·95 IN.) LIGHT INFANTRY HOWITZER (7·5 CM. I.I.G. 18)—BREECH RING AND SLIPPER BLOCK (CLOSED POSITION)

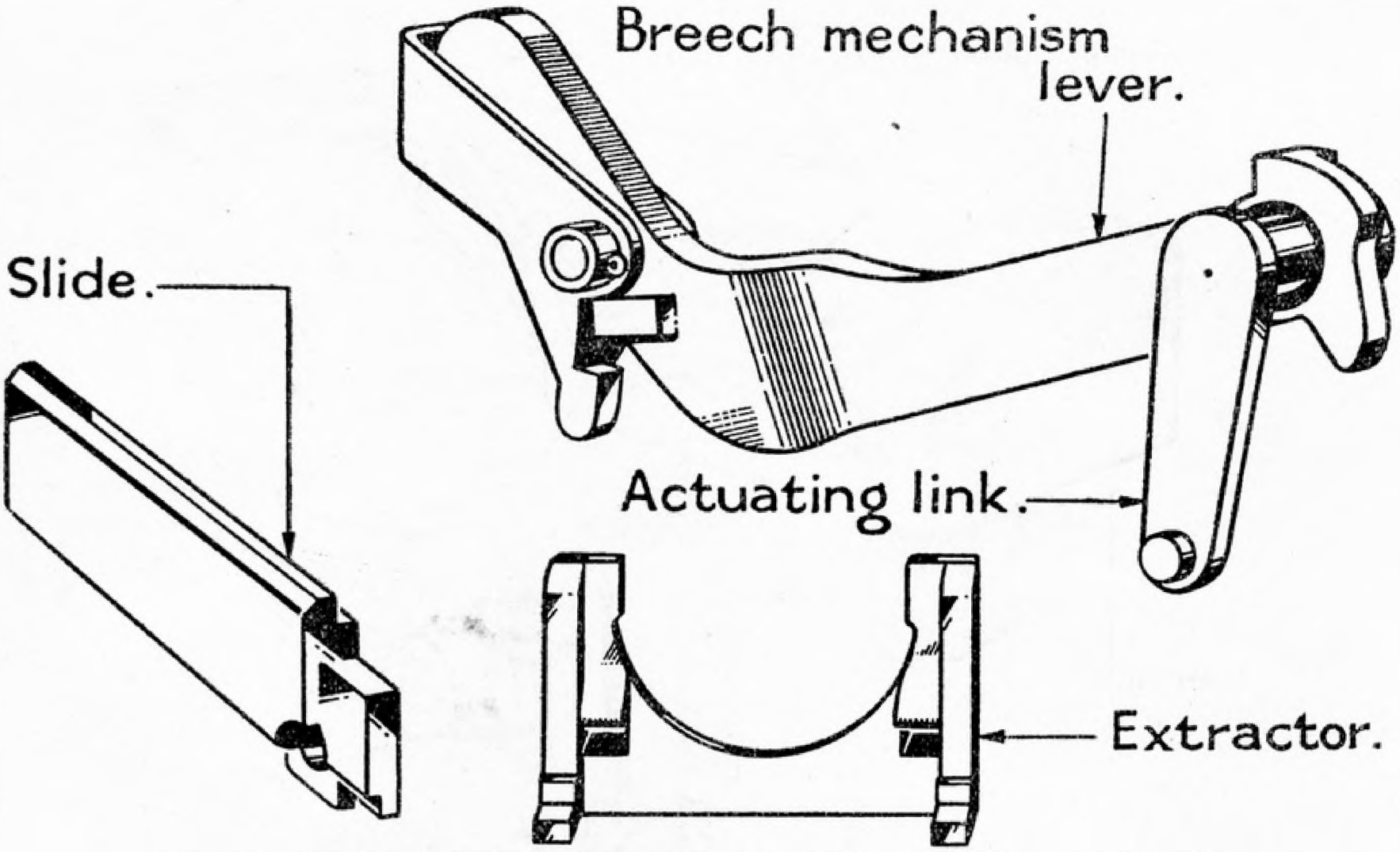


FIG. 4.—7·5 CM. (2·95 IN.) LIGHT INFANTRY HOWITZER (7·5 CM. I.I.G. 18)—BREECH OPENING MECHANISM AND EXTRACTOR

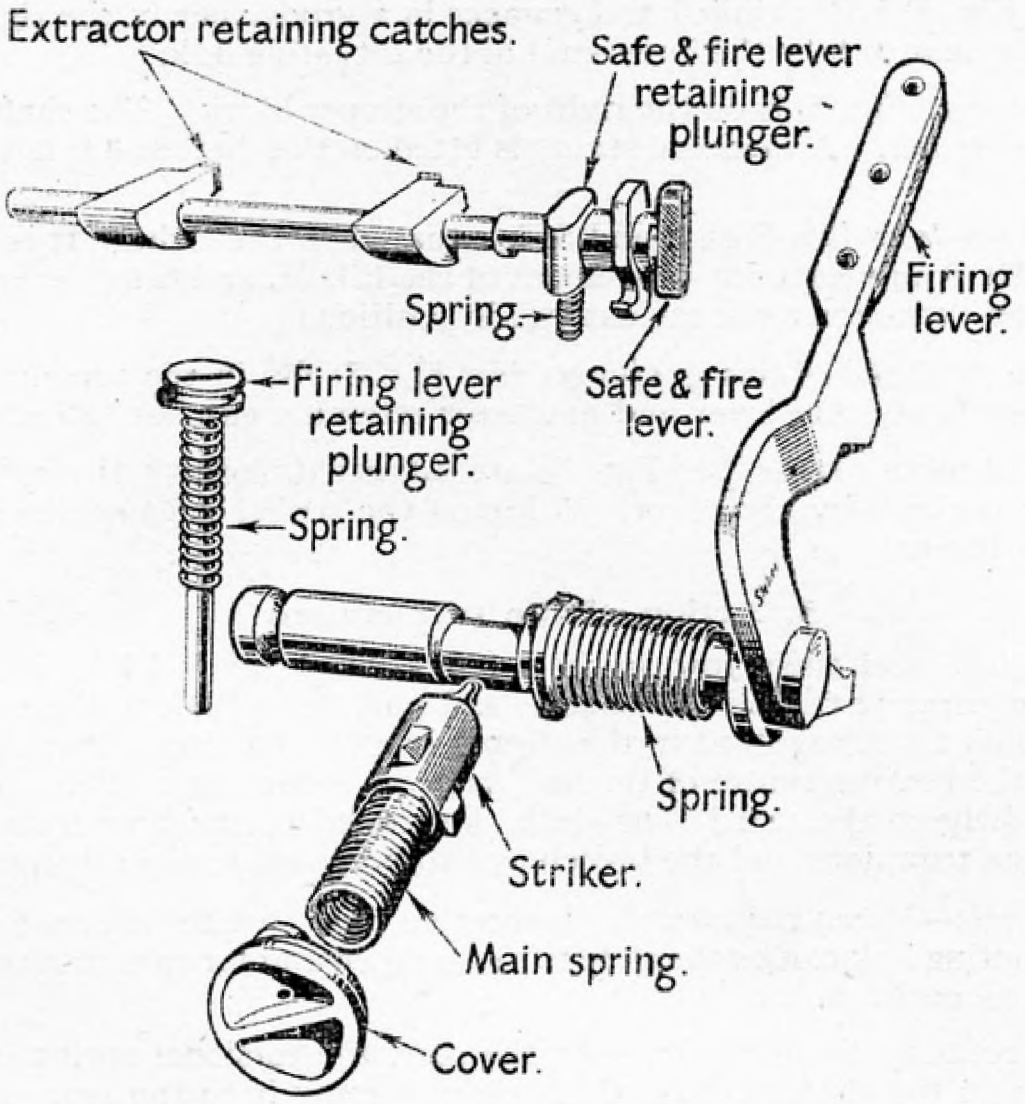


FIG. 5.—7·5 CM. (2·95 IN.) LIGHT INFANTRY HOWITZER (7·5 CM. 1.I.G. 18).—FIRING AND SAFETY MECHANISM

v. *The slide* (*see* Fig. 4) is dovetailed and engages in a groove cut in the right side of the breech ring. It is bored at the rear to take the inner stud of the actuating link.

vi. *The firing lever* (*see* Fig. 5) is on the right of the slipper block. The shaft has a spring-loaded lug, which engages the striker. A torsional spring is fitted on the shaft and is held in position between a collar and the lever.

vii. *The safe and fire lever* (*see* Figs. 3 and 5) is situated on the right. It is so shaped that,when set to SICHER (SAFE), it prevents any movement of the L.B.M. and firing lever. The shaft portion engages and retains the extractor retaining catches in position.

viii. *The safe and fire lever retaining plunger* (*see* Fig. 5) fits in the top right side of the slipper block ; it secures the safe and fire lever and extractor retaining catches.

ix. *The striker and main spring* (*see* Fig. 5) are admitted through the rear face of the slipper block and retained in position by the cover. A lug on the striker engages the spring-loaded lug on the shaft of the firing lever.

5. Action of the mechanism

i. *To open the breech.*—Set the arrow on the safe and fire lever to FEUER (FIRE). Disengage the retaining catch by gripping the L.B.M. handle, and pull the L.B.M. to the rear. This movement causes the actuating link to be revolved in the slipper block. The inner stud of the actuating link, being displaced from the bearing centre of the link, is given a circular motion, causing the slide to be raised and drawn slightly to the rear. The slide, dovetailed to the breech ring, causes the barrel to be revolved about its trunnions and the breech end to be raised to the open position.

ii. *To close the breech.*—When the cartridge is inserted the extractor is carried forward, the L.B.M. is rotated and the actuating link causes the slide to move down and forward in its groove, thus lowering the barrel to the closed position.

iii. *To fire.*—On rotating the firing lever to the rear, the torsional spring is put under tension. The spring-loaded lug on the shaft engages the striker, forcing it to the rear against its spring and

cocking it. When the lug on the shaft trips the lug on the striker, the latter is allowed to move forward and fire the gun.

6. Safety arrangements

i. The gun cannot be fired until the barrel is properly closed. A projection on the firing lever must enter a recess in the L.B.M. when fully closed.

ii. The L.B.M. and firing lever cannot be moved when the arrow on the safe and fire lever is at SICHER (SAFE) because :—

(*a*) The toe on the L.B.M. is engaged by the safe and fire lever and is so prevented from moving.

(*b*) The toe on the safe and fire lever engages a cut away portion in the firing lever and prevents any movement.

7. Stripping and assembly

i. *To dismantle the mechanism.*—Turn the safe and fire lever to FEUER (FIRE). Remove the striker cover by pushing it inwards, and rotating it through 90 degrees in an anti-clockwise direction. Take out the spring and striker. Release the firing lever retaining plunger by depressing it and rotating it ; remove the firing lever with the torsional spring and collar. Depress the retaining plunger of the safe and fire lever and remove the latter. Hold the barrel open and remove the extractor together with the extractor retaining catches. After taking out the taper pin rotate the L.B.M. to the fully open position and remove. Operate the actuating link until it disengages the slide, which can then be removed. If necessary the barrel can now be lifted out.

ii. *To assemble the mechanism.*—Place the slide in its groove in the barrel ; insert the actuating link in the slipper and engage it with the slide. Replace the L.B.M. and taper pin. Open the barrel until the extractor and the extractor retaining catches can be placed in position. Insert the safe and fire plunger and spring ; pass the safe and fire shaft in from the right side, when it will engage and retain the extractor retaining catches. Replace the firing shaft with the two feathers

engaging the feather ways in the recess, with the smaller feather at the top. Place a slight tension on the spring and push the shaft home. Insert the cocking and firing shaft retaining plunger and spring, and finally replace the striker, spring and cover.

8. The carriage

i. *The carriage* is of box type and consists of two side pieces supported by transoms at the front. Towards the front, it is prepared with bearings to receive the trunnions on the cradle. The rear end is fitted with a spade, trail eye and lifting handles. Two boxes for spares are fitted—one in the centre and the other at the rear.

ii. *The cradle* is trough-shaped and fitted with a cover plate. It is formed with trunnions which fit the trunnion bearings on the carriage; at the front brackets with spring-loaded plungers are fitted for the reception of an upper shield. The elevating arc is secured underneath and the recoil indicator to the right side.

iii. *The axle* slides in bearings. Brackets are fitted to the ends, in which the wheel suspension springs and locking plungers are housed. The locking plungers engage in the wheel cranks when in the firing position.

iv. *The elevating gear*, consisting of a worm gearing, rack, pinion and shafting, is on the right. The elevating pinion is housed on a shaft between the side plates of the carriage.

v. *The traversing gear* is operated from the left side and consists of a system of gear wheels and shafts. The carriage is traversed along the axle by means of a traversing nut and screw fitted to the right side of the axle.

vi. *The travelling clamp*, securing the cradle to the carriage in transport, is fitted to the left side of the carriage.

vii. *The sight bracket* (*see* Figs. 6 and 7) is fitted to the left side of the carriage. The lower end of its connecting rod is secured to the left cradle trunnion and the upper end to the sight reader.

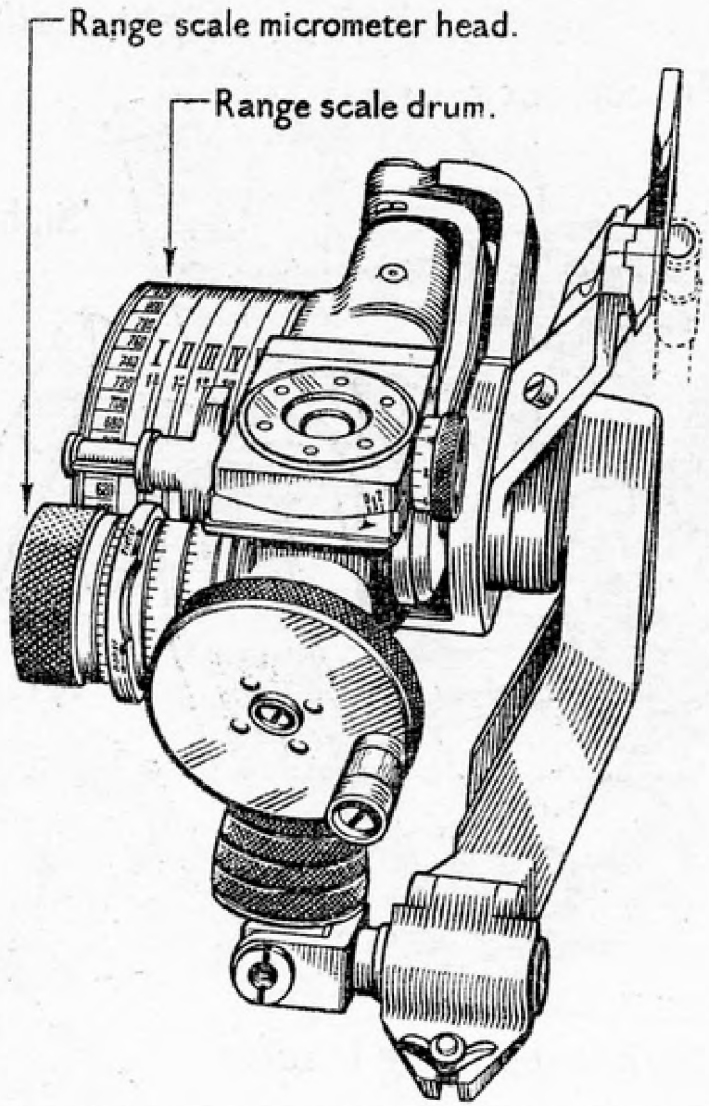


FIG. 6.—7·5 CM. (2·95 IN.) LIGHT INFANTRY HOWITZER (7·5 CM. 1.I.G. 18).—SIGHTING ARRANGEMENTS

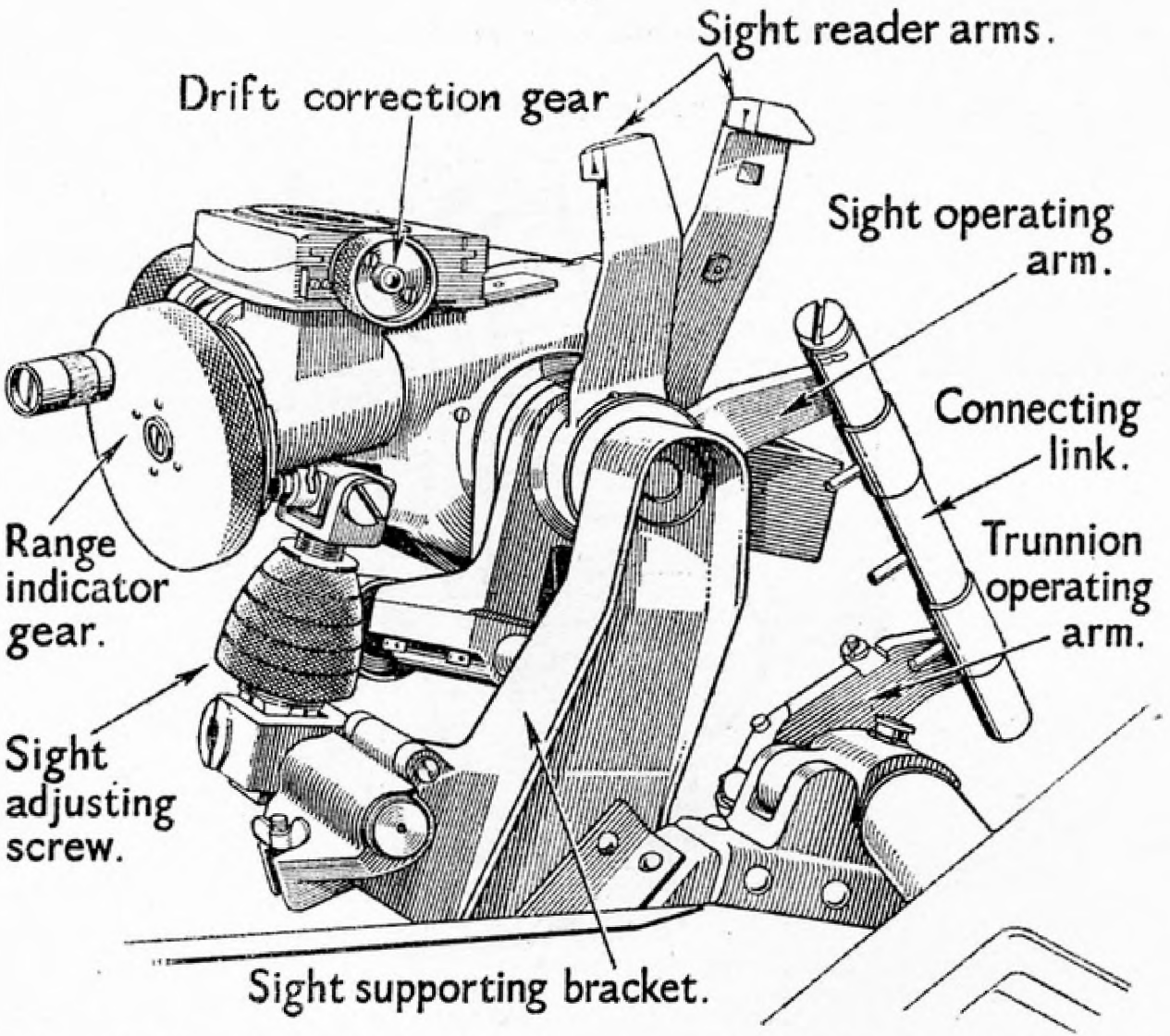


FIG. 7.—7·5 CM. (2·95 IN.) LIGHT INFANTRY HOWITZER (7·5 CM. 1.I.G. 18).—SIGHTING ARRANGEMENTS

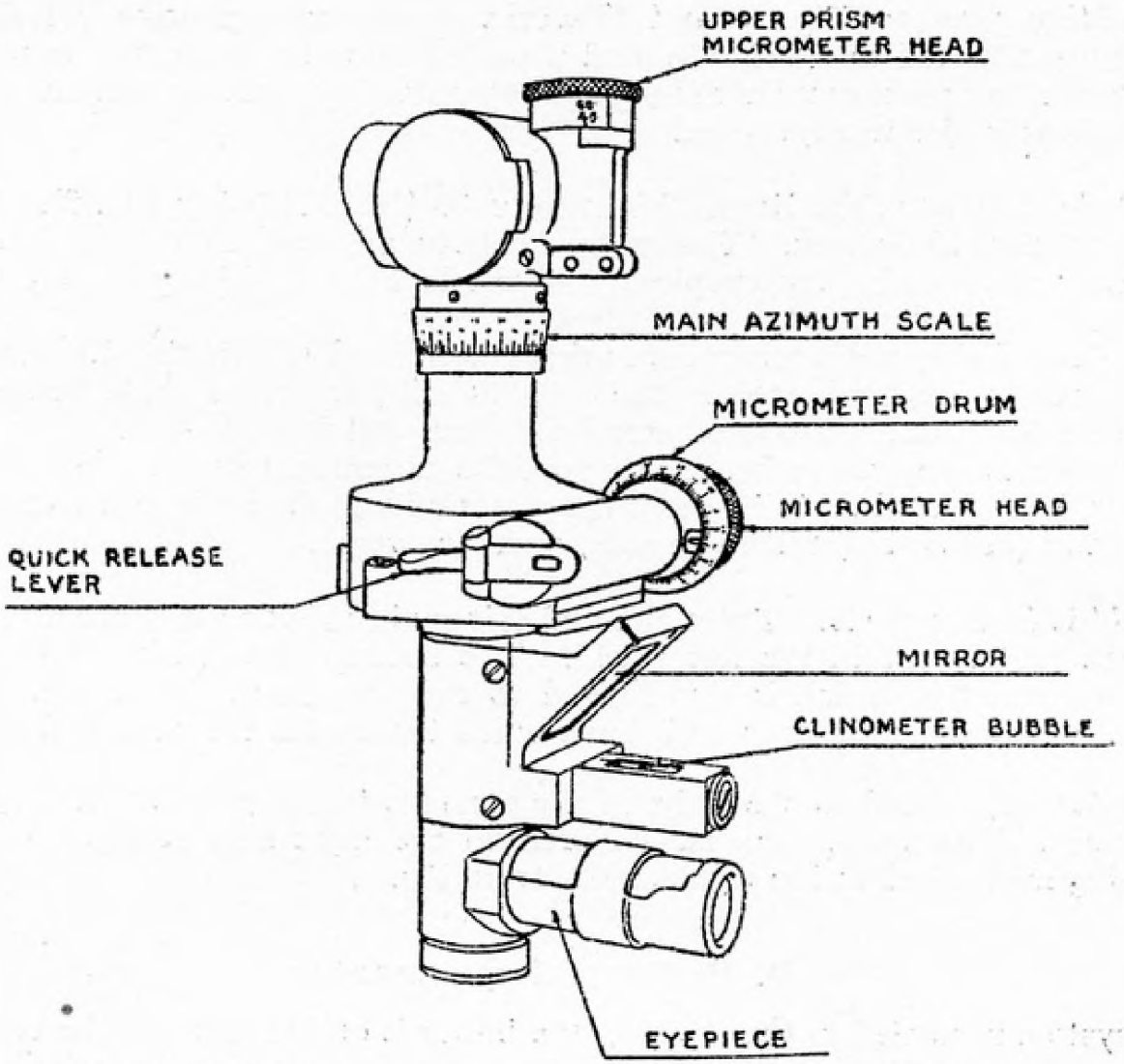


FIG. 8.—7·5 CM. (2·95 IN.) LIGHT INFANTRY HOWITZER (7·5 CM. I.I.G. 18).—DIAL SIGHT. Rbl. F. 16

viii. *The sighting gear* (*see* Figs. 6 and 7) works on the reciprocating principle. It is fitted with a range drum graduated to 1,320 mils and a correction scale graduated in metres for the five charges used. A rocking platform for the sight is operated by a worm spindle and deflection nut. A clicker arrangement is also incorporated.

ix. The dial sight fitted is the Rundblickfernrohr 16 (Rbl.F.16) (*see* Fig. 8). Its magnification is 4, and its field of view 10 degrees. The graticule shows an inverted V and a broken vertical line. There are no means of focussing the eyepiece, and the layer should keep his eye about ¾ in. away. There is provision for illuminating the graticule at night.

For zero angle of sight, the upper prism micrometer head is adjusted to a setting of 300 mils.

The azimuth scales are graduated from 0—6,400 mils, the main scale being numbered every hundredth mil from 0—64 and the micrometer scale every mil from 0—100.

The azimuth scales are numbered in the opposite direction to that which is usual in British dial sights. Thus, if it is required to traverse the gun x mils to the right, the setting on the azimuth scales of the sight should be reduced by x mils, and vice versa.

x. *The shield* is in five parts. The right and left main shields are secured to the front of the carriage. A sight port is cut in the left shield. The bottom flap is hinged to the side portions, together with a central flap which is also hinged to the bottom of the cradle. The upper shield is secured to the cradle and moves up and down when the gun is elevated and depressed.

xi. *The compensator* fitted to the right of the carriage frame, consists of a spring box and rod compressing springs. The spring box is anchored to the right side of the carriage, and the rod compressing spring is cranked to the right cradle trunnion.

9. Buffer and recuperator

The recoil system is carried in the cradle ; the buffer is on the left and the recuperator is on the right.

i. *The recuperator* is hydro-pneumatic. The H.P. cylinder is placed above the liquid cylinder, the two cylinders being connected by a communicating channel. A spring-loaded valve at the front of the H.P. cylinder regulates the flow of fluid between them.

The liquid cylinder has a piston and packing, and the rear end of the piston rod is secured to the lug in the slipper block.

ii. *The buffer cylinder*, containing a piston and a control rod with sliding valve, is closed at the front by a stuffing box and gland. The rear end has a nut to secure the cylinder to the slipper block lug.

10. Detachment

The gun detachment consists of :—Detachment commander, who commands, observes and, in the case of gun control, orders range and lead.

Layer, who lays for line, sets the range and A/S, and centres the elevation bubble.

Firer, who lays for elevation, opens and closes the breech, and fires.

Loader, who loads and assists in moving the trail round.

Ammunition number, when available, who assists the loader.

The following are notes on the drill to be used by British troops :—

i. *To lay*.—The telescopic dial sight is placed on the sight mounting.

The gun angle is ordered in mils (6,400 to a full circle) and set in hundreds on the dial ; the remainder is set on the micrometer by turning it in a clockwise direction. (*See* Appendix B for conversion of degrees to mils.)

An increase in mils takes the gun over to the left.

No open sight is provided.

ii. *To set the angle of sight.*—Angle of sight zero is set as 300 on the sight bracket.

A micrometer with a spiral graduation, along which the index slides in a groove, can be turned to angles of sight elevation (black graduations) or angles of sight depression (red graduations), ordered in mils.

The corresponding clinometer bubble is carried on the dial sight and is seen in a mirror.

The bubble is centred by turning a knurled, half-spherical knob under the dial sight seating.

iii. *To set the range.*—The tangent elevation, as given by the range table for each charge, is set on the left of the range drum.

The range in metres is set, for each charge, by sliding the index across to each charge. The scale is graduated every 25 metres and numbered every 100 metres. The layer must take care to set ranges in the lower register (up to 800 mils approx.) and not to use the upper register, where range decreases with increasing elevation.

iv. * *Laying for elevation.*—Setting the angle of sight and the tangent elevation, and centering the clinometer bubble moves an arm with an index.

Another arm is linked to the piece.

The firer turns the elevating handwheel until both indexes are in exact prolongation. This lays the gun for elevation.

v. *To load.*—The loader loads the shell, the firer rams.

The ammunition number makes up the appropriate charge, replacing the cup.

For charge V, the case is loaded as it is.

The rim of the case releases the breech.

---

*A correction for drift can be applied on the knob to the right of the dial sight seating. This tilts the dial sight; cross levelling the sight automatically corrects for drift.

With Charge V at 550 yards, drift moves the shot over to the right by only 3 ft.

The firer closes the breech.
The gun cannot fire until the breech is completely closed.

vi. *To fire.*—Set the safety catch (right of breech block) at FEUER (FIRE) (arrow pointing downwards).

Pull the firing lever to the rear. This action cocks and fires the gun.
In case of misfire, wait 1 minute and then pull the firing lever again.

vii. *Tangent elevation in mils.*—For charge V up to 500 metres.

Charge V : 100 metres—11 mils.
200 metres—29 mils.
300 metres—48 mils.
500 metres—86 mils.

II.—8·8 cm. (3·46 in.) Multi-Purpose Gun (8·8 cm. Flak 36)

(*See* Figs. 9-19)

1. General

The 8·8 cm. gun was introduced in 1934, under the name of the 8·8 cm. Flak 18, as the standard semi-mobile A.A. gun. As a result of experience gained in Spain and France, a more mobile carriage, Sonderanhänger 201 (trailer 201), was provided ; a shield was fitted, and a telescopic sight ; A.P.C.B.C. ammunition, and an H.E. shell with a percussion fuze for the engagement of ground targets were produced.

More recently a self-propelled mounting has been reported, from which it can engage ground, but not aerial targets. Apart from this purpose, the gun is still largely used as a purely A.A. weapon. It is also employed as a dual purpose C.D./A.A. weapon, has been mounted on a special shallow draft

craft, and is also said now to be mounted on U-boats. It is in service in both the Italian and Spanish armies. A high angle trajectory chart is at Appendix E, and a ground range table for use with the A.P.C.B.C. shell is at Appendix F.

The gun is normally towed by one or other of the following two semi-tracked vehicles :—

	Type	*H.P.*	*Laden weight*
i.	Sd. Kfz. 7	140	11½ tons
ii.	Sd. Kfz. 8	185	14½ tons

These vehicles carry the gun detachment, and a supply of ammunition in lockers at the rear.

2. Data

i. *General*

Muzzle velocity	2,690 f.s.
Maximum horizontal range	16,200 yds.
Maximum vertical range	32,500 ft.
Rate of fire (practical)	15—20 r.p.m.
Length of barrel	194 in. (56 cals.)
Length of bore	161 in. (46·5 cals.)
Rifling	32 grooves
Twist (right handed)	4°—6°
Height of trunnions	63 ins.
Weight of piece	1·4 tons
Weight in action	4·9 tons
Weight in draught	7·1 tons
Maximum elevation	+85°
Maximum depression	— 3°
Traverse (in firing position)	2×360°
Traverse (on trailer 201 with legs in travelling position)	4½° (1½° R. 3° L.)
Traverse (on trailer 201 with legs lowered)	88° (44° R. and L.)

To face page 20

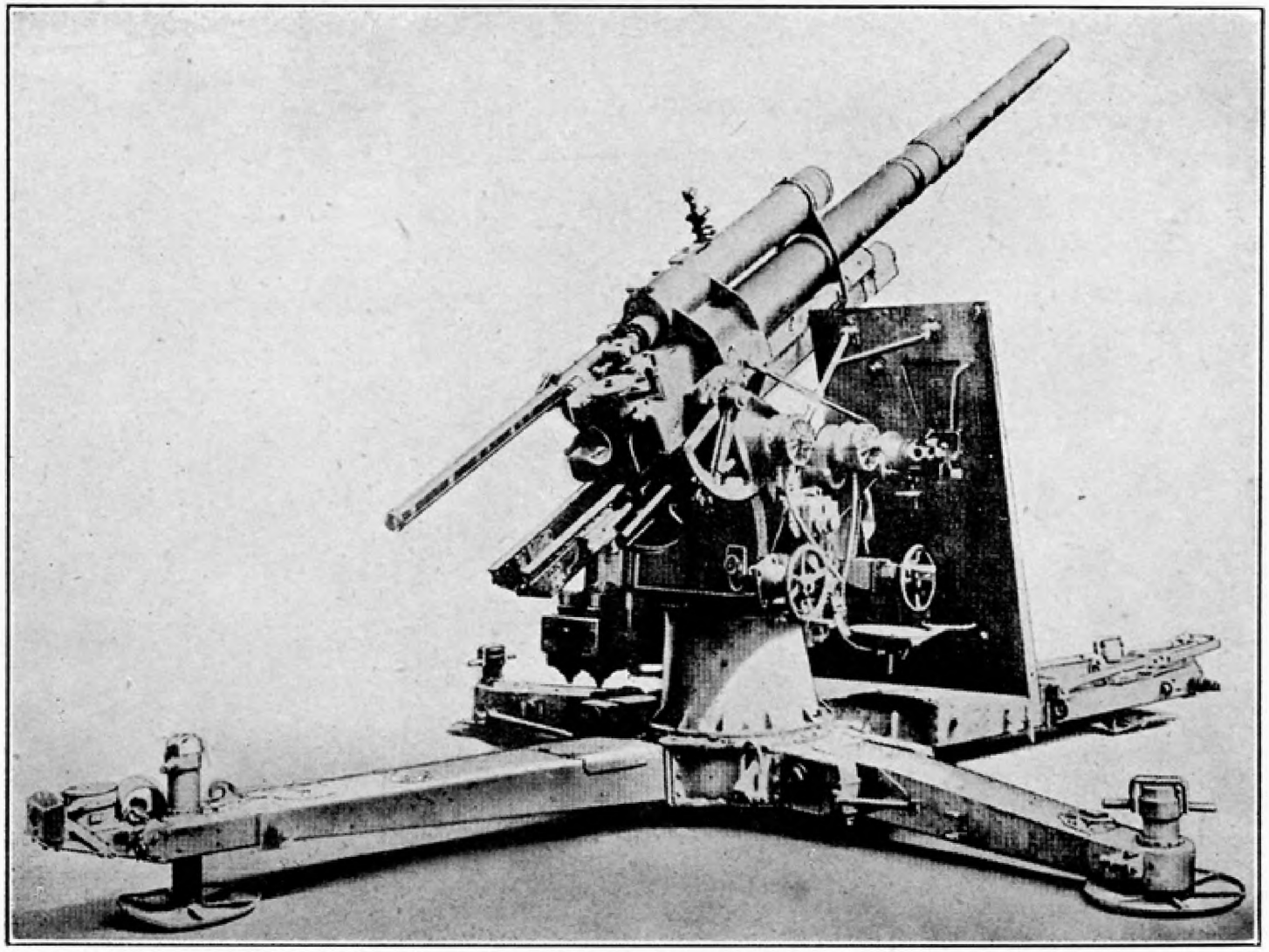


FIG. 9.—8·8 CM. (3·46 IN.) MULTI-PURPOSE GUN (8·8 CM. FLAK 36)

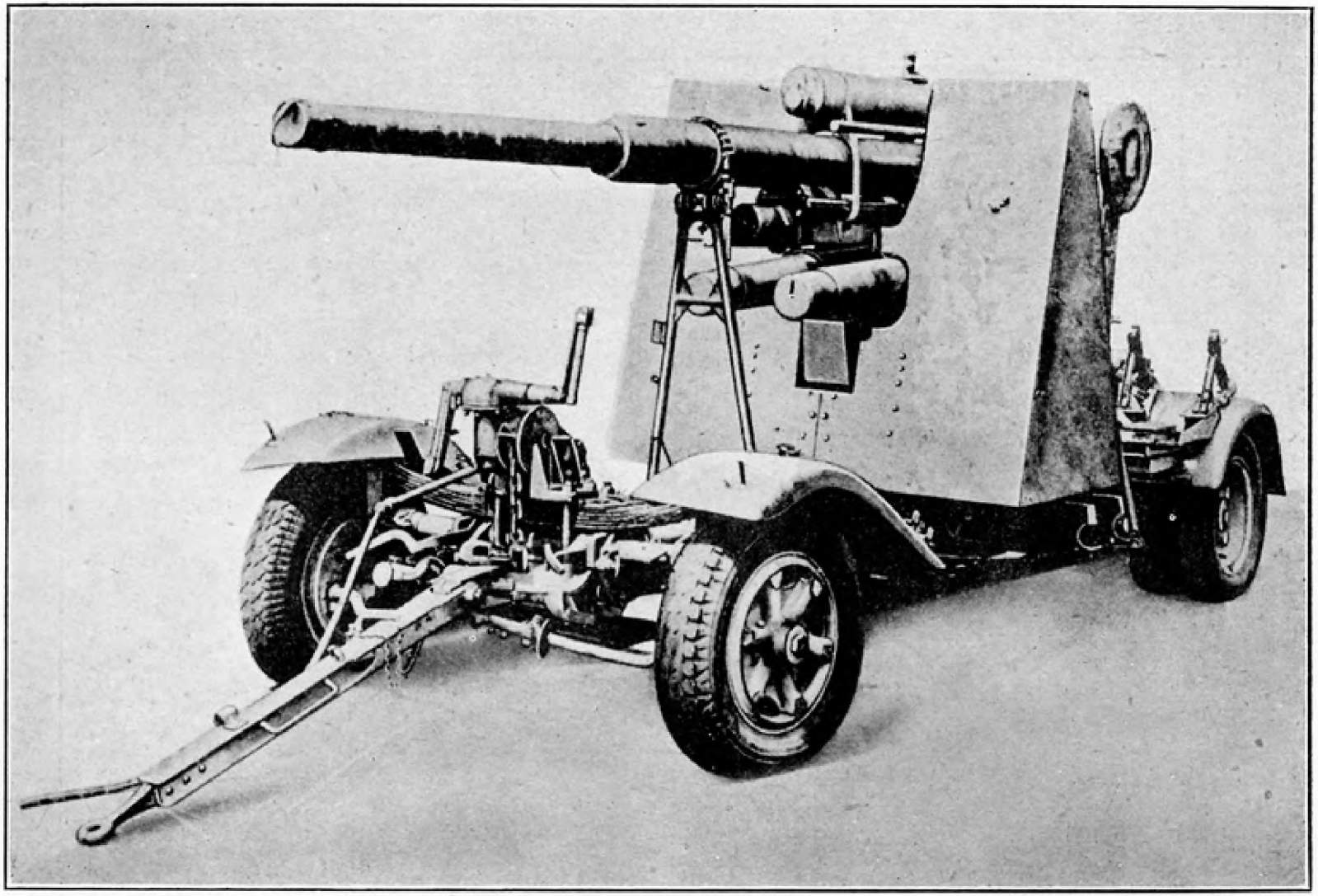


FIG. 10.—8·8 CM. (3·46 IN.) MULTI-PURPOSE GUN (8·8 CM. FLAK 36) IN TRAVELLING POSITION

ii. *Ammunition.*—Three types are fired :—

Type	Weight of complete round	Length of complete round	Weight of projectile	Length of projectile	Fuze	Identification
H.E. shell with time fuze (8·8 cm. Sprgr. Patr. L/4·5 (kz.) m. Zt.Z. S/30)	31 lb. 11½ oz.	36·69 in.	20 lb. 1 oz.	15·55 in.	Nose (clock-work) Zt. Z.S/30	Projectile painted yellow above driving band
H.E. shell with percussion fuze (8·8 cm. Sprgr. Patr. L/4·5 (kz) m. A.Z. 23/28)	32 lb.	36·69 in.	20 lb. 5½ oz.	15·55 in.	Nose(percussion) A.Z. 23/28	Projectile painted yellow above driving band
A.P.C.B.C tracer shell with base fuze (8·8 cm. Pzgr. Patr. m. Bd. Z.)	33 lb.	34·21 in.	20 lb. 12 oz.	14·49 in.	Base	Projectile painted black

iii. *Penetration.*—The following figures show the approximate penetration performance of this weapon against homogeneous armour plate :—

Range in yards	*Thickness of plate in mm.*	
	Normal	30°
500	129 (5·07 in.)	110 (4·33 in.)
1,000	119 (4·68 in.)	101 (3·97 in.)
1,500	110 (4·33 in.)	92 (3·62 in.)
2,000	100 (3·93 in.)	84 (3·30 in.)

3. The gun. (*See* Figs. 9-13)

The gun consists of a jacket, breech ring, interchangeable three-piece A-tube and removable guides. The A-tube is inserted into the jacket from the rear and is held in position by the breech ring, which is secured on the jacket by a screwed collar. The A-tube has a cartridge chamber at the rear end ; the remainder of the bore has 32 rifling grooves with a right hand twist.

The gun slides in a cradle on guideways secured to the breech ring and jacket. The breech ring is prepared to receive the various parts of the breech mechanism. Two recesses on the upper side have " FEUER " (FIRE) and " SICHER " (SAFE) engraved, and an assembly line for the safe and fire lever has the word " WIEDERSPANNER " alongside. A lug on top and another underneath are for attachment to the recuperator and buffer respectively.

4. The breech mechanism. (*See* Figs. 14-17)

The semi-automatic breech mechanism is of the horizontally sliding, self-cocking type, which opens as the gun is run-out, ejects the case, and at the same time compresses the striker and breech block operating springs.

The breech can be opened and closed by hand if necessary, the striker being cocked during the opening movement of the breech.

The extractors are released on loading, or by operating a hand lever.

Loading is by automatic rammer used in conjunction with the loading tray. Firing is by percussion. The withdrawal of the loading tray operates the firing mechanism unless set to " hand."

Safety arrangements incorporated ensure that the gun cannot be fired till the breech block is in the closed position. A safe and fire lever is fitted.

The opening and closing mechanism (Fig. 17) consists of the following parts :—

i. The *L.B.M.* is situated at the right rear of the top face of the breech ring. It is crank-shaped and consists of a handle, a casing portion, and a shaft.

The handle is L-shaped, and is bored at the angle to receive the axis pin of the L.B.M. retaining catch, which is housed inside the handle.

To face page 22

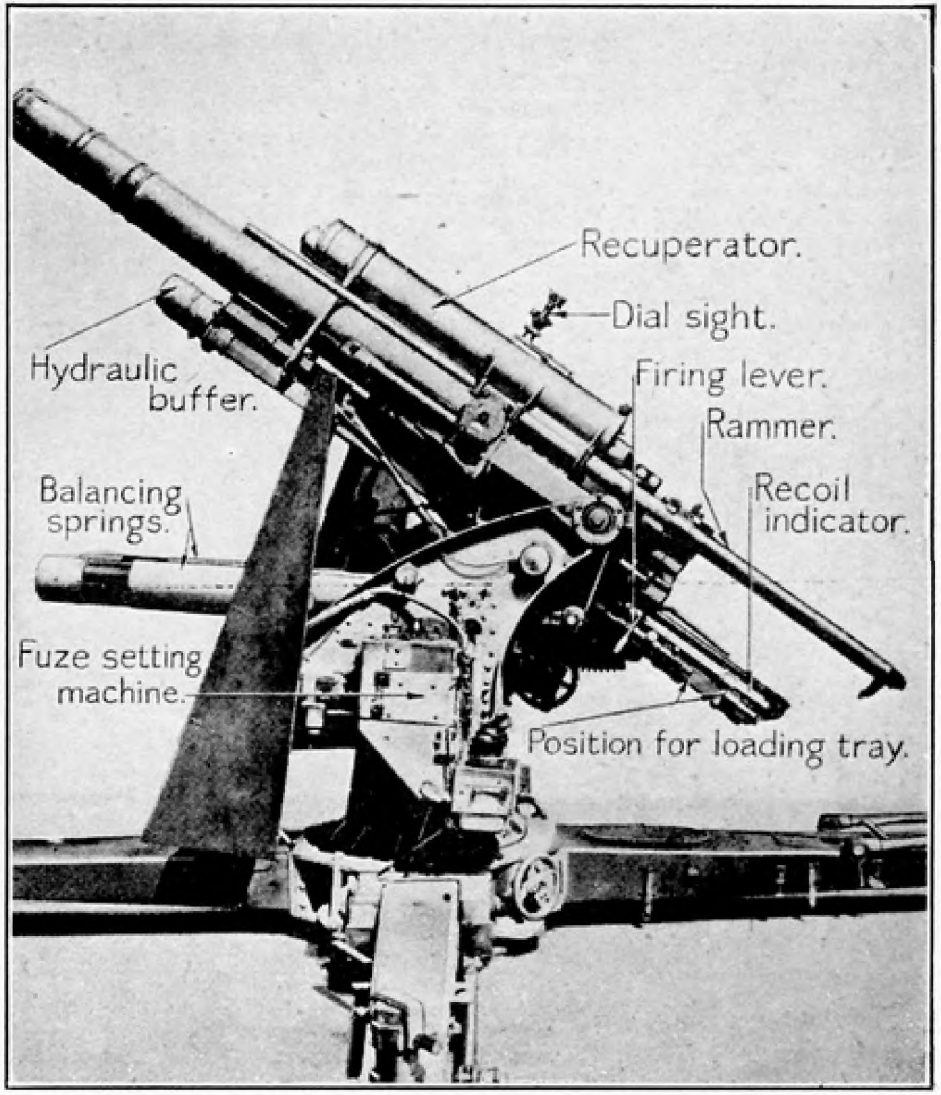


FIG. 11.—8·8 CM. (3·46 IN.) MULTI-PURPOSE GUN (8·8 CM. FLAK 36). DETAIL OF LEFT SIDE

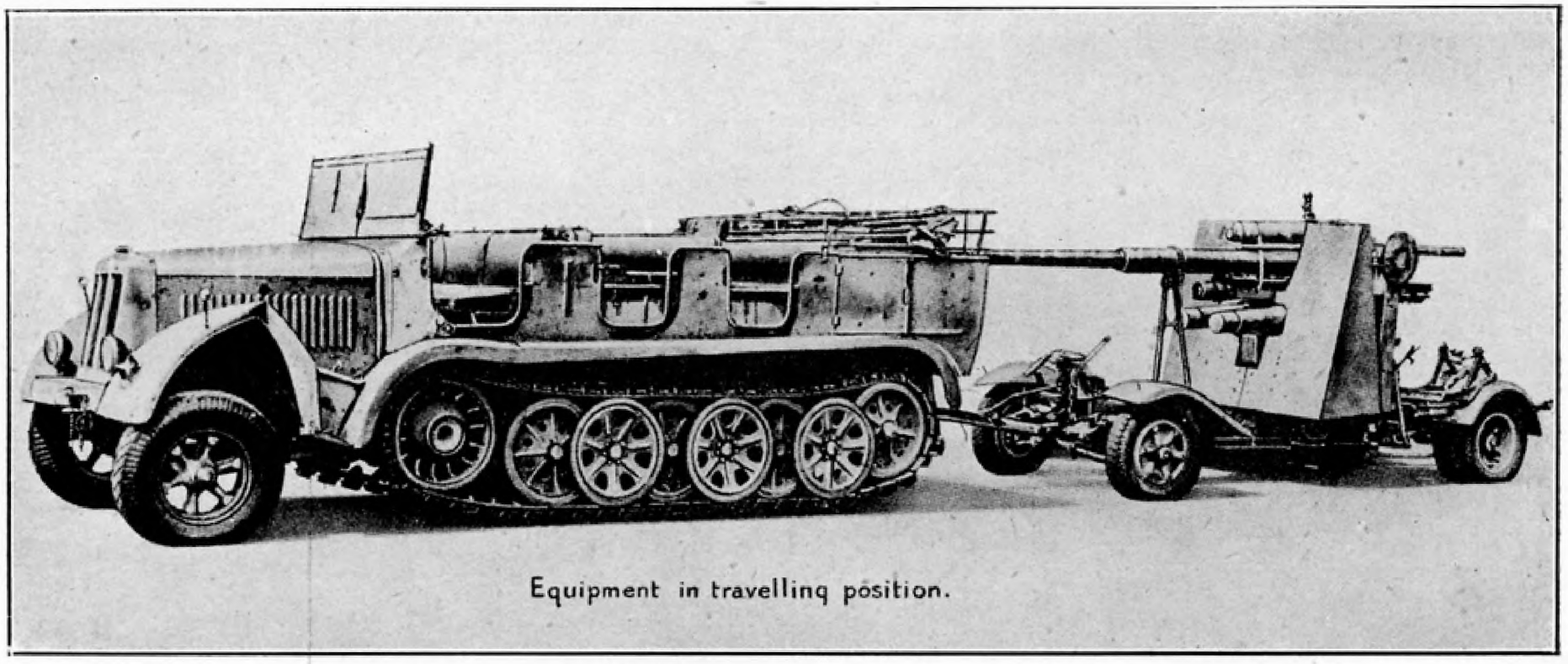


FIG. 12.—8·8 CM. (3·46 IN.) MULTI-PURPOSE GUN (8·8 CM. FLAK 36) WITH TRACTOR

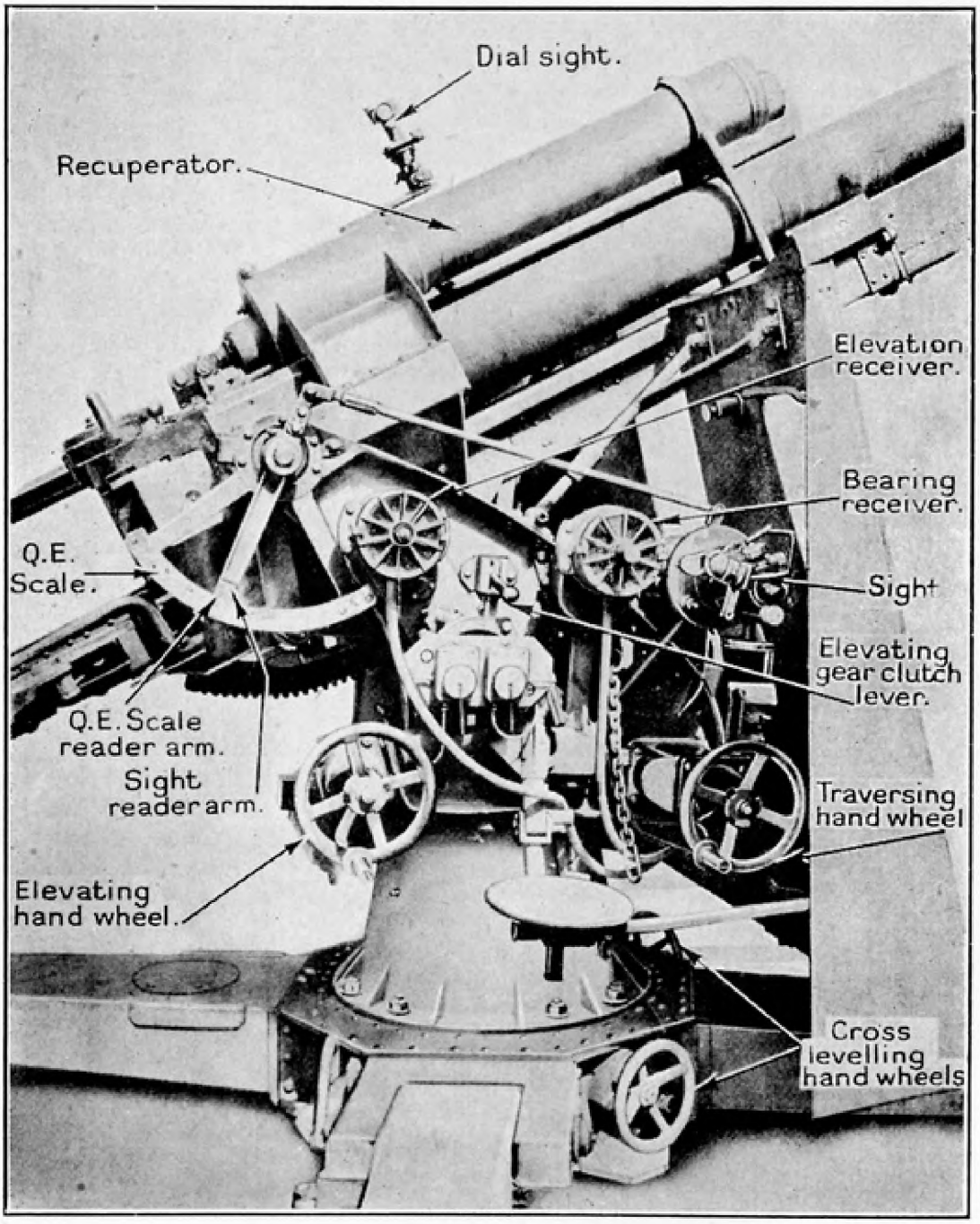


FIG. 13.—8·8 CM. (3·46 IN.) MULTI-PURPOSE GUN (8·8 CM. FLAK 36). DETAIL OF RIGHT SIDE

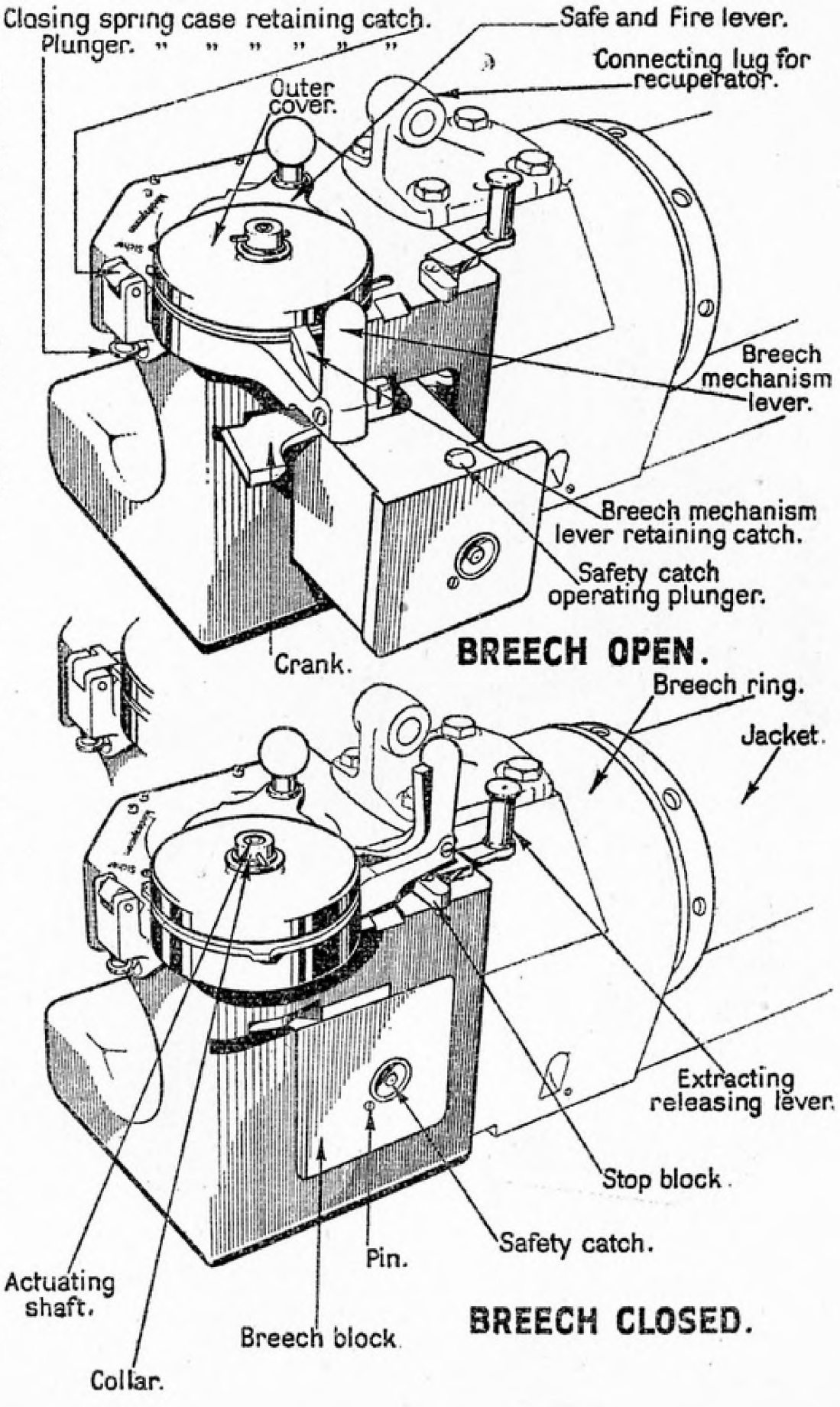


FIG. 14.—8·8 CM. (3·46 IN.) MULTI-PURPOSE GUN (8·8 CM. FLAK 36). BREECH RING AND BREECH MECHANISM

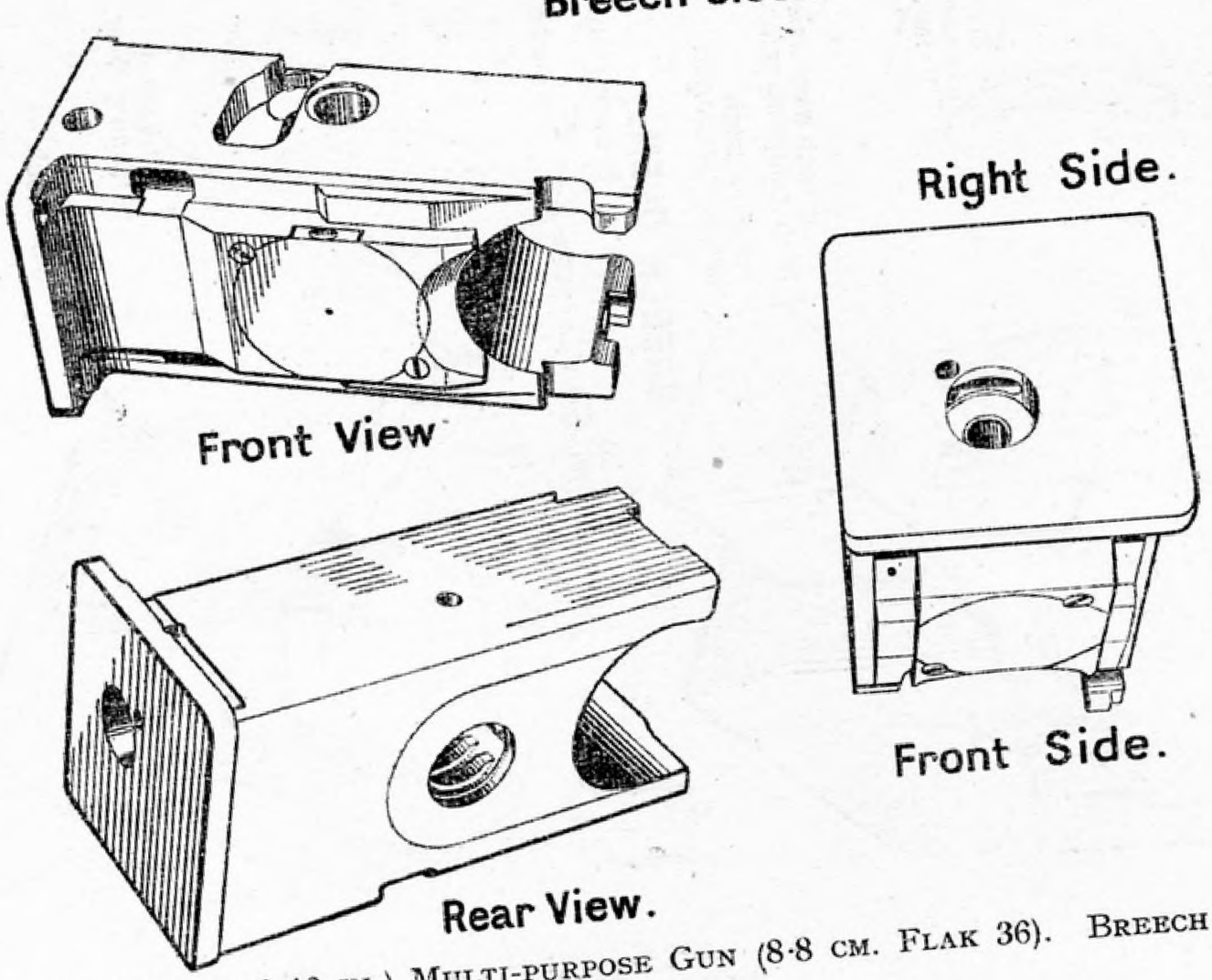


FIG. 15.—8·8 CM. (3·46 IN.) MULTI-PURPOSE GUN (8·8 CM. FLAK 36). BREECH BLOCK

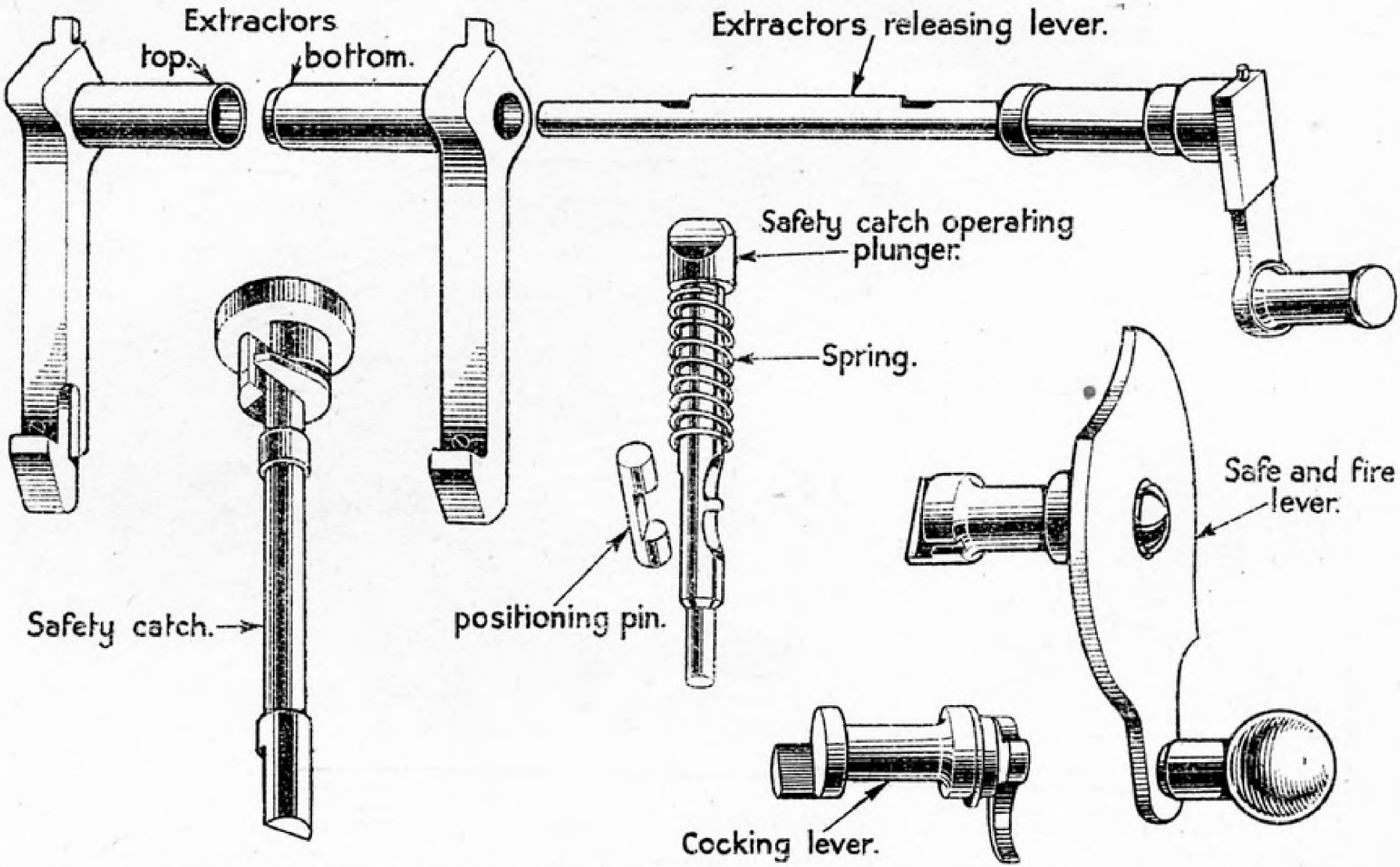


FIG. 16.—8·8 CM. (3·46 IN.) MULTI-PURPOSE GUN (8·8 CM. FLAK 36). EXTRACTORS, SAFETY AND COCKING MECHANISM

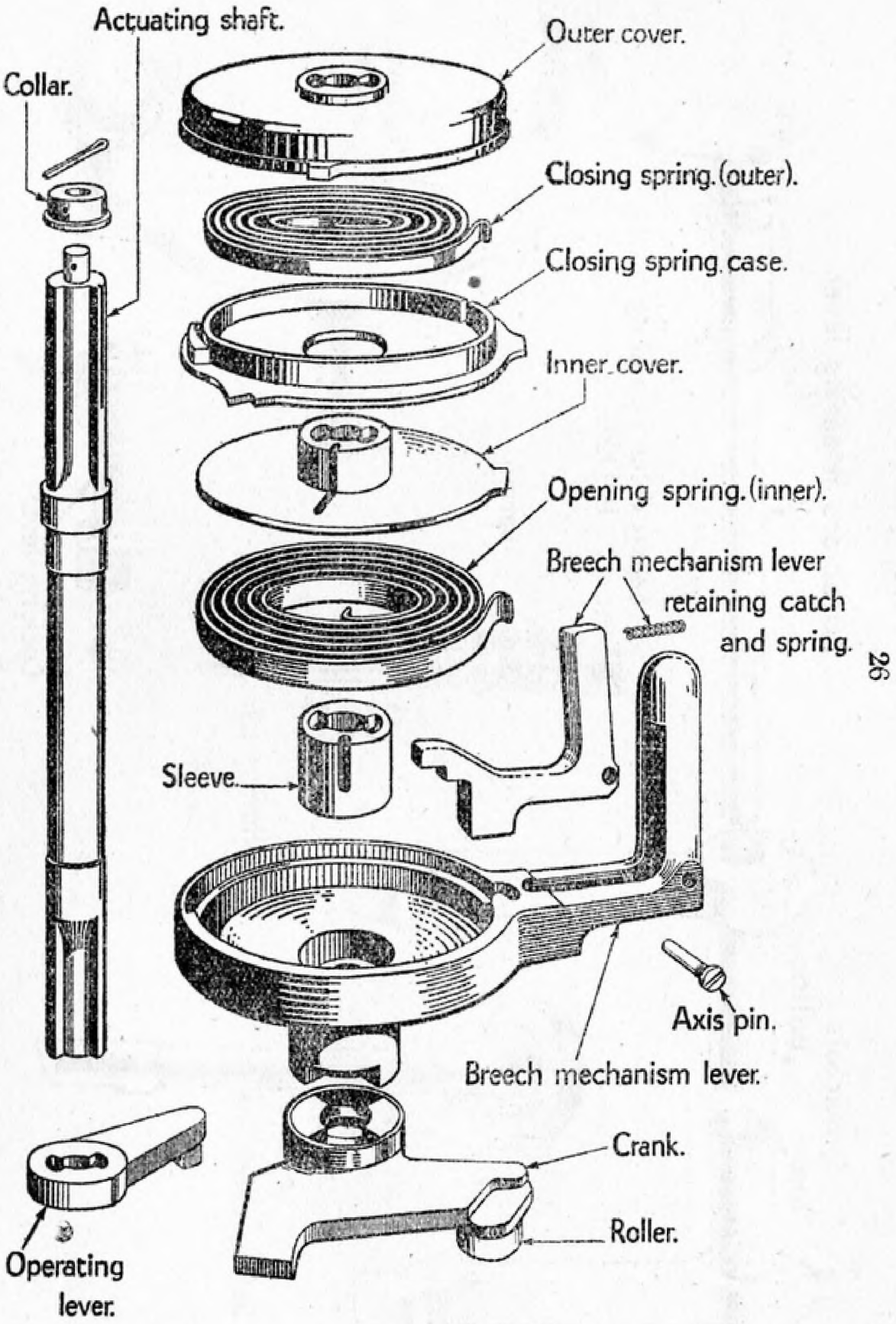


FIG. 17.—8·8 CM. (3·46 IN.) MULTI-PURPOSE GUN (8·8 CM. FLAK 36). BREECH MECHANISM

The casing portion is a flanged circular plate and houses the opening spring and inner cover. The flange is recessed internally for about half its circumference to allow a limited freedom of movement to a projection on the inner cover ; a slot at the junction of the handle and the casing anchors the outer end of the opening spring.

The shaft extends a short way through the upper face of the breech ring and is dogged to the crank. It is hollowed to receive the sleeve, which moves freely within it.

ii. The *L.B.M. retaining catch* is shaped to conform with the handle of the L.B.M., within which it is pivoted by means of a removable axis pin. The end of its lower arm has a stop which engages a recess in the top face of the breech ring, and a stepped projection, which is engaged by an inclined stop on the outer cover, to release the catch when the breech is opened semi-automatically. The catch is held in the engaged position by a small spring which forces the upper arm forward ; when the upper arm is pressed into the handle the catch is released.

iii. The *sleeve* rotates freely within the hollow shaft of the L.B.M. Internally it is splined to the actuating shaft, and an external groove receives the inner end of the opening spring.

iv. The *opening spring* is housed in the casing portion of the L.B.M. Its outer end is anchored in a groove in the latter and its inner end in a groove in the sleeve.

v. The *inner cover* is a circular plate with a central hollow boss. A projection on its edge moves within a recess in the casing portion of the L.B.M. The hollow boss is splined internally to the actuating shaft, and grooved externally to receive the inner end of the closing spring.

vi. The *closing spring case* is a flanged circular plate. It is bored centrally to receive the boss of the inner cover which moves freely within it. The flange is grooved to receive the outer end of the closing spring, and an external projection on it engages a stop inside the outer cover. A double projection on the edge of the case engages the closing spring case retaining catch at semi-automatic, so that the closing spring case is prevented from moving in either direction. Another projection on the edge engages the closing spring case retaining catch when the mechanism is being dismantled.

vii. The *closing spring* is housed in the closing spring case, to the flange of which its outer end is anchored. Its inner end is anchored to the boss of the inner cover.

viii. The *outer cover* is cup-shaped and forms a top covering for the breech mechanism. It is splined to the actuating shaft which passes through its centre and is secured outside it by a collar and split pin. An internal stop engages an external projection on the flange of the closing spring case. An inclined projection on the edge disengages the L.B.M. when the breech is opened semi-automatically.

ix. The *actuating shaft* runs through the breech ring from top to bottom. At the top it is secured, on the outside of the outer cover, by a collar and split pin. It is splined for about a quarter of its length to fit the outer cover, the inner cover and the sleeve. Below the sleeve it is cylindrical, (passing through the shaft of the L.B.M. and the crank) until it passes through the lower face of the breech ring, when it is splined to the operating lever.

x. The *operating lever* is splined to the actuating shaft on the lower face of the breech ring. On run-out it is rotated by a curved lever on the cradle.

5. Action of the mechanism

i. *To open the breech*

(*a*) *By hand. Closing spring case retaining catch in the disengaged position.*

Grasp the L.B.M. ; release the retaining catch and rotate L.B.M. as far as it will go in a clockwise direction. During this movement the crank, which is dogged to the lever, rotates and pulls the breech block to the right into the open position, when the extractors revolve through engagement by the breech block and the hooked projections engage and retain the breech block.

The crank also engages and rotates the cocking lever to cock the striker. The first movement of the crank releases the safety catch operating plunger which, under action of its spring, rotates the safety catch in the striker recess.

The inner cover is rotated by the L.B.M., and the cover rotates the actuating shaft, so rotating *en bloc* the springs and fitments attached.

(*b*) *By hand (second method). Closing spring case retaining catch in the engaged position.*

Open the breech as described above. The differences are :—

(1) A strong pull is necessary.

(2) The closing spring case cannot revolve, so that the inner cover winds up the closing spring, until the breech block is held by the extractors.

(*c*) *Automatic. Closing spring case retaining catch in the disengaged position.*

On recoil, the actuating shaft operating lever rides over a spring-operated curved lever on the cradle. On run-out, the operating lever engages the curved lever and is rotated, so rotating the actuating shaft. The L.B.M. is held in the closed position by its catch.

The actuating shaft rotates the sleeve inside the L.B.M., so winding up the opening spring. It also rotates the inner cover inside the L.B.M. The inclined projection on the outside of the outer cover rides under the stepped projection of the breech mechanism retaining catch, thus allowing the L.B.M. to be rotated to the open position under the influence of the opening spring. At the same time the projecting stop on the inner cover rides round in the L.B.M. to the end of the recess.

The L.B.M. rotates the crank, the action being as described in (*a*) above.

(*d*) *Automatic (second method). Closing spring case retaining catch in the engaged position.*

On recoil, the actuating shaft operating lever functions as in (*c*) above.

The L.B.M. is held in the closed position by its catch, and the closing spring case is held by the closing spring case retaining catch.

The actuating shaft rotates the sleeve inside the L.B.M., thus winding up the opening spring. It rotates the inner cover inside the L.B.M., winding up the closing spring. It rotates the outer cover till the inclined projection on the outside of the outer cover rides under the stepped projection of the breech mechanism retaining catch, thus allowing the L.B.M. to be rotated to the open position under the influence of the opening spring. At the same time the projecting stop on the inner cover rides round in the L.B.M. to the end of the recess.

The L.B.M. rotates the crank, the action being as described in (*a*) above.

ii. *To close the breech.*

(*a*) *By hand. Closing spring case retaining catch in the disengaged position.*

Release the extractors by loading a cartridge, or by rotating the extractor releasing lever. Rotate the L.B.M. to the closed position. The L.B.M. rotates the crank, which forces the breech block to the left into the closed position. The final movement of the crank forces down the safety catch operating plunger (compressing its spring), and rotates the safety catch clear of the striker in the striker recess. The L.B.M. is secured in the closed position by its catch entering the recess in the breech ring.

The opening spring rotates the sleeve which rotates the actuating shaft, carrying with it the springs and fitments. This action only applies to hand closing and not to (*b*) below.

(*b*) *Automatic. Closing spring case retaining catch in the engaged position.*

On releasing the extractors by loading a cartridge, or by rotating the extractor releasing lever, the closing spring reasserts itself and rotates the inner cover. This action rotates the L.B.M. to the closed position, where it is secured by its catch. The L.B.M. rotates the crank, which forces the breech block to the left into the closed position ; the safety catch is operated as in (*a*) above.

The inner cover also rotates the actuating shaft. The actuating shaft rotates the sleeve and opening spring with the L.B.M. ; it also rotates the outer cover, the projecting stop inside the latter engaging with that on the closing spring case.

6. To assemble the breech mechanism

Assembling the safety catch.—Place the positioning pin in the right end of the breech block and the safety catch operating plunger with spring vertically in position, engaging the flat on the plunger with that on the pin. Force the plunger down as far as it will go, and insert the safety catch in the right end of the block and release the plunger.

Assembling the trigger.—Place the sear and spring in the hole underneath the breech block by inserting them through the cocking lever hole in the top of the block. Force the sear downward, insert the trigger from the left of the block, and then release the sear.

Assemble the cocking lever in the upper side of the breech block and rotate it so that the projection on the lever rides in the under cut groove in the block.

Assembling the automatic mechanism.—Place the sleeve in position in the centre of the L.B.M.; assemble the opening spring by anchoring it to the sleeve and L.B.M. Place the L.B.M. spring and sleeve on the upper end of the actuating shaft. Place the shaft in position in the breech ring and attach the actuating shaft operating lever, thus preventing the shaft from turning. Place the inner cover on the upper end of the shaft; rotate the L.B.M. in an anti-clockwise direction until the inner cover can be pressed down into the semi-circular recess in the L.B.M. Release L.B.M.; the spring is now held in compression.

Place the closing spring case on the shaft and assemble the closing spring, anchoring one end in the inner cover and the other in the closing spring case. Raise the closing spring case retaining catch, so that the small projection on the closing spring case engages the right of the retaining catch. Rotate the L.B.M. in a clockwise direction until the outer cover can be placed in position to retain the spring, push down the outer cover, and secure it to the shaft by means of the collar and keep pin; the closing spring is now in compression. Release the retaining catch.

Insert the breech block into the breech ring from the right. Remove the actuating shaft operating lever and raise the actuating shaft until the crank can be assembled, ensuring that the crank engages the breech block, and secure it by lowering the shaft, the dogs engaging with the L.B.M. in the open position. Replace the actuating shaft operating lever.

Place the extractors in position, and close the breech until the assembly line on top of the block is flush with the breech ring.

Insert the extractor releasing lever and fully close the breech. Secure the extractor releasing lever by rotating the stop block on top of the breech ring.

Place the actuating shaft operating lever on the lower end of the shaft and secure it with its pin.

Place the safe and fire lever in the central hole on the top of the breech ring, with the assembly lines coinciding, and rotate the lever to " FIRE."

Place the striker and main spring in position, rotate the trigger, force in the striker cover and rotate it until it is locked by being forced into its bayonet joint by the main spring. The breech must be closed during assembly to prevent engagement by the cocking lever and the safety catch.

7. To dismantle the breech mechanism

The breech mechanism should be dismantled in the reverse order.

8. The mounting

The mounting has a platform which rests squarely on the ground when in the firing position. Four pickets are provided to stabilize the platform.

For transport a four-wheeled carriage is attached to the platform which is raised and lowered by winches. Knorr air pressure brakes are actuated from the towing vehicle. There is an emergency hand brake on the carriage.

The *platform* has four legs. The side legs fold up and are secured by stays and chains to the body during transport. They are secured by " D " pins when in the firing position. Raising screws support the outer ends of the legs on uneven ground and level the platform approximately. There are levelling bubbles on the left and rear legs. Trunnions on the front and rear legs fit in supporting hooks on the carriage and limber, and receive the hooks on the elevating chains.

The *pedestal* is secured to the platform and supports a gimbal ring.

The *gimbal ring* supports a body pivot housing and facilitates cross-levelling.

The *body pivot housing* is capable of being rocked in the gimbal ring by the cross-levelling gear and may be depressed 5 degrees in any direction by rotating the two cross-levelling gear handwheels on the platform. By this means the pivot is made vertically upright. This is necessary for accurate laying when indirect laying for elevation is used.

The *body* rotates horizontally in the housing. It carries the elevating, traversing, and sighting gears on the right side, and a supporting bracket for the fuze setting machine on the left side.

Various cables for the fuze setting machine and receiver dials pass through the centre from the rear leg of the platform.

The *cradle* pivots on trunnions in the body. The right trunnion supports a quadrant elevation reader arm and a sight reader arm ; the former is clamped, the latter free to rotate. It also supports the buffer, cut-off gear, packing tightening rod, recuperator, firing gear (which may be operated from

either side), loading tray, and power rammer. A recoil indicator is fitted to the right side. A dial sight carrier is fitted on top of the recuperator cylinder.

Compensators are fitted to the body and cradle to counter-balance muzzle preponderance. They contain three springs which press against a piston. Each compensator takes a load of 2,800 Kgs. (2·75 tons) at 8 degrees elevation. They should be so adjusted that the elevating gear works easily when elevating or depressing.

The shield has an aperture on the right side opposite the sight. The aperture cover is rotated clear by releasing a plunger and raising the cover, which is retained by a spring-loaded catch.

A small aperture is provided in the cover to enable the layer to observe when the sight is horizontal.

The *elevating gear* has a spring-operated catch to change gear ; one revolution of the hand-wheel is equivalent to 1 degree in slow gear or 2 degrees in fast gear. A clutch is incorporated to declutch the gear when travelling. This clutch can only be operated when the gun is at 0 degrees elevation.

The *traversing gear* has a spring-operated catch to change gear ; one revolution of the hand-wheel is equivalent to 1·8 degrees in slow gear or 3·6 degrees in fast gear. A stop prevents more than two complete revolutions to the right or left and ensures that the cables are not damaged by twisting. A plate indicates revolutions from zero, " L " and " R " and the word " MÜNDUNG " being engraved on it.

Note.—The indicator and the position of the stop must agree when the gear is being assembled. The graduations on the graduated ring on the body pivot housing are in mils, marked off in 10's to 6,400 and numbered in 100's (6,400 mils. =360 degrees).

The *Q.E., bearing, and fuze receivers* are connected electrically to the predictor, normally Kommandogerät 36. Each receiver dial at the gun—whether for bearing, angle or fuze—is provided with three mechanical pointers pivoted centrally on the dial. There are three circles, each with ten holes numbered 0 to 9, each fitted with a small bulb. The outer circle represents units, the centre 10's and the inner circle 100's. The appropriate bulb lights up in accordance with the data transmitted from the predictor. The two gun layers and the fuze-setter bring their mechanical pointers into coincidence (covering the illuminated bulbs with the transparent celluloid ends of

the pointers) by operating the traverse and elevation handwheels on the gun and the fuze setting handwheels on the fuze setting machine. The gun is then correctly laid and the correct fuze set.

The units (i.e. on the outer circle) have the following values for each of the different receivers :—

Bearing receiver 0·36 degrees.

Elevation receiver 0·10 degrees.

Fuze 0·5 degrees.

It should be noted that the German fuze scale reads from 0 to 350 degrees. 0·5 is therefore approximately equivalent to ·05 of a British fuze length.

9. Recoil system

The recoil system comprises a hydraulic buffer and a hydro-pneumatic recuperator. A cut-off gear, operated when the gun is elevated, automatically controls the flow space through the piston head.

The buffer is connected to a lug underneath the breech ring. It is filled with buffer fluid—10·7 litres (18·8 pints). If the buffer becomes warm, some of the fluid may overflow into the fluid compensating chamber in the cylinder head where are the filling, air, and emptying holes. There are three holes on the top front side of the head ; the two on the right are for filling and air, while that on the left is to fill a small chamber in which a spring-loaded valve is operated by the head of the piston on final run-out. The drain hole is underneath the head. A cover is secured over the front of the head.

The packing for the stuffing box is tightened by a wrench applied on the square end of a rod inside the cradle at the rear end.

The cut-off gear operating rod is attached to the cradle balancing spring connector on the right of the cradle and may be adjusted for length by a nut, so adjusting the cut-off gear.

The recuperator is connected to a lug on top of the breech ring. The contents of the recuperator consist of approximately 20 litres of air under 39 ats. (573 lb. per sq. in.) pressure and 19 litres of fluid (4½ gals.). Three holes on the rear end of the cylinder are for charging ; two for fluid and air escape, one for charging with air.

The length of recoil is 1,050 mm. (41·34 in.) at 0 degrees elevation and 850 mm. (33·46 in.) at 25 degrees elevation. Time of recoil is approximately 1-5th second.

10. The rammer

The automatic rammer consists of the actuating mechanisms, return cylinder, and loading tray. The internal construction of the return cylinder resembles that of the recuperator. Its contents are approximately 1 litre of fluid and 1 litre of air under 15 atms. (220 lb. per sq. in.) pressure.

Before the first round is fired, the rammer must be brought back by hand by means of the lever. The round, which is placed on the loading tray, is forced into the breech by the rammer by means of the lever until the rim of the cartridge operates the extractors and the breech is closed. As soon as the round has left the loading tray, the loading number swings the loading tray clear and fires simultaneously by doing so, if the cam is at " automatic." If the cam is at " hand," the gun is fired by the firing lever operated by hand.

The rammer is cocked again on recoil as the pawl on the barrel causes the return cylinder to travel back with it.

11. Fuze setter

The automatic fuze setter consisting of two setting cups, a flywheel, an electrical receiver dial with mechanical pointers, a circular scale for fuze readings, and an indicator window fitted to the left side of the body. The flywheel is rotated continuously, thus providing power for setting the fuze, and the data shown on the dial are matched by the mechanical pointers. A white disc appears at the indicator window to show that the round has been properly set.

12. Telescopic sight. (*See* Fig. 18)

The latest mark of telescopic sight used for direct fire is the ZF. 20E. This sight is of the monocular type and is secured to the sight bracket by two studs and a screw. It has a field of view of 17·5 degrees, and a magnification of x 4. The graticule consists of two cross lines interrupted in the centre with the apex of an inverted V in the middle. The distance between the ends of the thin cross lines is equal to 20 mils, and between the thick ends 80 mils.

On the sight are :—

i. *A range drum* graduated in 100 metre (109 yds.) steps from 0 to 9,400 metres (10,340 yds.). From 0 to 7,000 metres (7,700 yds.) every 500 metres (550 yds.) is numbered, and from 7,000 to 9,400 metres every 200 metres (220 yds.) is numbered.

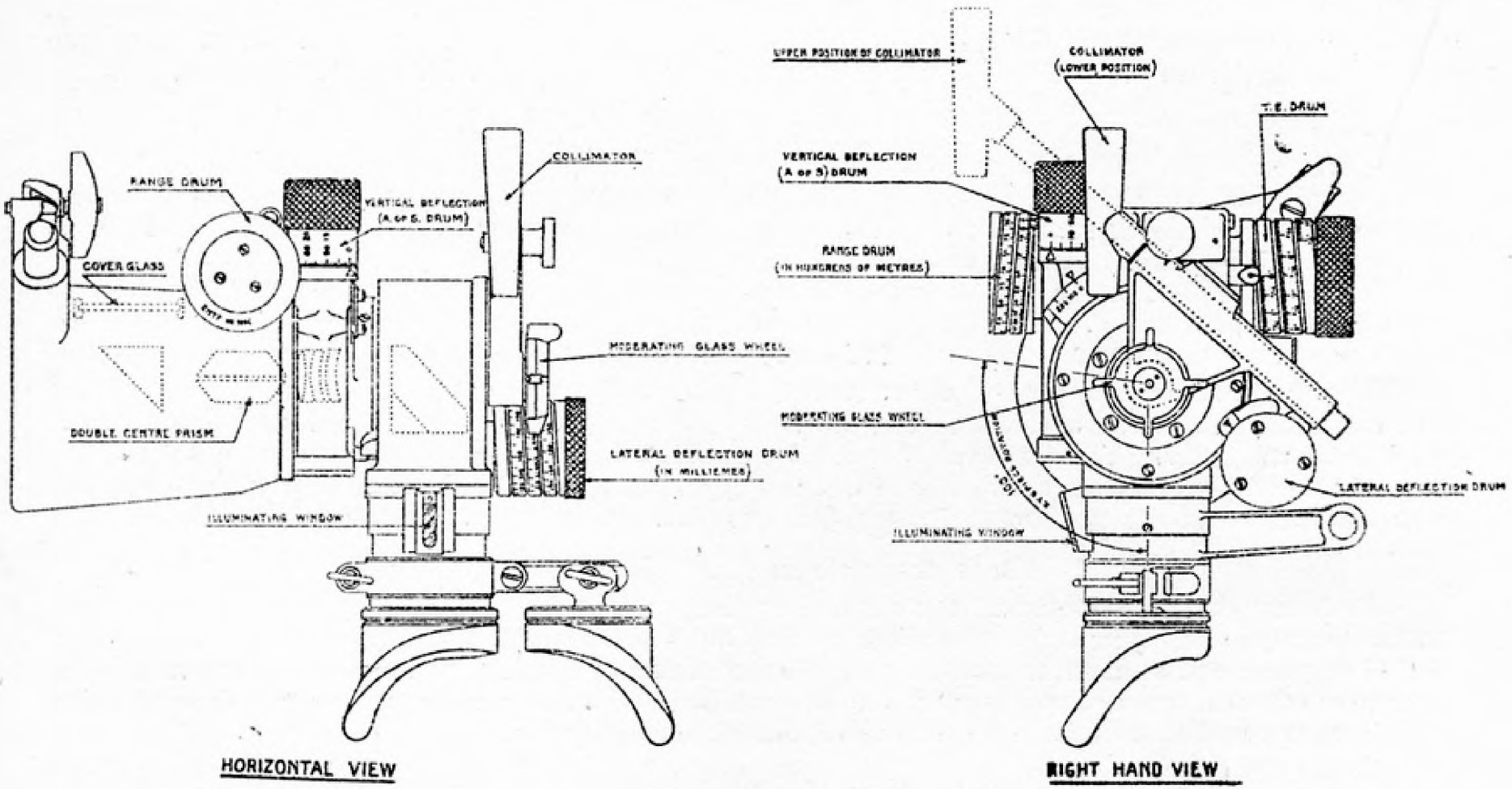


FIG. 18.—8·8 CM. (3·46 IN.) MULTI-PURPOSE GUN (8·8 CM. FLAK 36). TELESCOPIC SIGHT ZF. 20E

ii. *A tangent elevation drum* marked in 1-16th degrees from 0 to 12 degrees, and numbered every $\frac{8}{16}$ degree ($\frac{1}{16}$ degree is equal to about 4 minutes).

iii. *An angle of sight or vertical deflection drum* graduated in hundreds of mils from 0 to 200 either side of zero. The red graduations are for angles of depression. The micrometer drum is graduated in mils and numbered every 10 from 0 to 100. Increase in elevation is set on the black figures, depression on the red.

iv. *A lateral deflection drum* graduated every 5 mils and numbered every 10 mils from 0 to 250 right and left. The red graduations (marked " LINKS ") take the gun to the left, and the black (marked " RECHTS ") take the gun to the right.

The sight is set up on the right side of the gun on a mounting carried by the cradle graduated from 0 degrees to 80 degrees. An increase in range on the sight brings the graticule back to the target. As the sight mounting turns, a link moves an arm pivoted on the right gun trunnion.

Another arm is pivoted on the same trunnion and is fixed to the gun trunnion itself. When this arm is brought in coincidence with the first one the gun is laid in elevation. The layer has the traversing wheel on his left. This has two gears (slow and quick) actuated by two dogs, a lever in the handwheel being used for change of gear. The elevating handwheel, operated by another gun number, also has two gears.

Anti-tank use of the sight

The angle of sight drum and scale are set at zero and the target is engaged using the range drum for range and the graticule for leads (from the end of the thin graticule line to the point of the V is equal to a lead of " one "). Corrections are made from observation of tracer.

There is an older mark of sight, the ZF. 20, which has no range drum. In this case, the detachment commander has to memorize the T.E. of a certain number of round ranges. These need only differ by large amounts such as 500 owing to the gun's very flat trajectory.

13. Detachment

i. *Engagement of aerial targets*

The German detachment for anti-aircraft action consists of a detachment commander and nine men. Their duties are as follows :—

Detachment commander.
No. **1**—Layer for elevation.
No. **2**—Layer for line.
No. **3**—Loading and firing number.
No. **4**, No. **5** } Ammunition numbers.
No. **6** Fuze setter.
No. **7**, No. **8**, No. **9** } Ammunition numbers.

ii. *Engagement of ground targets*

For the engagement of ground targets, the duties of the German gun detachment are as follows :—

Detachment commander.
No. **1**—Layer for elevation.
No. **2**—Layer for line.
No. **3**—Loading and firing number.
No. **4**, No. **5**, No. **6**, No. **7** } Ammunition numbers.
No. **8** Range setter.
No. **9** Lateral deflection setter.

The following drill will be used by British troops :—

The detachment consists of nine men :—

1. In command.
2. Layer for line. Sight operator at gun control.
3. Layer for elevation.
4. Fuze dial operator (with M.F.S.) fuze setter (without M.F.S.).
5, 6, 7. Loading and firing numbers.
8. Fuze setter operator (with M.F.S.) F.F. board reader (without M.F.S.).
9. Second in command, i/c ammunition supply.

(*a*) *To come into action*

S.L. : " Action."

1 places himself so that he can see when his gun is in the required position, and where he can be seen by the tractor driver. He then orders : " Halt. Action."

The detachment dismount.

1 disconnects the brake gear from the tractor.

2 applies the hand brake.

8 and **9** support the engine draught connector.

After he has disconnected the brake gear, **1** orders " Clear."

8 and **9** release the towing hook.

1 orders " Drive on." The tractor advances **5** yards and halts.

8 supports the engine draught connector, while **9** makes it rigid by means of the pin provided.

4 and **6** go to the right gun leg, **5** and **7** to the left gun leg.

6 and **7** disconnect the safety chains and house them on the brackets on the mounting. They withdraw the spring-loaded plungers of the tie rods. The legs are then lowered to the horizontal position. **6** and **7** lock the legs in position by turning the locking levers through 180 degrees.

2 and **3** take post on the rear carriage.

8 and **9** on the fore carriage.

3 and **8** unlock the winch handles.

2, 3, 8, and **9** operate their winches in the "Raise" direction, until the weight of the mounting is being supported on the chains. They release the spring-loaded plungers of the trail hooks, and disconnect the hooks by pulling upwards on the levers ensuring that the plungers re-engage.

1 orders " Lower."

2, 3, 8, and **9** operate their winches in the " Lower " direction until the platform is resting on the ground and the chains are slack. **4** on the rear end and **7** on the front disengage the chains from the platform, directing the winch operators as necessary.

2 releases the hand brake.

2, 3, 4, and **5** tilt the rear carriage, **6, 7, 8,** and **9** tilt the fore carriage to disengage the supporting hooks from the rings on the platform. They wheel the carriages 5 yards clear of the mounting.

4, 5, 6, and **7** take post on the rear, left, right and front jacks respectively.

Under the orders of **1,** the platform is roughly levelled.

4, 5, 6, and **7** each obtain a picket. They place them in their respective leg or girder, and drive them into the ground.

8 removes the muzzle cover.

2 opens the armoured shutter in the shield.

9 releases the muzzle supporting stay.

3 elevates the gun to 40 degrees.

9 lowers the stay to the firing position.

2 raises his seat to the firing position, and traverses the gun through 180 degrees.

He places his telescope in position.

2 and **3** take post on the right and left levelling handwheels respectively.

They operate their handwheels until their levelling bubbles are in the centre of their run.

1 removes the breech cover and opens breech.

5, 6, 7, 8, and **9** remove stores and ammunition from the tractor and prepare ammunition.

9 orders " Drive On " and the tractor proceeds to the wagon line.

5, 6, and **7** put on their loading gloves.

The detachment take post.

1 reports " No. ..... Ready for Action."

(*b*) *Cease firing*

G.P.O.: " Unload."

G.P.O.: " Cease firing."

2 and **3** take post on the right and left levelling handwheels. Under the orders of **1** they operate their handwheels until the mounting is approximately level with the platform.

2 traverses the gun until the muzzle is over the travelling position. He lowers his seat to the travelling position and removes his telescope. He closes the armoured shutter in the shield.

5, 6, and **7** remove their loading gloves.

1 signals the tractor to approach the gun position.

5, 6, 7, 8, and **9** if necessary reset fuzes to " Safe," replace the ammunition and close the boxes. They replace ammunition and stores in the tractor.

2 and **3** at the rear, **4** at the right, **5** and **7** at the left, and **8** and **9** at the front remove the pickets.

3, 5, 6, and **8** replace the pickets on the bracket provided.

1 closes the breech and replaces the breech cover.

9 swings the muzzle supporting stay into the travelling position.

3 depresses the gun on to the stay.

9 clamps the gun in the travelling position.

8 replaces the muzzle cover.

4, 5, 6, and **7** take post on their jacks. They operate their jacks until the pads are in the fully raised position.

2, 3, 4, and **5** wheel the rear carriage into position.

6, 7, 8, and **9** wheel the fore carriage into position. They tilt the carriages and ensure that the supporting hooks engage with the rings on the platform.

4 on the rear, **7** on the front connect the lifting chains to the platform, directing **2** and **3,** and **8** and **9** to operate their winches as necessary until the chains are taut.

2 applies the hand brake.

1 orders " Raise."

2, 3, 8, and 9 operate their winches in the " Raise " direction until the mounting is in the fully raised position, **1** stopping the operation of one winch if it gets in advance of the other.

2, 3, 8, and **9** release the spring-loaded plunger of the trail hooks, and connect the hooks by pushing the levers downwards until the plungers re-engage. They operate their winches in the "Lower" direction until the chains are slack.

3 and **8** lock the winch handles.

6 and **7** unlock the gun legs by turning the locking levers through 180 degrees.

4 and **6** raise the right gun leg.

5 and **7** raise the left gun leg into the travelling position.

6 and **7** connect the legs to the tie rods by means of the spring plunger, and place the safety chains into position. If possible they assist **2, 3, 8,** and **9** in raising the platform, **4** and **5** at the rear, **6** and **7** at the front.

8 supports the engine draught connector.

9 removes the locking pin. They lift the draught connector and attach it to the tractor by placing the eye on the towing hook.

2 releases the hand brake.

1 connects the brake gear to the tractor.

The detachment mount.

(*c*) *Engagement of close targets* (*with M.F.S.*)

G.P.O. or No. **1** : "Plane—gun control."

No. **1** : "Fuze 25 (35)." (Equivalent approx. to F. 1.5 and 3 on Fuze 199.) He indicates the target to **2.**

6 and **7** each place a round in fuze setter.

8 turns the fuze setting handle, and continues to turn at a steady rate, thus continuously setting fuzes.

4 sets the pointers of the fuze receiver dial to the fuze ordered. (The fuze dial has three concentric rings, each with its individual pointer. The outer ring indicates units, the middle ring 10's and the inner ring 100's. To set F.25, therefore, **4** positions his pointers as follows:—outer ring to **5**, centre ring to **2**, inner ring to zero.)

5 withdraws a round from the fuze setter. He aligns the round with the axis of the bore, entering the head of the round in the chamber. He forces the round home and stands clear, grasping the firing handle.

9 sets the T.E. drum to $\frac{8}{16}$ degrees, thereby setting T.E. for approx. 1,500 yds. (The T.E. drum is the large drum below and at the front of the sight.) **2,** by means of the gun traversing handwheel and the sight elevation handwheel (on left below the sight holder) lays on the target and reports " On." He keeps the target in the centre of his field of view.

3 keeps the elevation pointers (at the right trunnion) matched, and reports " On target."

1 estimates vertical and lateral deflection. He orders vertical deflection to **9**, who sets it on the vertical deflection drum and reports " Up (Down)—Set." (The vertical deflection drum is the small drum on top of the sight. It is graduated in mils. To set an Up deflection, black figures are used, red figures give a Down deflection. Thus " Up 2," **9** sets 40 black.)

1 sets the lateral deflection on the lateral deflection drum—at the right of the sight. (This drum is also graduated in mils, marked in black figures " Rechts " (Right) and red figures " Links " (Left). Thus—" Left 6," **1** sets 120 red.)

1 orders " No.— Fire."

5 fires the gun. He continues to load and fire as fast as possible, obtaining rounds from the m.f.s. **6** and **7** keep the m.f.s. supplied with ammunition. The drill continues until " Cease loading " or " Stop " is ordered.

1 orders fresh vertical deflections to **9** and fresh fuzes as necessary. He sets fresh lateral deflections as necessary, estimating corrections from observation of fire.

(*d*) *Engagement of close targets* (*without M.F.S.*)

G.P.O. or No. **1** : " Plane. Gun control."

No. **1** : " Fuze 25 (35)." He indicates the target to **2.**

4 positions himself in rear of gun with a fuze key, kneeling on his right knee.

5 obtains a round and places it between **4's** left arm and thigh.

6 obtains a round.

8 assists with ammunition and removes fuze covers.

4, with his fuze key, sets the fuze to the setting ordered by **1**, and reports " Set."

5 removes the round, right hand at the base of the cartridge case, left hand at the point of balance. He aligns the round with the axis of the bore, entering the head of the round in the chamber. He forces the round home and stands clear, grasping the firing handle.

6 places his round between **4's** left arm and thigh.

7 obtains a round.

9 sets the T.E. drum to 8/16 degrees.

2, by means of the gun traversing handle and the sight elevation handwheel, lays on the target and reports " On." He keeps the target in the centre of his field of view.

3 keeps the elevation pointers matched and reports " On target."

1 estimates vertical and lateral deflection. He orders vertical deflection to **9**, who sets it on the vertical deflection drum and reports " Up (Down)—Set."

1 sets the lateral deflection on the lateral deflection drum.

1 orders " No. — Fire."

5 fires the gun. The gun is loaded and fired by **5, 6**, and **7** at its maximum rate of fire until " Cease loading " or " Stop " is ordered.

1 estimates corrections from observation of fire. He orders fresh vertical deflections to **9**, fresh fuzes to **4** and sets fresh lateral deflections as necessary.

Notes.—If the breech fails to close when the first round is loaded, **5** closes it by means of the L.B.M. He withdraws the spring plunger on the top right of the rear face of the breech ring, and sets the projecting stop to the outward position.

The wiring of the gun allows for only 720 degrees traverse from the central position. After each engagement, **2** traverses the gun to the central position as indicated by the pointer below the sight holder.

No. F.F.C. is necessary for the engagement of close targets.

(*e*) *The sight* (*anti-tank fire*)

The sight gun number sits behind the sight having the traversing handwheel to the left.

For ground targets :—

The vertical deflection drum (top right) should be set at zero.

The range in tangent elevation set in degrees and one-sixteenths (drum bottom centre), as ordered by the detachment commander, or in metres on drum top left (on ZF. 20 E. only).

The deflection, if large, is set in mils on the drum (right end of sight)—Red graduations bring the piece over to the left.

30 minutes equal roughly 10 mils—lead of 1.

1 degree equals roughly 20 mils—lead of 2.

The graticule has two cross lines, thicker at outer ends of diameter, thinner towards the centre. They stop short of the centre, which is marked by an inverted V. Interval between thin ends of two lines :—20 mils=1 degree and between the thick ends 80 mils=4 degrees.

Examples of leads are shown in Fig. 19. The leads required are small at short ranges, about a half for a direct crosser at 10 m.p.h. and one for 20 m.p.h.

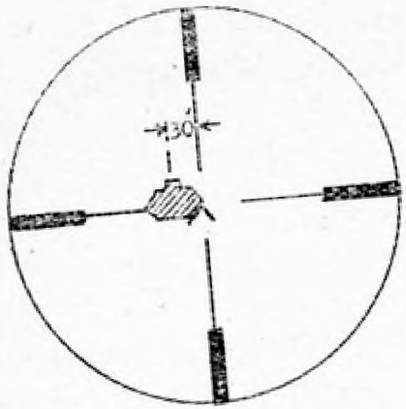
The trajectory being flat, alterations in range need not be less than 200 at short ranges.

Setting an increased range on the T.E. drum lowers the horizontal line of the graticule. To bring the graticule back on the target, the " sight number " turns the small crank handle of the sight bracket (*see* Fig. 19). This itself turns and by means of a link brings forward a large pointer pivoted on the sight cradle trunnion. Another large pointer follows the cradle itself in its movements.

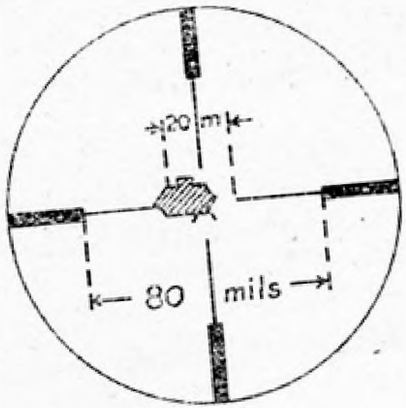
By making both pointers coincide, the gun is laid for elevation.

Both the traversing and elevating handwheel have a slow and fast gear.

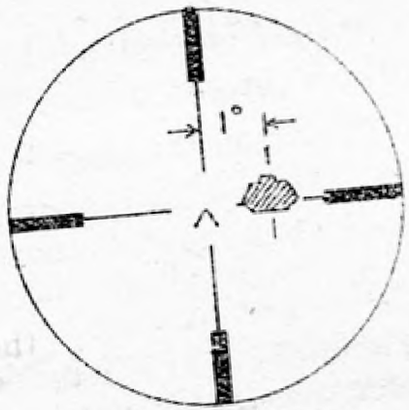
A lever can be moved to engage the corresponding dogs.



RIGHT ONE



RIGHT A HALF



LEFT TWO

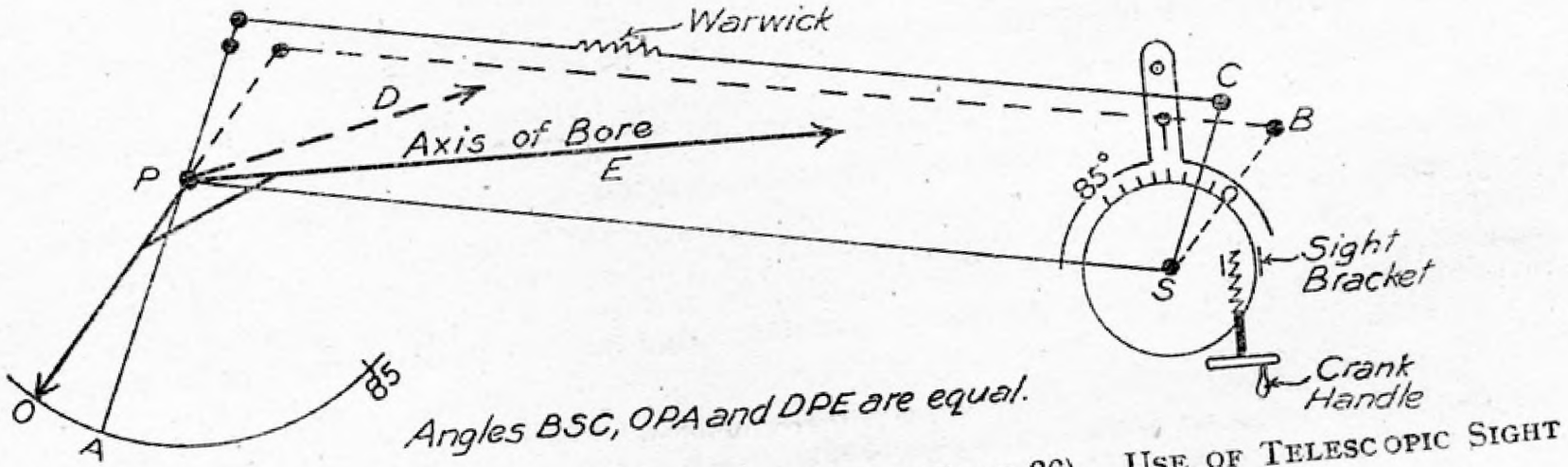


FIG. 19.—8·8 CM. (3·46 IN.) MULTI-PURPOSE GUN (8·8 CM. FLAK 36). USE OF TELESCOPIC SIGHT ZF.20 E

(*f*) *Sequence of operations.*—TANK ALERT has been given and the gun is loaded.

Detachment commander	Sight No.	Elevation No.	Loader	Ammunition No.
Target ! Slow left ! $\frac{9}{18}$ths ! Right a half ! On ! Fire !	Sets the range (having verified that the vertical deflection drum is at zero). Traverses and follows the target. Reports "On" when laid.	Brings the pointers in coincidence and follows. He fires at the report "On" from the sight number providing the pointers coincide.	Prepares to load the gun again.	Removes loading tray.
Corrects lead and range.	etc.			

A spare gun number could set the T.E. as this facilitates quick laying.

When " on target " the slow gear should be used as the quick gear is practically " free traverse " and the gun is liable to move off target.

III.—10·5 cm. (4·14 in.) Gun-Howitzer (10·5 cm. 1. F.H. 18)

(*See* Figs. 20-26)

1. General

The 10·5 cm. 1.F.H.18 (*see* Fig. 20) was introduced prior to 1939 as a standard German divisional artillery weapon, and is comparable to the British 25-pounder. It fires H.E. with either percussion or T & P fuzes, A.P. shell, A.P.C.B.C. shell, a hollow charge shell and smoke shell.

British users have found that the equipment is easy to handle both in and out of action, and that the carriage is very steady. Laying is smooth and easy, and definitely good against tanks or moving targets. Recent models of the gun have been fitted with muzzle-brakes.

The gun is normally drawn by a half-tracked tractor, but may also be horse-drawn.

A range table for use with the H.E. shell is attached at Appendix G, and a range table for use with the hollow charge shell is at Appendix H.

2. Data

i. *Ballistic particulars.*—H.E. shell (32·6 lb.) with percussion fuze A.Z.23.

Charge	M.V. (f.s.)	Max. range (yards)	Time of flight (secs.)	50 per cent. zone		Drift (mils)
				Length (yards)	Breadth (yards)	
I	656	3,910	26·6	131	10	29
II	761	5,060	30·2	112	7	29
III	866	6,290	34·4	96	10	28
IV	1,040	8,310	39·8	55	15	28
V	1,283	10,010	43·8	46	14	28
VI	1,542	11,670	48·9	59	9	29

To face page 48

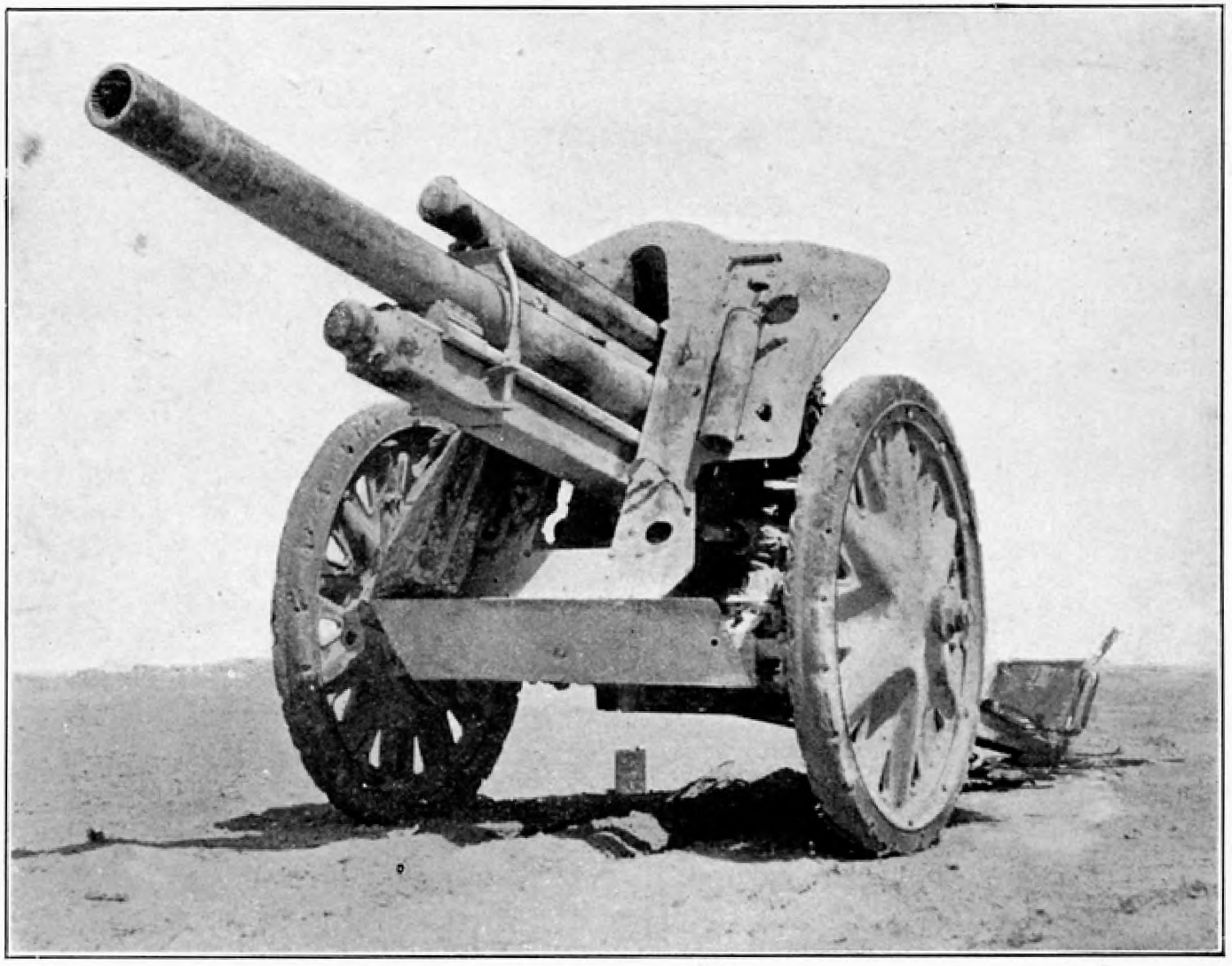


FIG. 20.—10·5 CM. (4·14 IN.) GUN-HOWITZER (10·5 CM. 1.F.H.18)

ii. *Gun and carriage*

Weight of complete equipment	38½ cwt.
Weight of the piece	10¼ cwt.
Calibre	10·49 cm. (4·13 ins.)
Length of piece (including breech ring)	106·8 ins. (25·7 cals.)
Length of bore	94·2 ins. (22·8 cals.)
Rifling	32 grooves.
Twist of rifling	6°–12°.
Length of chamber	8·35 ins.
Volume of chamber	134·25 cu. ins.
Max. elevation	40° 30′ (1 turn handwheel=45 mins.)
Max. depression	6° 30′
Traverse	56° (1 turn handwheel=15 mins.).
Normal recoil	43·3 ins.
Trunnion height	46·5 ins.

iii. *Ammunition.*—The 10·5 cm. 1.F.H. 18 fires the following types of ammunition :—

(*a*) *H.E. shell* (F.H. Gr. and F.H. Gr. 38 Stg.) :—

Length complete	49 cm.	19·29 ins.
Weight (fuzed)	14·81 kg.	32·6 lb.

This shell is filled with 3 lb. T.N.T., and is fitted with either a percussion fuze A.Z.23.v. (optional delay 0·25 secs.) or a time and percussion fuze Dopp.Z S/60. Another percussion fuze, A.Z. 23/42 (0·15) has recently been introduced. The shell is painted dark green and has a single driving band.

(*b*) *A.P. tracer shell* (10 cm. Pzgr.)

Length complete	29·2 cm.	11·5 ins.
Weight (fuzed)	14·25 kg.	31·25 lb.

This A.P. shell is fitted with a base fuze (Bd.Z.f.10 cm. Pzgr.), and is used to engage tanks up to 1,600 yards ; for this purpose charge 5 is used ; muzzle velocity is 1,295 ft. sec.

(*c*) *A.P.C.B.C. tracer shell* (10 cm. Pzgr. rot)

Length complete	44 cm.	17·32 ins.
Weight (fuzed)	15·71 kg.	34·6 lb.

This shell, which has both a piercing cap and a ballistic cap, is replacing the 10 cm. Pzgr. shell for the attack of tanks. It has a base fuze (Bd.Z.f.10 cm. Pzgr.) and is thought to be fired with charge 5.

(*d*) *Hollow charge shell* (10 cm. Granate 39 rot)

Length complete	36·83 cm.	14·5 ins.
Weight (fuzed)	11·76 kg.	25·9 lb.

This A.P. shell, which embodies the hollow charge principle, has a percussion (nose) fuze (A.Z.38), is fired with charge 5, and is used at ranges from 110 to 1,650 yards. The estimated performance of this shell is 80 mm. (3·15 in.) homogeneous armour at 30 degrees and 95 mm. (3·74 in.) homogeneous armour at normal.

There are also two other types of hollow charge shell, 10 cm. Gr.39 rot Hl.A and Hl.B. These are fired with charge 6, and a range table is given at Appendix H.

(*e*) *Smoke shell* (F.H.Gr.Nb)

Length complete	48·9 cm.	19·25 ins.
Weight (fuzed)	14 kg.	30·8 lb.
Weight of charge (containing oleum and pumice)	1·87 kg.	4·1 lb.

The smoke cloud formed on burst has a diameter of 80–100 ft.

(*f*) *Smoke shell* (F.H.Gr.38 Nb)

Weight (fuzed)	14·71 kg.	32·4 lb.

This shell is an improvement on F.H.Gr. Nb ; the smoke cloud formed on burst has a diameter of 100–130 ft. The fuze used with both smoke shells is a D.A. and graze fuze, kl.A.Z.23 Nb.

(*g*) A new shell (F.H. Gr.F.) has recently been introduced. It is presumably a H.E. shell, and is fired only by the l.F.H.18 with muzzle brake.

iv. *Penetration*

The following figures for penetration of homogeneous armour with the A.P.C.B.C. shell are estimated :—

Range (*yards*)	*Thickness of armour in mm.*	
	30 *degrees*	*Normal*
500	56 (2·20 ins.)	67 (2·64 ins.)
1,000	52 (2·05 ins.)	62·5 (2·46 ins.)
1,500	49 (1·93 ins.)	59 (2·32 ins.)

3. The breech mechanism (*See* Figs. 21-24)

i. *The breech block* is hand-operated and moves horizontally, protruding in the open position through an aperture in the right face of the breech ring.

The right face of the breech block consists of a plate slightly larger than the aperture in the breech ring, which, consequently, prevents the block from moving too far to the left when closing. There are two borings : one, roughly central, for the safe and fire shaft, the other, directly above the latter, for the firing plunger. A horizontal groove runs from the axis of the firing plunger boring to the front, and accommodates the firing lever with lanyard. The words " Feuer " (FIRE) and " Sicher " (SAFE) are stamped in red and black respectively beside the boring for the safe and fire shaft to show the positions of the latter.

The left face is shaped to fit the cartridge.

The lower face is grooved longitudinally to guide the movement of the block within the breech ring.

The upper face is similarly grooved. At the right front is a boring for the axis pin of the firing lever. To the left of this, from front to rear, is the actuating groove in which the toe of the crank moves ; at the rear end of the groove a cam-shaped crank stop is screwed. To the left of this groove

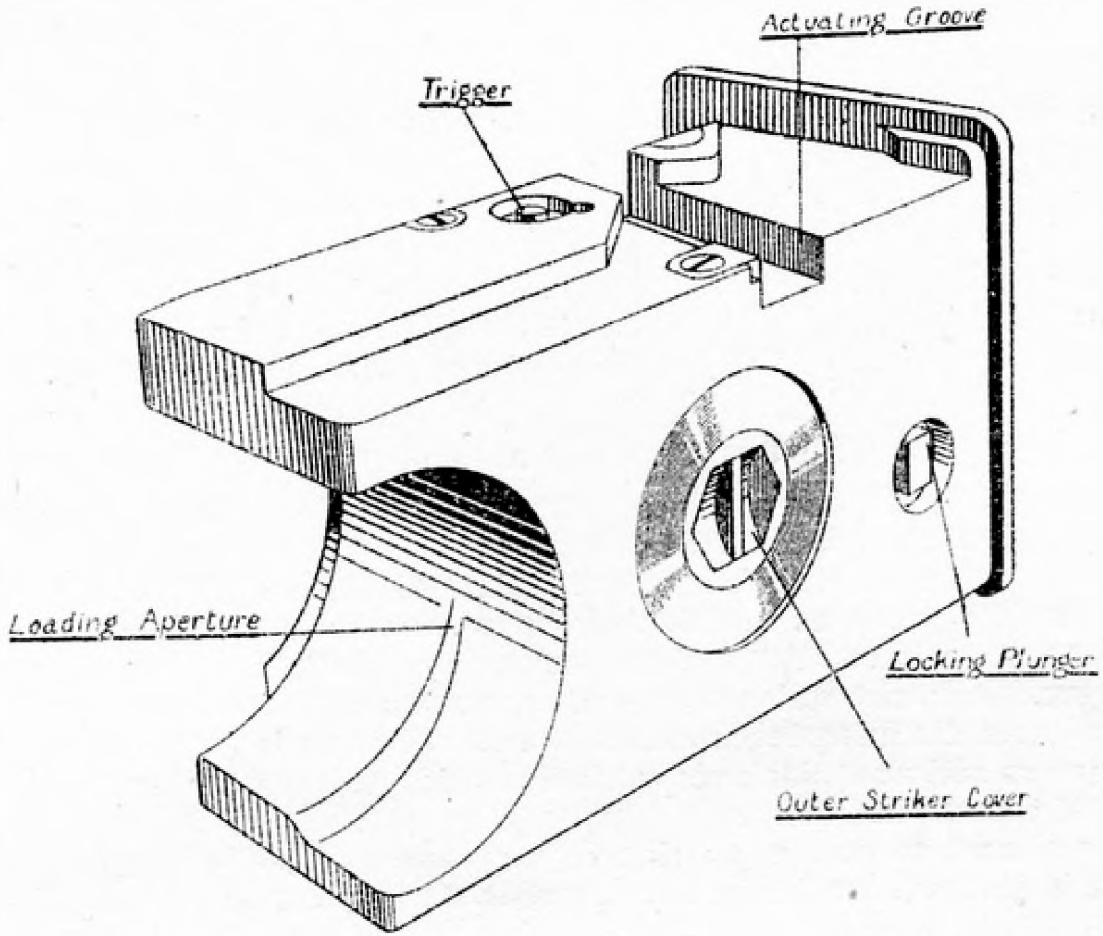


FIG. 21.—10·5 CM. (4·14 IN.) GUN-HOWITZER (10·5 CM. 1.F.H.18). BREECH BLOCK

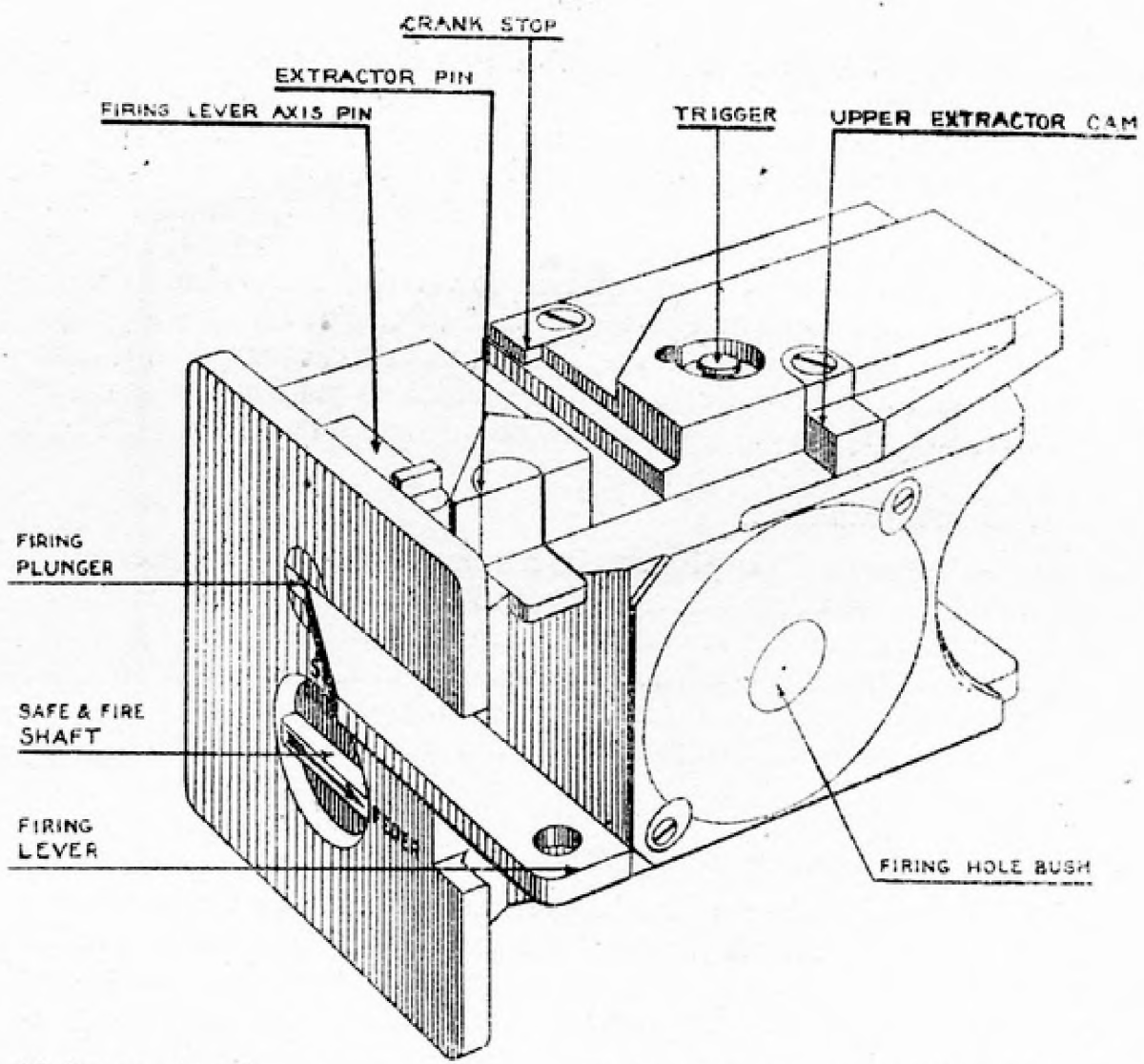


FIG. 22.—10·5 CM. (4·14 IN.) GUN-HOWITZER (10·5 CM. 1.F.H.18). BREECH BLOCK

a line is marked transversely as a guide for assembling the mechanism, and roughly in the centre of the face is a boring for the trigger.

The rear face has two borings ; a large central boring houses the striker, striker spring, and inner and outer covers. There is a smaller boring to the right of this for the spring-loaded breech block locking plunger.

The front face is slotted horizontally at top and bottom to form the extractor ways. Near the left end of the extractor ways are the upper and lower extractor cams which, by engaging the heels of the extractor, serve both to limit the movement of the block as it opens and to unseat and eject the cartridge. At the right, forming an extension of the extractor ways, is a removable extractor pin. The firing hole bush is fitted into a central plate which is held in a recess by two sunk washers secured by screws. The cartridge head space may be adjusted by placing shins beneath the plate.

ii. *The opening and closing mechanism.*

The L.B.M. is crank-shaped, and is pivoted in a removable bush at the right rear of the upper surface of the breech ring. A retaining catch is pivoted in the handle and engages, when the breech is closed, a stop at the front of the upper surface of the breech ring. The L.B.M. may be removed by turning it beyond the fully opened position ; a feather in the shaft of the L.B.M. then engages a feather way in the breech ring and the former may be withdrawn upwards. The crank fits at one end on to the squared shaft of the L.B.M. ; a toe at the other end moves in a transverse groove on the upper face of the breech block.

iii. *The cocking and firing mechanism* (*see* Figs. 23-24)

The firing lever is a roughly L-shaped bar, drilled at the outer end of each arm. The hole at the end of the shorter arm receives the axis pin on which the firing lever is pivoted. The other hole is for the attachment of the firing lanyard. The firing lever is so positioned in a groove in the right face of the breech block that its angle rests against the head of the firing plunger.

The firing plunger, which is spring-loaded, passes horizontally from the right face of the block to the trigger, a projection on which is engaged in a recess in the plunger.

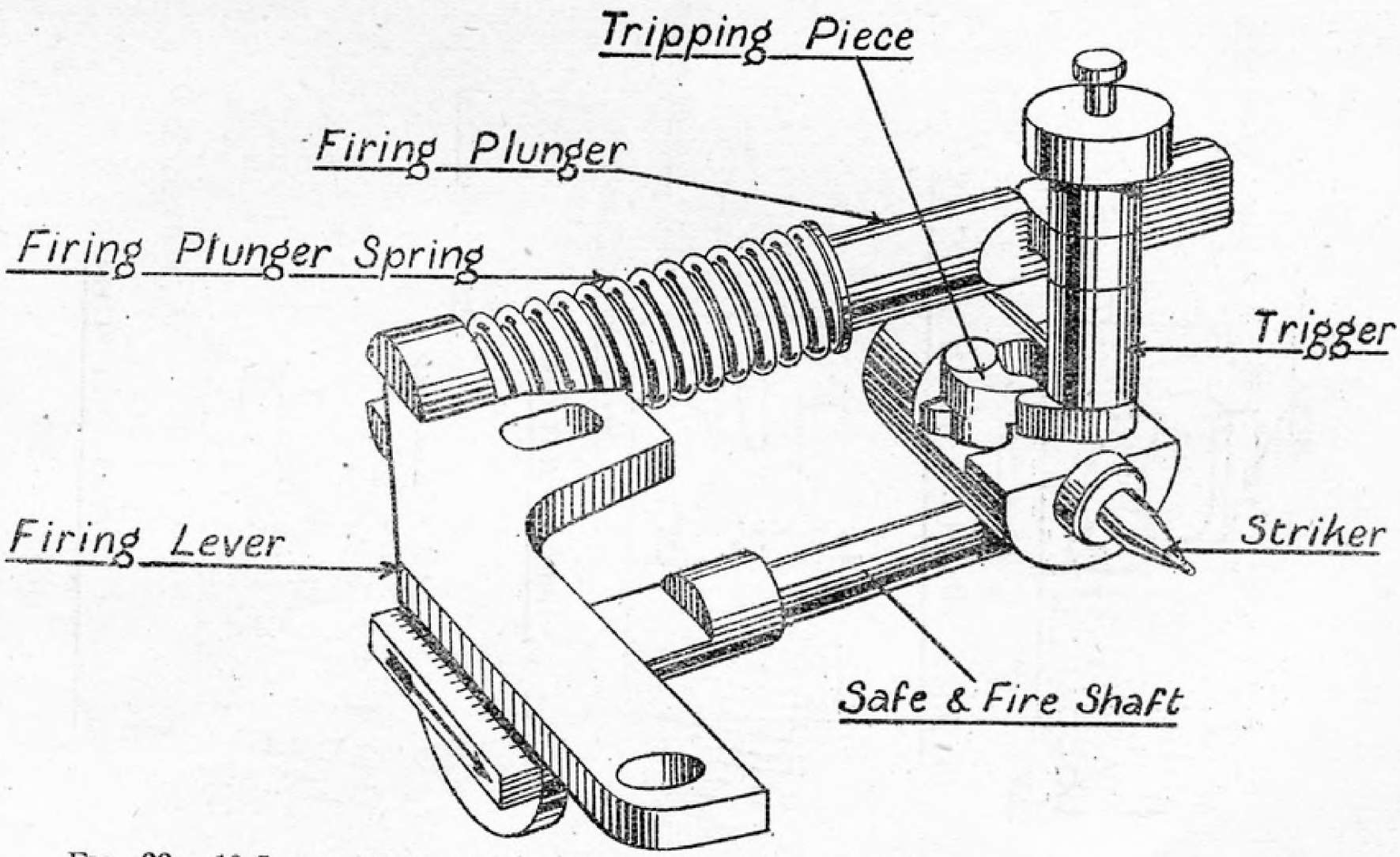


FIG. 23.—10·5 CM. (4·14 IN.) GUN-HOWITZER (10·5 CM. 1.F.H.18). FIRING MECHANISM

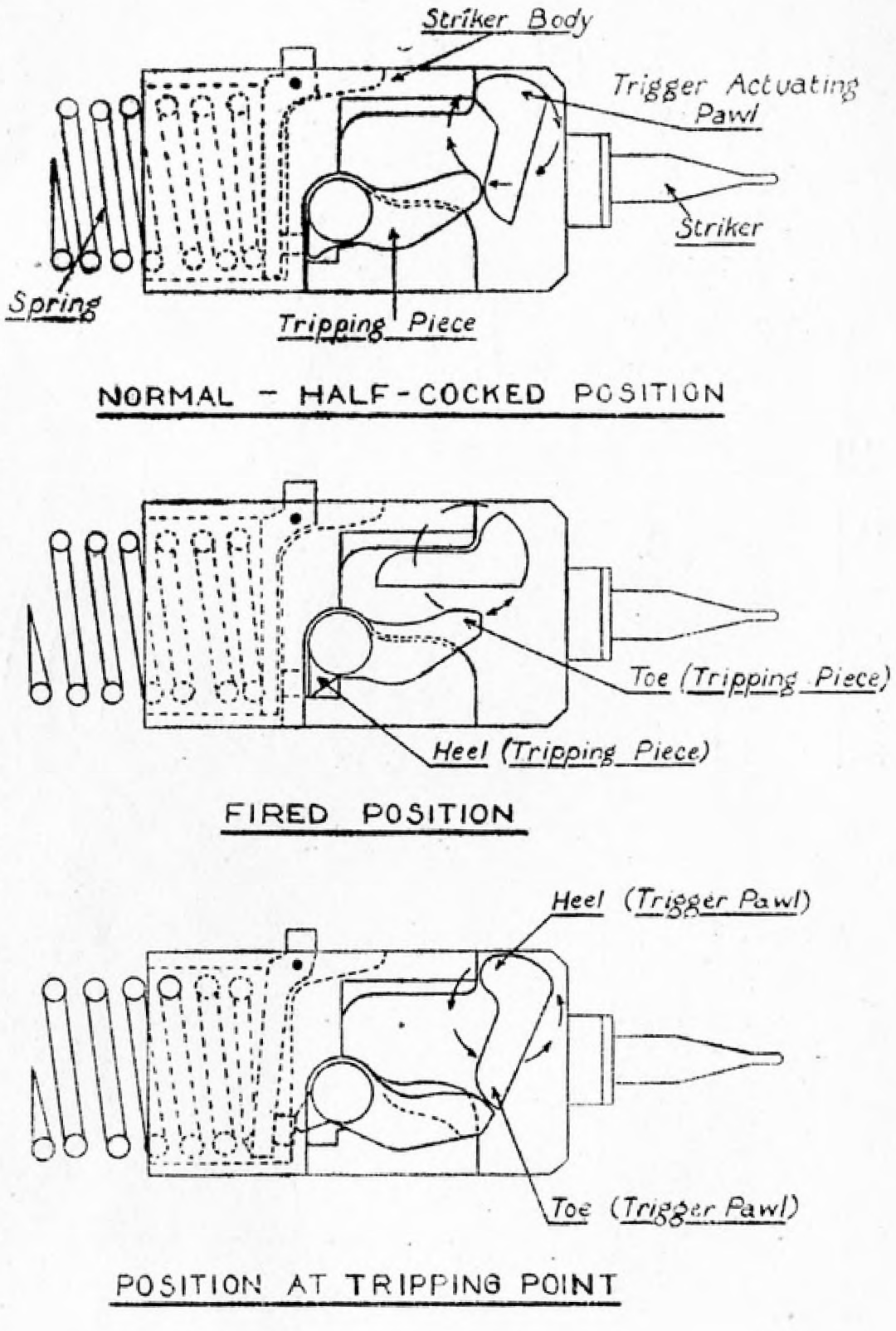


FIG. 24.—10·5 CM. (4·14 IN.) GUN-HOWITZER (10·5 CM. I.F.H. 18).—ACTION OF FIRING MECHANISM

The trigger passes from a boring in the top of the block to the striker way. A projection near the top is engaged in a recess in the firing plunger. A heel and toe at the bottom engage the striker and striker tripping piece respectively.

The striker consists of the striker proper, the striker spring, and the inner and outer covers, and is housed in a boring in the rear face of the block. The striker spring is held between the outer and inner covers, and the latter, which is pivoted in the striker body, bears against the striker body and the striker tripping piece.

The striker tripping piece is pivoted in the striker. It has a toe which engages the toe of the trigger, and a heel which engages the inner cover of the striker spring.

iv. *The safety mechanism*

The safe and fire shaft passes from the right face of the block to the striker way. Its right end is formed into a grip, marked with an arrow which may be set to " Sicher " (SAFE) or " Feuer " (FIRE), so marked on the block. At the other end it is reduced to a semi-circular section ; it is so positioned that the flat surface either engages a surface of the striker, or, if the shaft is turned through 90 degrees, is cleared by it.

The breech block locking plunger passes from the rear face of the block to the safe and fire shaft. It is held against a surface of the latter by a spring. When the safe and fire shaft is set to " SAFE," the rotation of the shaft forces the locking plunger back against its spring so that it projects beyond the block and engages a recess in the breech block way, thus locking the block in the closed position.

When the safe and fire shaft is set to " FIRE " the locking plunger is enabled under pressure of its spring, to re-enter the block, which is then free to move.

v. *The extractor mechanism*

The extractor consists of a cross bar and two arms. Hardened extractor pawls are let into the ends of the arms, and the extremities of the cross bar are formed into heels which engage the upper and lower extractor cams on the breech block when the latter is open. The effect is to limit the opening movement of the block and to jerk the arms of the extractor backwards so that the cartridge is unseated and ejected.

The extractor lies in a recess in the breech ring, and when the breech is closed the heels of the extractor rest upon the removable pin which forms an extension of the extractor ways on the front face of the block. The purpose of this pin is to enable the extractor to be removed with the block; this is done by opening the block and removing the pin; the breech is then closed again and the extractor slips into the recess formed by the removal of the pin; if the breech is now opened again the extractor will be carried with it.

4. Action of the mechanism

i. *To open the breech*

The L.B.M. is gripped, and the catch pressed inwards. This raises the latter clear of the stop on the breech ring, so that the L.B.M. can be rotated.

The L.B.M. is then rotated clockwise through 180 degrees.

The rotation of the L.B.M. forces the toe of the crank against the right side of the groove in the top face of the block, thrusting the block to the right into the open position.

ii. *To close the breech*

The L.B.M. is returned to its original position and the handle released, so that the catch is held behind the stop on the breech ring.

The rotation of the L.B.M. forces the toe of the crank against the left side of the groove in the top face of the block, thrusting it to the left into the closed position.

As the breech closes a projection on the toe of the crank comes into position behind the cam of the crank stop so that the block is locked in the closed position.

iii. *To fire* (Fig. 24)

The firing lanyard is pulled to the right rear. This rotates the firing lever on its axis pin so that the angle of the former bears against the head of the firing plunger, forcing it into the block against its spring.

The recess in the plunger in which the upper projection of the trigger is engaged turns the latter in a clockwise direction.

The toe of the trigger engages the toe of the tripping piece, which is pivoted on the striker, so that both striker and tripping piece are forced back against the striker spring.

As the rotation of the trigger continues its toe clears the toe of the tripping piece, and the striker spring asserts itself, driving the striker forward on to the primer of the cartridge.

The firing lanyard is now released, and the firing plunger, under pressure of its spring, moves to the right.

The upper projection of the trigger, being engaged in the recess of the plunger, turns the trigger in an anti-clockwise direction.

The toe of the trigger, riding on the inside of the tripping piece, forces it to the right so that the heel of the tripping piece forces the inner cover to the rear. At the same time the heel of the trigger, pressing against a projection on the striker body, forces it, too, to the rear. At the end of this movement the toe of the trigger trips the toe of the tripping piece, which is returned by the striker spring to the normal position, with the striker half-cocked and withdrawn from the firing-hole bush.

5. Stripping and assembly

i. *The guide ribs* are removed by removing the bolts through which the ribs are attached to a spring steel clip fitting in a circumferential recess on the exterior of the barrel. The guide ribs can then be withdrawn to the rear.

ii. *The jacket* is then removed by :—

(*a*) removing the locking plate at top rear of the breech ring ;

(*b*) unscrewing the jacket by means of a suitable tool. (R.H. thread) ;

(*c*) passing the jacket over the muzzle of the barrel.

iii. *The breech ring* is removed by withdrawing it over the breech end of the barrel. (*Note.*— The plate attached to the breech ring which locates the barrel may be removed, but this is not essential.)

iv. *The breech mechanism* may be removed, before or after stripping, in the following order :—

(*a*) Set safety catch to " FIRE " (" Feuer ").

(*b*) By means of the L.B.M., open the breech mechanism until the extractor bolt is clear.

(*c*) Hold the firing lever in the " FIRE " position and remove the extractor bolt ; allow the firing lever to return to its normal position and remove the extractor.

(*d*) Crank the breech block clear of the cam and withdraw.

(*e*) Remove the L.B.M. by aligning the key with the keyway and lifting.

To re-assemble, reverse the stripping operation.

Note.—Care should be taken to ensure that the packing rings in the jacket are replaced ; these rings appear to act as damp excluders.

6. The carriage

The carriage consists principally of :—

i. *Wheels*

These are fitted with solid rubber tyres 3 ins. thick (diameter 50 ins.). 24-in. brake drums are operated from one lever. Means for quickly adjusting the brake shoes on each wheel by hand are provided. The lever is in front of the shield and straps are fitted so that the brake can be pulled or released from behind the shield.

ii. *Trails and spades*

The trail cross beam carries a vertical pivot at each end for the trail legs. It has a third and central pivot underneath for the saddle.

The jaw of the trail hinge is on the trail ; a steel sleeve fits in the bush in the body and acts as a distance piece between the jaws. The hinge bolt passes through this and tightens the jaws on to it, not on to the body. The extensions for locking the articulation are on the upper halves of the jaws. These operate a mechanism which locks the springing when the trails are opened.

The folding spades fold over the trails for travelling. Fixed spade plates are also fitted for use on ice or hard ground.

iii. *Saddle*

This is slung under the cross beam. Minimum ground clearance is about 14 ins.

iv. *Elevating gear*

The arc is under the centre of the cradle. The worm and worm wheel are on the right hand side. The worm of the elevating gear is spring-loaded. Maximum elevation is 40 degrees 30 minutes, and maximum depression is 6 degrees 30 minutes.

v. *Traversing gear*

This is of the nut and screw type, operated by the layer on the left-hand side. The arc is 56 degrees.

vi. *Cradle*

The cradle is continued to the rear of the piece for about the full length of recoil. There is no quick-loading gear, but the elevating gear is operated by the breech number, who lays the gun by following a pointer operated by the sight. He can, therefore, bring the gun to a loading angle without disturbing the sight.

On the right-hand side of the cradle is a recoil indicator graduated in centimetres. Graduations are in black for normal recoil, and in red for abnormal.

vii. *Balancing gear*

The elevating mass is balanced by means of a single pneumatic ram in a cylinder on the right-hand side of the saddle behind the shield. The sealing of the gland is effected by means of a single U-leather, packed in grease and graphite, and a small quantity of liquid separating the gland from the air inside. No soft packing is used.

viii. *Body and axle*

The body is cylindrical. The main axle is circular, and is pivoted to the centre of the body. Independent wheel springing is fitted. The ends of the axle are cranked back to take the stub arms. A transverse spring fixed under the centre of the axle and connected to the stub arms takes most of the vertical load. The bearing housings for the stub arms project behind the body, which fits between guides on the axle and on the stub arm bearing housings, so that horizontal travelling stresses are transferred direct from the wheels to the body.

ix. *Sight and range indicator*

This is on normal lines with cross levelling gear, but is not a calibrating sight. The range drum is graduated for the 5th charge and in mils with a sliding pointer for elevation.

The dial sight is the new standard German type, the Rbl. F.32 (*see* Fig. 25), which is also used with the 10 cm. medium gun—K.18 and the 15 cm. medium howitzer—s.F.H.18.

It is a modification of Rbl. F.16 which it is replacing. Differences in the sights are :—

Dial sight 32—Slipping scales on dial and micrometer.
No levelling bubbles.

Dial sight 16—Two levelling bubbles at right angles observed in a 45 degree mirror.

(*a*) The dial sight 32 has a field of 9 degrees and a magnification of 4x.

It consists of :—

1. *A stem* which fits inside a tubular socket of the sight bracket.

2. *A prismatic optical system* in which the object glass can be pointed in any direction by means of the micrometer drum or by quick release. The eye piece at the end of an arm can be turned by hand in any direction. The graticule has an interrupted central vertical line and an inverted " V " for elevation ; a window to the right can be fitted with an illuminating apparatus.

The object glass can also tilt up to 200 mils or down to 200 mils. This tilt can be measured in hundreds on a small scale numbered 100-300-500 by means of a micrometer (graduated in mils and numbered every ten in black above the horizon and in red below the horizon).

There is no levelling bubble.

3. *A dial with slipping scale* and quick release. The dial graduation and slipping scale are the same; in hundreds of mils numbered anti-clockwise every 200 from 0 to 64 in black on the dial (except for the red cardinals 16-32-48-64).

The slipping scale is numbered to the left in red from zero to 32, to the right in black from zero to 32. The slipping scale is below the dial and separated from it by a fixed ring and index in black. The two words " mehr " (in white) and " weniger " (in red) below the slipping scale mean respectively " more " and " less." The slipping scale follows every movement of the object glass and dial graduation but can be moved independently by hand.

4. *A micrometer drum* with slipping scale, graduated in mils. Both are numbered every 10 mils, clockwise in red, anti-clockwise in black.

The index is on a fixed ring between the two scales.

5. *A quick release.*—By lifting a lever on the left, the worm screw of the micrometer is disengaged from the worm wheel of the dial which is then freed and can be turned by hand. Another flat lever can be brought forward and this extends the quick release action to the micrometer drum.

(*b*) *Directions for use by British troops*

1. *Laying the original line*

i. Determine the angle for each gun in degrees and minutes by any one of the British methods (aiming point, individual angles, T.O.B. method) using the director, compass or hand.

ii. Convert to mils. (*See* Appendix B.)

iii. Set the mils in hundreds on the dial and in mils on the micrometer, using the black graduations.

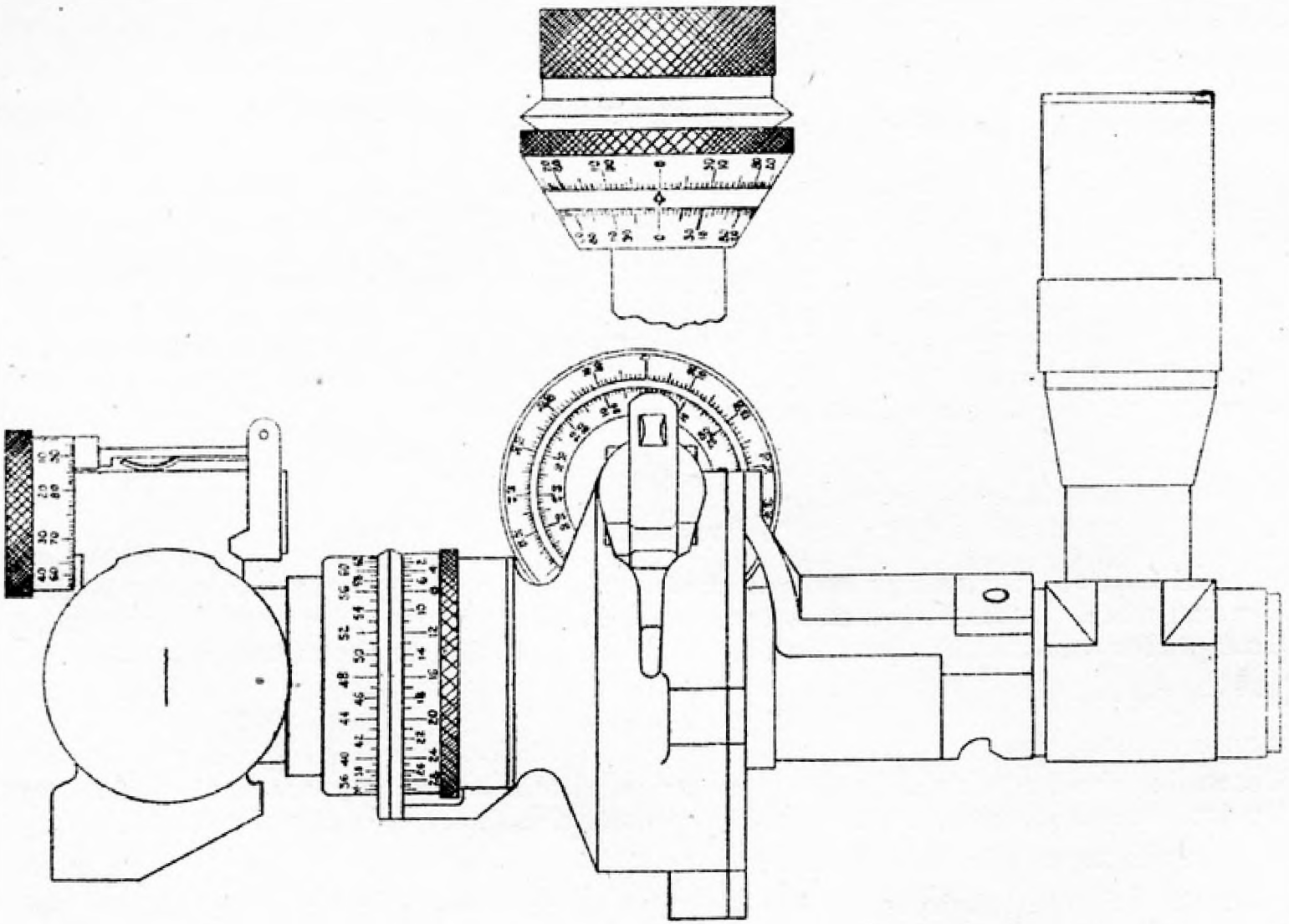


FIG. 25.—10·5 CM. (4·14 IN.) GUN-HOWITZER (10·5 CM. 1.F.H.18). DIAL SIGHT RBL.F.32

iv. Lay the gun.

v. Pick up a G.A.P.

vi. Slip the zero of the slipping scale to the index.

2. *To set the switches*

Convert the order from the O.P. from degrees to mils. Set the result on the slipping scale. If it is more, use the red scale turning the micrometer *away*.

If it is less, use the black scale of the slipping scale, turning the micrometer *towards*.

Take no notice of the words " mehr " or " weniger."

One whole turn of the micrometer equals 100 mils.

7. Buffer and recuperator

i. *The hydraulic buffer.* (*See* Fig. 26)

The buffer consists of :—

(*a*) *The cooling cylinder,* which is secured to the carriage, is water-filled. Internal flanges at both ends centralize the hydraulic buffer cylinder inside it, and a lug at the front engages the front cap when correctly positioned. At the front, also, is a supporting ring which, in conjunction with a flange of the hydraulic buffer cylinder, makes a water-tight joint. At the rear is a bronze packing ring which, together with a rear nut, also makes a water-tight joint with the hydraulic buffer cylinder.

Near the front of the cylinder are two external hollow bosses, one at the top, the other at the bottom. The former is for filling the cylinder with water, and is closed by a filler cap with bayonet joint. A spring fitting inside the cap prevents spilling while travelling and acts as a safety valve should the water become overheated during firing. The boss at the bottom is for draining the cylinder and is closed by a drain plug.

(*b*) *The hydraulic buffer cylinder* is lead-coated externally. An external flange at the front forms an inner supporting ring for packing in conjunction with a supporting ring on the cooling cylinder ; another, at the rear, is threaded to suit the rear nut securing the cooling cylinder.

Internally, the cylinder is threaded at both ends, to receive at the front the front cap, and at the rear the stuffing box.

(*c*) *The front cap* is threaded externally at the rear end to suit the front of the hydraulic buffer cylinder. A slotted internal flange engages a lug on the front of the cooling cylinder when the cap is correctly positioned. An expansion chamber is formed between this flange and the front of the cap, and is connected by a small port to the buffer cylinder. There are two oblique openings (closed with plugs) at the top of the expansion chamber ; one is for filling the buffer cylinder with fluid, the other is an air release. At the front end of the expansion chamber is a plug for draining it, and at the bottom of the front cap, immediately behind the flange, is a plug for draining the buffer cylinder.

The front of the cap is closed by a cover which is held in position by an interrupted flange with spring plunger.

(*d*) *The stuffing box* is threaded externally at front and rear, at the front to suit the rear end of the buffer cylinder, and at the rear for the gland. It contains a front supporting ring, twelve turns of packing, and a rear supporting ring which is held in position by an internally-threaded cap, with a spur wheel outside.

(*e*) *The piston* is hollowed to receive a sliding bush and threaded internally at front and rear ; at the front to receive a sleeve which limits the forward movement of the sliding bush, and at the rear for the front of the hollow piston rod. The rear face of the piston is bevelled at an angle of 15 degrees, and eight ports are bored through the bevelled surface.

Externally the piston is recessed to receive the piston wall, which is secured by the sleeve controlling the sliding bush. The piston wall makes an oil-tight fit inside the buffer cylinder.

(*f*) *The sliding bush* is free to move horizontally within the piston in such a way that, in the forward position (where it is held by the sleeve) the ports in the bevelled surface of the piston are fully opened. In the rear position (which is determined by the angle of the bevelling of the piston) it partially blocks the ports.

It is bored from front to rear to allow passage for the control rod. There are four grooves in the boring to allow passage from the space B, via the ports in the piston, to the space A.

(*g*) *The piston rod* is threaded externally at the front to suit the piston. The rear end is closed by a screw plug containing an air release plug, and, being secured to the piece, is drawn to the rear when the gun recoils. The piston rod is hollow throughout.

(*h*) *The control rod* is flanged externally at the front ; the flange is threaded to connect with the front cap and is closed by an air-release plug. The rod is tapered externally and bored internally and passes through the sliding bush into the hollow piston rod. At the rear it is threaded internally to receive the control plunger.

Eight holes in the rod form channels from space C to space A.

(*i*) *The control plunger* is threaded externally at the front to suit the rear end of the control rod, the junction being secured by a riveted pin. Externally it is tapered to the rear. From the rear a horizontal groove, decreasing in depth, runs for about five-eighths of its length.

The plunger is hollow ; eight holes in it form channels from space C, via the groove on the outside, to space D.

ii. *Action of the buffer*

(*a*) The gun fires and recoil commences. The piston rod, and with it the piston, is drawn to the rear.

(*b*) The fluid in space B is forced through the ports in the rear end of the piston, driving the sliding bush to the forward position, so that the ports are fully opened.

(*c*) The fluid from space B, after passing through the ports, is forced along the grooves in the boring of the sliding bush (between the sliding bush and the control rod) into space A.

(*d*) As recoil continues, the pressure on the fluid in space A forces it through the channels in the control rod into space C (i.e. the interior of the control rod and control plunger).

(*e*) Further recoil drives the fluid in space C through the channels in the control plunger, along the groove on the outside of the control plunger, into space D. Space D increases in size as recoil proceeds, and the flow from space C increases likewise owing to the increase in depth of the groove.

(*f*) Since the control rod increases in diameter to the rear, the space between it and the sliding bush gradually diminishes so that a diminishing quantity of fluid is able to pass from space B to space A. This diminution brings the recoil to a standstill.

(*g*) As soon as recoil ceases, run-out is initiated by the recuperator.

(*h*) Space D immediately decreases in size so that the fluid in it is driven along the groove on the outside of the control plunger into space C. The diminishing depth of the groove acts as a brake on run-out.

(*i*) Increased pressure in space C drives the fluid through the channels in the control rod into space A.

(*j*) Similarly the pressure on the liquid in space A, arising both from the forward movement of the piston and the influx from space C, forces the sliding bush into the rear position, thus partially closing the ports at the rear of the piston. This serves as an additional brake on run-out, as only a limited amount of liquid is able to pass from space A, along the grooves in the boring of the sliding bush, through the partially closed ports, into space B.

(*k*) The gun is thus returned gently to the run-out position.

(*l*) As the liquid becomes heated during firing it will expand. The surplus then travels through a small port in the buffer cylinder into the expansion chamber, compressing the air in it. As the liquid cools, the compressed air drives it back into the buffer cylinder.

iii. *The hydro-pneumatic recuperator.* (*See* Fig. 26)

The recuperator consists of :—

(*a*) *The hydro-pneumatic cylinder* forms the outside wall of the recuperator. The front end is closed by a welded plug, the lower part of which is drilled and threaded internally to receive the liquid cylinder. Near the top of this plug are an air valve and two openings closed by plugs. One of these openings, which is connected by a duct to the air valve, is for air filling and testing ; the

other is for liquid filling. The air valve and plugs are secured by locking plates and wire. An interrupted external flange at the front of the plug receives the front cover, which is secured by a spring plunger.

Towards the rear the cylinder is flanged externally for engagement with the bracket supporting the recuperator on the carriage, and at the rear end it is threaded externally to suit a securing nut.

At the rear end an internal sleeve is formed inside the lower part of the cylinder. The front end of this sleeve receives the rear end of the liquid cylinder. Two lateral ports are bored near the front of the sleeve, affording passage from the interior of the sleeve to the H–P cylinder proper. The rear end of the sleeve is threaded internally to receive the stuffing box.

The rear face of the cylinder is drilled to receive the screws which hold the two gland locking plates in position.

(*b*) *The liquid cylinder* is eccentrically positioned in the lower part of the H–P cylinder. It is threaded externally at its front end to suit the welded plug of the H–P cylinder. The front end is closed by a dust cap containing an air valve which keeps the head of the recuperator piston in contact with the atmosphere. At the rear, the cylinder fits inside the sleeve of the H–P cylinder. Its rear end has a bevelled internal flange which forms a seating for the retarding valve.

(*c*) *The retarding valve* is hollowed to allow passage for the piston rod and four small ports are bored through it from front to rear. It is held on its seating at the rear of the liquid cylinder by a coil spring whose rear end is held by a spigot on the front of the stuffing box.

(*d*) *The stuffing box* is threaded to suit the sleeve at the rear of the H–P cylinder. A spigot on the front face holds the rear end of the spring of the retarding valve. At the rear, it is closed by a gland which is secured by a wire and the locking plate at the rear of the H–P cylinder.

(*e*) *The recuperator piston rod* slides horizontally within the liquid cylinder. At its rear end are two U-leathers with supporting rings and a nut securing the ram to the ramrod.

(*f*) *The piston rod* is secured at the front to the rear of the recuperator piston by means of a nut. It passes through the retarding valve, stuffing box, and gland, and is threaded at the rear for attachment to the gun by means of two washers (one concave and one convex) and a nut.

iv. *Action of the recuperator*

(*a*) As the gun recoils, the piston rod (and with it the recuperator piston) is drawn to the rear.

(*b*) The recuperator piston draws the liquid in the liquid cylinder to the rear, so that the pressure forces the retarding valve back from its seating against its spring.

(*c*) The liquid is thus enabled to pass through the two ports in the sides of the sleeve of the H–P cylinder into the H–P cylinder itself, so that the air in the latter is compressed.

(*d*) As recoil comes to an end, the pressure on the front of the retarding valve ceases, and it is returned to its seating by the spring.

(*e*) At the same time the air in the H–P cylinder ceases to be compressed. Its consequent re-expansion drives the liquid in the H–P cylinder back through the two ports in the side of the sleeve.

(*f*) The liquid passes through the valve from rear to front by means of the four small ports, which consequently act as a brake on run-out.

(*g*) The influx of liquid into the liquid cylinder drives the recuperator piston forward, and with it the piston rod. The gun, being attached to the piston rod, is thus returned to the run-out position.

8. Filling and charging the recuperator

i. *To prepare recuperator*

(*a*) See gun is in the fully run-out position and secured.

(*b*) Remove front cover cap.

(*c*) Remove air valve plug and filling plug.

(*d*) Open air valve.

(*e*) Lay gun at zero and cross level.

(*f*) Pour in liquid through filling plug until it overflows at filling plug.

(*g*) Replace filling plug.

(*h*) Elevate and depress several times, leaving gun at zero.

(*i*) Remove filling plug and liquid should just appear; if not, pour in more liquid until it overflows.

(*j*) Attach adapter, connect pipe and air reservoir to recuperator at air valve plug.

(*k*) Attach Gauge Pressure No. 22 to adapter.

(*l*) Close air valve.

(*m*) Open up air reservoir slowly until 750 registers on gauge; close reservoir. Air pressure should remain constant; if not, check connections.

(*n*) Open air valve.

(*o*) Open air reservoir and charge recuperator to 730 lb. per square inch.

(*p*) Close air reservoir.

(*q*) Close air valve.

(*r*) Remove connecting pipe.

(*s*) Replace cap on adapter.

(*t*) Open air valve, pressure should read 710 lb. per square inch. If it is below, add more; if it is above, release by slackening the blanking cap slightly.

ii. *To test recuperator*

(*a*) *Check oil level*

(1) Lay gun at 10 minutes depression.
(2) Remove front cover cap.
(3) Slacken oil filling plug slightly and liquid should appear; if not, screw up plug and repeat with gun laid at 30 minutes depression. If oil still does not appear recuperator requires complete recharging.

(4) Screw up plug.
(5) Lay gun at 1 degree 30 minutes elevation and repeat. Air only should appear; if oil appears, completely empty and recharge recuperator.

(*b*) *Check air pressure*

(1) Lay gun horizontal and cross level.
(2) Remove front cover cap.
(3) Remove air valve connecting plug.
(4) Attach adapter and pressure gauge to recuperator at air valve connecting plug.
(5) Ensure that blanking cap on the adapter is tightened up.
(6) Open air valve. Pressure should read 710 lb. per square inch; if not, proceed as from (*j*) in para. i.
(7) Close air valve.

9. Filling and charging the buffer

i. *To prepare and to fill buffer*

(*a*) See that gun is in the fully run-out position.

(*b*) Remove the two filling plugs from the front end of cradle.

(*c*) Remove front cover and remove the two air release plugs (one on the expansion chamber and one at the end of the control rod).

(*d*) Remove air release plug from rear end of buffer piston rod.

(*e*) Place gun horizontal.

(*f*) Pour in liquid at one of the top filling holes slowly until it overflows at air release plugs, closing each in turn as liquid appears.

(*g*) Continue to pour in liquid until it appears at filling hole.

(*h*) Replace filling plugs.

(*i*) Elevate and depress several times ; bring the gun to 5 degrees on completion.

(*j*) Remove the two filling plugs from the front end of cradle.

(*k*) Pour in more liquid (it should be only a very small amount) until it appears at filling plugs.

(*l*) Replace filling plugs. Approx. amount of oil—10½ pints.

ii. *Tests*

(*a*) Lay gun horizontal.

(*b*) Remove filling plugs from front end of cradle and oil should appear. If it does not remove front cover and ease air release plugs. Oil should appear ; if not, proceed as from (*f*) in para. i above.

10. Filling and charging the balancing gear

i. *To prepare and charge balancing gear*

(*a*) Remove filling plug.

(*b*) Open air valve and allow all air to escape.

(*c*) Remove press complete.

(*d*) Remove the leather cover protecting the piston at its lower end.

(*e*) Withdraw piston rod.

(*f*) Pour in approximately half-pint of liquid into the cylinder.

(*g*) Replace piston rod and secure leather cover.

(*h*) Replace press on mounting.

(*i*) Attach adapter and Gauge Pressure No. 22 to filling hole.

(*j*) Attach connecting pipe to adapter and compressed air reservoir to connecting pipe.

(*k*) Close air valve on balancing press.

(*l*) Open valve on reservoir slightly and test connections up to 600 lb. per sq. in.

(*m*) Open air valve on balancing press and charge to 520 lb. per sq. in.

(*n*) Close valve on air reservoir.

(*o*) Close valve on balancing press.

(*p*) Remove connecting pipe from adapter.

(*q*) Elevate and depress gun for trial of efforts.

(*r*) If hard, add slightly more pressure up to 550 lb. per sq. in. If effort is still found to be hard, allow air to escape, testing effort as every 5 lb. drop is recorded. Do not drop below 480 lb., as in this case there must be a defect in the elevating gear of balancing press. Approximate working pressure is 510 to 520 lb. per sq. in.

(*s*) Remove adapter and pressure gauge.

(*t*) Replace filling plug.

ii. *To test*

(*a*) Try elevating gear of carriage for efforts. If these are found good, the balancing press is in order.

(*b*) If found to be hard, check the air pressure, as follows :—

(1) Remove filling plug.

(2) Attach adapter and gauge pressure No. 22 to hole for filling plug.

(3) See joints are tight and blanking cap is on the adapter.

(4) Open air valve. Pressure should read between 510 and 520 lb. per sq. in. ; if not, note the pressure, and, if below 250 lb. per sq. in., balancing press should be examined at joints and packings, and a complete recharge given. If above 250 lb., repeat as from (*r*) in para. i above.

NOTE.—British service buffer oil can be safely used in the buffers and recuperators of German guns, which should, however, be drained first.

11. Detachment

The general duties are practically the same as those of a detachment manning a 25-pdr. Carriage Mark V (split trail).

A detachment of 6 is the minimum required ; the German detachment numbers 11, 5 of which are ammunition numbers and reserves in case of casualties.

i. *To prepare for action*

B.L. or T.L.

" Prepare for action."

1 sees that the bore is clear, examines the spade on the off side.

2 removes the muzzle cover, breech and sight covers if provided. He releases the cradle clamping gear, opens the breech and with **3** examines the cradle clamping gear and shield. He examines the brake, elevating mechanism, and tests the firing gear and safety device, after closing the breech. He replaces the covers unless otherwise ordered.

3, with **2**, examines the cradle clamping gear and shield.

He examines the sights and traversing gear.

4 examines the spade on the near side, aiming posts and, when provided, the paralleloscope.

5 and **6** examine the ammunition in the towing vehicle and, when provided, the handspikes and dragropes.

As soon as the examination is completed, the detachment form detachment rear.

1 collects reports and reports to the B.L. or T.L.

" No.. . . . ready for action " or otherwise.

ii. *To come into action*

The drill set out below envisages the gun being towed by a tractor carrying the ammunition, stores and detachment.

iii. *Action rear*

T.L.

" Action rear."

On approaching the position, **1** dismounts and places himself where he can see when his gun is in the required position.

He then orders " Halt—Action rear."

The detachment dismount. **1** places himself in a position to signal to the driver when the gun has been disconnected.

2 and **4** go to the near trail, **2** at the spade handle bar, **4** at the trail handle bar.

3 and **5** go to the off trail, **3** at the spade handle bar, **5** at the trail handle bar ready to unhook.

All help to lift the trail off the hook.

5 signals " Clear " to **1** by raising his head.

1 signals the tractor to advance 1 yard.

The trail is lowered to the ground.

5, and **6** if present, unload the ammunition from the tractor, and prepare it for firing.

2 and **3** release the cradle clamping gear, easing the elevating and traversing handwheels if necessary, **2** folds it back.

1 releases the trail locking gear. **1, 2, 3** and **4** step inside the trail and, facing outwards (**1** and **3** to the left), open the trails to their full extent.

1 and **4** tilt the spades over to the rear, **1** on the left.

1 and **3** at the left trail ; **2** and **4** at the right trail lift the trails on to the spades.

2 removes the covers and places them on the right of the gun. He lowers the bottom shield. He opens the breech and by means of the elevating handwheel brings the elevation indexes in coincidence.

3 fixes the dial sight in its carrier, sets the sight clinometer at 300 and centres the bubble.

He sets the tangent elevation at 300 mils.

He opens the sight port cover.

4 removes the dragropes and handspikes (when provided) and places them to the right and left of the gun, 1 yard outside each wheel.

5 and **6** arrange the ammunition on the ground, opening the boxes and interposing a groundsheet or mats between the ground and the shells.

The detachment take up their positions in action.

iv. *Action front, Action right, Action left*

At " Action front " the trail is carried through a half circle to the right.
At " Action right (left) " the trail is carried through a quarter of a circle to the left (right).

v. *To lay the gun in the original line*

2, 4, 5, and **6** man the trails, **2** and **4** on the right, **5** and **6** on the left.
After the gun is laid, **2** puts on the brakes.

vi. *To lay the gun*

3 sets the dial sight at the angle ordered, the sight clinometer at the angle ordered* and the range (or tangent elevation in mils) as ordered.
He reports : " Elevation . . . set."
He roughly centres the sight clinometer bubble, then accurately centres the cross levelling bubble.
He lays roughly for line by means of the traversing handwheel.
2, by means of the elevating handwheel, brings the elevation indexes in coincidence.
3 lays accurately for line, accurately centres the sight clinometer bubble.
2 accurately brings the elevation indexes in coincidence.

vii. *To make safe*

The firing mechanism is at safe when the index on the right face of the breech block is set at SICHER, i.e. when it is at right angles to the axis of the gun.

viii. *To open the breech*

No. **2** grasps the lever breech mechanism firmly with his right hand, pressing in the catch and pulling the lever to the rear, opens the breech and ejects the cartridge case. The breech is held in the open position by the catch.

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*Angle of sight zero is set as 300 on the sight clinometer, 10 mils E being 310, 10 mils D being 290.

ix. *To close the breech*

The round having been loaded, No. **2** grasps the lever breech mechanism with his right hand, presses the catch and rotates the lever to the front.

x. *To fire*

The safety device being at FEUER, i.e. parallel to the line of fire, the gun is fired on the order of No. **1** by pulling the lanyard fully to the rear. For the first round, before the spades are driven in, **1** orders the detachment to " Stand clear."

xi. *Misfires*

After a misfire, two more attempts will be made. If unsuccessful, the breech will be opened after an interval of 1 minute, and the defective cartridge case unloaded. The G.P.O. will decide whether to have the charges destroyed or not.

xii. *Run up*

The positions will be as follows :—

5 and **6** respectively at the left and right wheels.
1 and **4** respectively at the left and right spade handles.
3 and **2** at the piece.
2 takes off the brake and the gun is pushed forward so as to clear the spades.

xiii. *Rear limber up* (when the tractors are getting near the gun position)

G.P.O. or T.L.
" Cease firing—Rear limber up. "
1 orders " Run up " to clear the spades.
2 closes the breech.
3 traverses the gun approximately central. He replaces the dial sight in its case and closes the sight port cover.

1, 2, 4, and **5** go to the trails, **1** and **5** at the left trail, **2** and **4** at the right trail lift the trails up and tilt back the spades, after releasing them by means of locking lever, which is then turned back to secure them.

1, 2, 4, and **5** close the trails and **1** secures them by means of the locking lever, **3** releasing the trail locking catch.

5 and **6** collect the ammunition to be reloaded in the tractor.

2 and **3** fix the cradle clamping gear.

4 brings in and replaces aiming posts. He replaces dragropes and handspikes.

2 releases the brakes and raises the lower shield.

The detachment take up their positions ready to hook in as follows :—

1 about 10 yards to the left rear of the gun in a convenient position for directing the movement of the tractor.

2 and **4** go to the right trail, **2** at the spade handle bar, **4** at the trail handle bar.

3 and **5** go to the left trail in similar positions, **5** ready to hook in.

The tractor is driven up, backed and halted at the signal from **1.**

1 orders " Hook in " and goes to the left gun wheel, **6**, if present, to the right gun wheel.

The detachment lift the trails and **5** hooks in.

All spare ammunition is replaced in the tractor.

All mount the tractor without further orders.

IV.—10 cm. (4 in.) Medium Gun (s.10 cm. K.18) and 15 cm. (5·9 in.) Medium Howitzer (15 cm. s.F.H.18)

(*See* Fig. 27)

1. General

These two weapons, which have interchangeable carriages, were introduced prior to 1939 as the standard German divisional medium artillery. The s. 10 cm. K.18 (actual calibre 10·5 cm. (4·14 in.)) is, apart from the length of its barrel and the ammunition it fires, identical with the 15 cm.

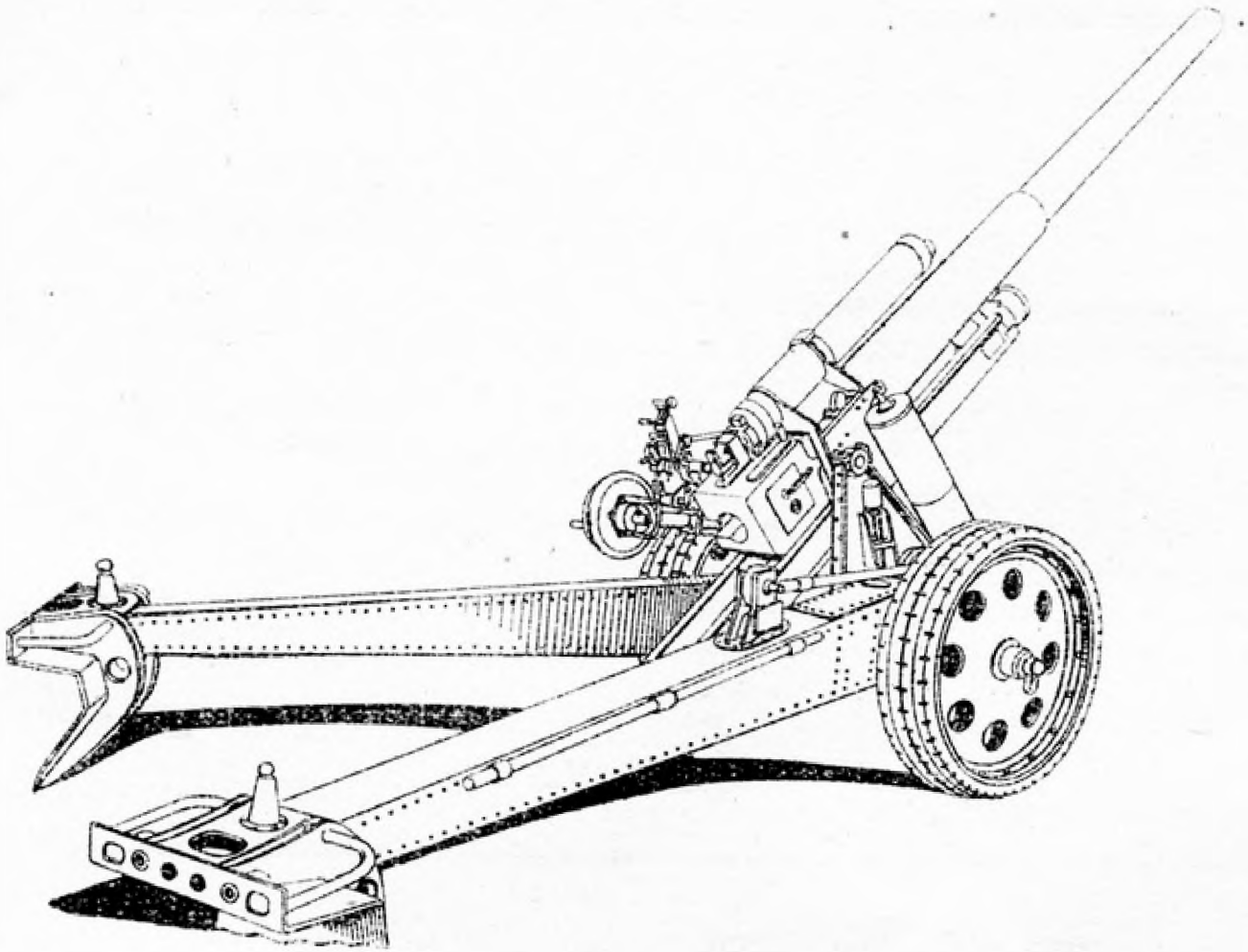

FIG. 27.—15 CM. (5·91 IN.) MEDIUM HOWITZER (15 CM. S.F.H. 18)

s.F.H. 18, which is described in detail here. The latter gun, under the name of Obice da 149/28, is also in service in the Italian Army.

The gun and carriage, when horse-drawn, are moved in two separate loads of 4 tons each. When tractor-drawn, the barrel is brought back to a transport position on the cradle. Maximum road speed is 28 m.p.h.

A range table for use with the 15 cm. s.F.H. 18 firing H.E. shell is at Appendix J.

2. Data

i. *Ballistic particulars.* (H.E. shell)

(*a*) *s.10 cm. K.18*

Charge	Min. range Yards	Max. range Yards	Time of flight Secs.	50 per cent. Zone	
				Length Yards	Breadth Yards
Small	55	13,900	52	106	17
Medium ...	55	17,200	62	117	20
Full	12,000	20,800	70	208	22

(*b*) 15 *cm. s.F.H.*18

Charge	M.V. (f.s.)	Range Yards		Time of flight (Max. range) Secs.	50 per cent. Zone Yards (Max. range)		Drift (Max. range) Mils.
		Max.	Min.		Length	Breadth	
I	690	4,370	25	27	61	8	30
II	755	5,170	3,280	30	62	8	31
III	820	6,010	3,830	34	71	9	34
IV	920	7,300	25	36	66	9	33
V	1,050	9,020	5,470	41	71	10	30
VI	1,230	10,690	25	45	75	11	27
VII	1,425	12,330	5,470	51	81	13	31
VIII	1,705	14,570	9,300	55	89	14	34

ii. *Ammunition*

(*a*) The 10 cm. K.18 fires the following types :—

H.E. shell with percussion fuze. (10 cm. Granate 19.)
Weight, 33½ lb.
Fuze, A.Z. 23, with or without optional delay (0·25 secs.)

H.E. shell with T. and P. fuze.
Weight, 33½ lb.
Fuze, Dopp. Z. S/60.

A.P. shell with base fuze (10 *cm. Pzgr.*).
Weight, 31 lb. 4 oz.
Fuze, Bd.Z. 317.

A.P.C.B.C. shell with base fuze (10 cm. Pzgr. rot).
Weight, 34 lb. 10 oz.
Fuze, Bd.Z. 317.

(*b*) The 15 cm. s.F.H. 18 fires the following types :—

The H.E. shells may be fitted with either a percussion fuze (A.Z.23) or a T and P fuze (Dopp. Z. S/60).

H.E. shell (15 *cm. Gr.* 19).—This is an H.E. shell with a screwed-in baseplate. The bursting charge is of pressed T.N.T., and is in a series of cardboard containers. A smoke-box is situated at the base of the shell. The standard gr. Zdlg. c/98 Np. exploder system is fitted. The weight of the shell is 95·7 lb.

H.E. shell (15 *cm. Gr.* 19 *m. Zdlg.* 36).—This is also an H.E. shell with a screwed-in baseplate. The bursting charge consists of T.N.T. poured. The Zdlg. 36 exploder system (indicated by the number " 36 " stencilled on the side of the shell) is fitted. A smoke-box is situated below the exploder system. The weight of the shell is 95·7 lb.

H.E. shell (15 *cm. Gr.* 19 *Stg.*).—This is an H.E. shell made of cast steel. The bursting charge consists of poured T.N.T. The standard gr. Zdlg. c/98 Np. exploder system is fitted. A smoke-box is situated below the exploder system. The weight of the shell is 95·7 lb.

Anti-concrete shell (15 *cm. Gr.* 19 *Be.*).—This is an anti-concrete shell with a screwed-in baseplate and a base fuze. The bursting charge is of pressed T.N.T. and is in a series of cardboard containers. The T.N.T. blocks contain varying amounts of wax. The standard gr. Zdlg. c/98 Np. exploder system is fitted. The base fuze is fitted with an optional delay. The weight of the shell is 95·7 lb.

Smoke shell (15 *cm. Gr.* 19 *Nb.*).—This is a smoke shell with a bursting charge of picric acid, and a percussion fuze (A.Z. 23 Nb.). The weight of the shell is 95·7 lb.

Smoke shell (15 *cm. Gr.* 38 *Nb.*).—This is a smoke shell with a bursting charge of T.N.T.

A.P. shell (15 *cm. Pzgr.* 39).

(*a*) *s.* 10 *cm. K.* 18.

Calibre	...
Length of piece	...
Weight in action	...
Maximum depression	...
Maximum elevation (trails open)	...
Maximum elevation (trails closed)	...
Traverse (trails open)	...
Traverse (trails closed)	...
Practical rate of fire	...

(*b*) 15 *cm. s.F.H.* 18.

Calibre	...
Length of bore	...
Length of piece	...
Rifling	...
Twist (right handed)	...
Weight in action :—	
M.T. drawn	...
Horse drawn	...
Length of piece (incl. breech ring)	
Length of chamber	...
Cubic capacity of chamber	...
Recoil (normal)	...
Recoil (safety limit)	...
Maximum elevation (trails open)	...
Maximum elevation (trails closed)	...
Maximum depression	...
Traverse (trails open)	...
Traverse (trails closed)	...
Practical rate of fire	...

... ...	10·49 cm. (4·13 in.).
... ...	50 cals.
... ...	5 tons 8 cwts.
... ...	1° 30′.
... ...	45°.
... ...	15°.
... ...	60°.
... ...	6°.
... ...	4 r.p.m.
... ...	14·9 cm. (5·866 in.).
... ...	24 cals. (142·6 in.).
... ...	29·6 cals. (174·8 in.)
... ...	40 grooves.
... ...	5°–10°.
... ...	5 tons 8 cwt.
... ...	5 tons 5 cwt.
... ...	173·16 in.
... ...	14·25 in.
... ...	440·59 cu. in.
... ...	44·09 in.
... ...	44·88 in.
... ...	45°.
... ...	15°.
... ...	1° 30′.
... ...	60°.
... ...	6°.
... ...	4 r.p.m.

3. The piece

The piece consists of :—

i. *Loose barrel.*—The barrel is solid and loose in the jacket. At the breech end a collar is formed to fit into a bored-out recess in the jacket.

ii. *Jacket.*—The jacket is conical at the front and cylindrical at the rear.

iii. *Breech ring.*—The breech ring is secured to the jacket either by thrust ring or tension screw. A flat-sided cut is made for the breech ring, and the loading aperture is on the left. The recuperator coupling collar is on top, while below are the rear barrel guide rib, the buffer coupling lug and lever, and the locking device for use during transport.

A recoil indicator is fitted on the right.

4. The breech mechanism

This is of the horizontal sliding block type, and is similar to the 10·5 cm. I.F.H.18 breech mechanism described in Section III, para. 3.

5. The mounting

i. *The cradle.*—The cradle supports the barrel and guides it during recoil and run-out. It is closed in front by a cover plate and a recoil indicator is fixed to the right. Two sockets at the rear take the clamping bolts of the securing link, which fixes the cradle during transport and saves the elevating gear from stresses.

ii. *The saddle.*—The trunnions of the cradle rest in the saddle, which rotates on the pivot of the gun carriage head cross beam.

iii. *The elevating gear.*—The elevating gear has a double action ; a quick one by crank and link on the right, and an accurate one by handwheel on the left. There is no quick loading position.

iv. *The traversing gear.*—The traversing gear is of the simple arc and pinion type. The handwheel i on the left.

v. *The compensators.*—Two compensators, each consisting of two springs inside a cylinder, take up muzzle preponderance. As recoil is constant, the trunnions are far to the rear.

vi. *The carriage* consists of :—

(*a*) *The head cross beam* is reinforced by cross plates and angle irons. The saddle pivot is fixed on top with a thrust bearing. The two vertical shafts of the trails are to the left and right. A locking device, actuated by giving half a turn to two levers on the rear of the cross beam, locks the trails in the open position.

When the trails are opened, the road spring is released and two locking bolts fix the cross beam rigidly to the axle. The bolts are wedged against the axle pintle by turning the handwheels of the bolts. When the trails are closed, side plates come into contact with the end-plates of the spring, and lift the carriage on to the spring again.

(*b*) *The trails* are two independent box trails, which can be opened to 60 degrees. They are clamped in the open position by two slide bolts and locked in the closed position. The trail eye is in two parts.

Small spades (ice spades) are permanently fitted for use in hard ground. Larger spades, carried on the trails, can be used for soft ground. The cradle is clamped to the trails during transport by the clamping link and bolts.

(*c*) *The axle pintle* passes through a central bushing and can swing up and down inside the head cross beam.

(*d*) *The wheels* consist of double discs with detachable felloes and are fitted with solid rubber tyres. Brake drums are fixed to rings inside the wheel. Braking is by hand, either directly or by a long strap. When the gun is tractor-drawn, an automatic air brake is connected with the engine of the towing vehicle.

6. The sight

The sight used is Zeileinrichtung 34 and is of the rocking bar type. All firing data are set on the sight. The gun is then elevated to the total Q.E., and swung round by the appropriate switch from zero line.

For elevation, every angle is added from the horizontal by the movement of an oblique pointer. The gun is laid in elevation when the index of this pointer and that of a similar pointer fixed to the cradle are made to coincide.

The sight consists of :—

i. *The sight and socket.*—The sight bracket, fixed to the left trunnion, can rotate up or down, and carries the various parts of the sight.

ii. *The line of sight device corrects :—*

(*a*) The tilt forward of the carriage owing to the slope of the platform.

(*b*) The difference in height between gun and target.

(*c*) Loss of M.V. (as the sight is not a calibrating sight).

Correction for difference in height is provided by angle of sight plus a non-rigidity correction given in mils as a total angle of sight under " Libellentafel " in the range tables. Corrections for loss in M.V. in mils for the various angles and charges are read by the layer from the table inscribed on the shield.

iii. *The tangent elevation (range) mechanism* consists of an oscillating threaded shaft, an elevating nut and cross piece, and the angle of sight scale. 300 corresponds with angle of sight zero.

The threaded shaft is fixed at the top to the sight bracket, and below to the elevating nut. The elevating nut is fixed to the cradle. The distance between the cradle and the sight bracket is moved by the value of angle of sight when the bubble is centred again after being thrown off by moving the angle of sight index against the scale. All parts on the bracket, including the range drum and its index, are moved through the same angle. These include the sight pointer arm, which therefore turns by the angle of sight. This arm is keyed to the range drum. When the range drum is turned against the index of the bracket, which remains stationary, the sight pointer arm turns again by a new angle equal to tangent elevation. Angle of sight and T.E. are therefore added together. The gun is finally laid for elevation by bringing the cradle pointer arm, which has not moved, into coincidence with the sight index arm.

iv. *The cross levelling bubble* on the dial sight corrects for difference in level of the platform, but not for drift. Corrections for drift are given in Appendix J.

v. *The elevation pointer and cradle pointer* are coincident when the gun is properly laid in elevation.

vi. *The panoramic dial sight* used is either Rundblickfernrohr 16 (Rbl. F.16) which is described in Section I, para. 8, or Rbl. F.32, which is described in Section III, para. 6.

7. Recoil system

The recoil system is similar to the 10·5 cm. l.F.H.18 recoil system described in Section III, para. 7.

8. Detachment

The service of the gun is divided among the German detachment as follows :—

Detachment commander.
No. **1** operates the sights.
No. **2** operates the breech.
No. **3** rams.
No. **4** operates elevating gear.
No. **5** ammunition number.
No. **6** ammunition number.
No. **7** loads.
No. **8** loads.

Sequence of drill is :—

The detachment commander orders type of ammunition and fuze, charge, range (elevation in mils), and type of fire.

No. **1** lays on the aiming point, while No. **5** doubles to the director, No. **7** or **8** loads.

On No. **3**'s order " In," No. **7** or **8** pushes the shell home with the rammer. No. **5** or **6** loads a cartridge, ensuring that the primer is properly screwed home.

No. **2** closes the breech.

No. **3** holds the rammer and assists No. **4** with the elevating gear.

No. **1** lays accurately for line.
On the order " Fire," No. **2** grasps the lanyard and fires.
No. **2** opens the breech, catches the cartridge case, and throws it to No. **5** or **6.**

V.—15 cm. (5·9 in.) Heavy Infantry Howitzer (15 cm. s.I.G. 33)

(*See* Figs. 28-29)

1. General

The 15 cm. s.I.G. 33 is a standard German infantry support weapon. It fires a H.E. shell with a percussion fuze, or a smoke shell, and is used for high or low trajectory shooting. The gun may be horse or tractor drawn. Versions exist on either artillery or rubber-tyred wheels.

A range table for use with the H.E. shell is at Appendix K.

2. Data

i. *Ballistic characteristics* (83·6 *lb. H.E. shell with percussion fuze s.Igr.Z.*23)

(*a*) *Lower register.*

Charge	Max. range Yards	M.V. f.s.	50 per cent. zone Length Yards	50 per cent. zone Breadth Yards	Time of flight Secs.	Weight of charge Oz.	Drift Degs.
I	1,613	410	21	3·5	16·6	6	1·69
II	2,324	500	29·5	3·5	20·4	9·5	1·69
III	3,281	610	42·5	3·5	23·2	13·5	1·52
IV	4,101	690	52·5	4·5	26·7	17	1·58
V	4,785	750	62·5	4·5	29·1	20	1·63
VI	5,140	790	66·5	5·5	30·6	21·5	1·69

(*b*) *Upper register.*

Charge	Min. range Yards	M.V. f.s.
I	1,012	410
II	1,449	500
III	2,023	610
IV	2,515	690
V	2,925	750
VI	3,117	790

ii. *The gun and carriage*

Calibre ... ...
Length of piece ... ...
Maximum elevation ... ...
Maximum depression ... ...
Traverse ... ...
One turn of elevating handwheel ...
One turn of traversing handwheel ...
Rifling (44 grooves, twist 8° constant)
Width of grooves ... ...
Depths of grooves ... ...
Diameter of wheels ... ...
Width of wheels ... ...

0

50 per cent. zone		Drift Degs.
Length Yards	Breadth Yards	
43·5	10	2·81
47	12	3·66
47	15·5	4·50
46	17·5	5·07
47	18·5	5·57
47	18·5	5·91

...	149·1 mm.	5·87 ins.
...	1,640 mm. (11 cals.)	64·57 ins.
...	+1,300 mils.	73°.
...	−0 mils.	− 0°.
...	200 mils.	11° 15′.
...	12 mils.	41′.
...	2·2 mils.	7′.
...	6·64 mm.	0·26 in.
...	1·5 mm.	0·06 in.
...	1,100 mm.	43·30 ins.
...	160 mm.	6·30 ins.

To face page 90

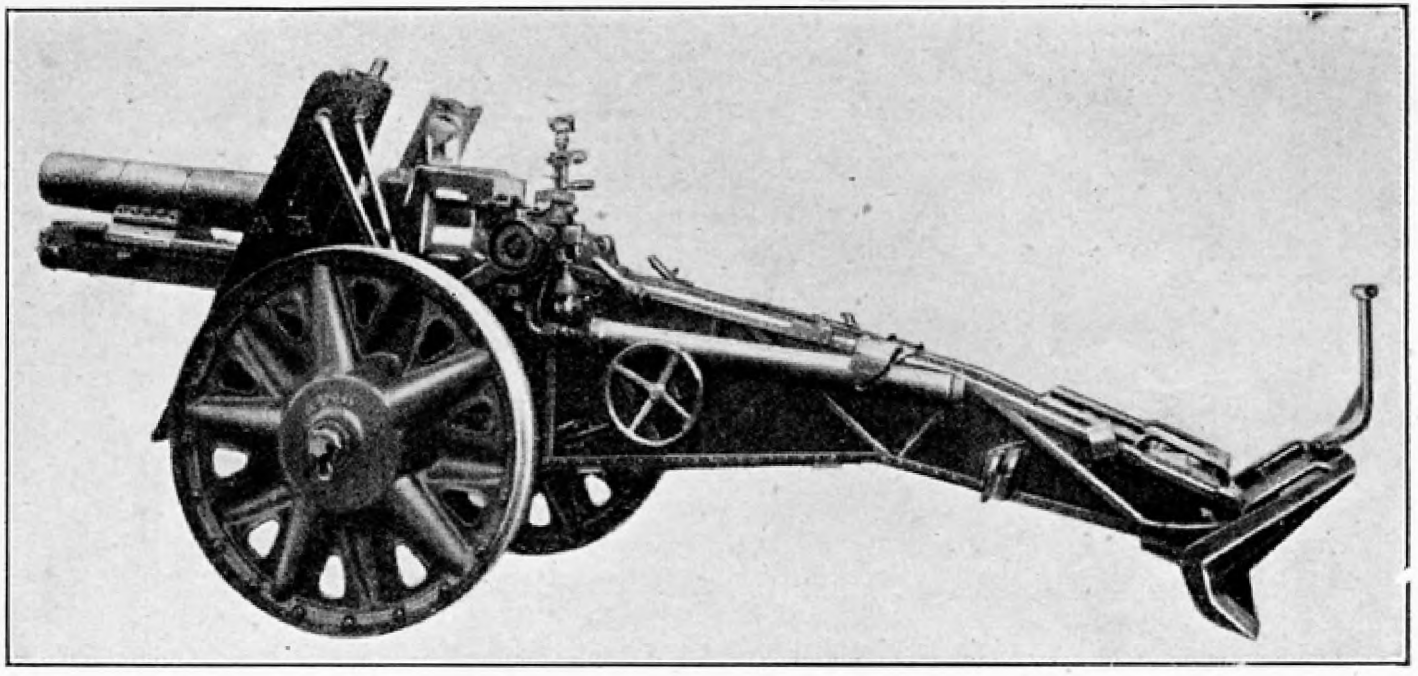

FIG. 28.—15 CM. (5·91 IN.) HEAVY INFANTRY HOWITZER (15 CM. s.I.G.33)

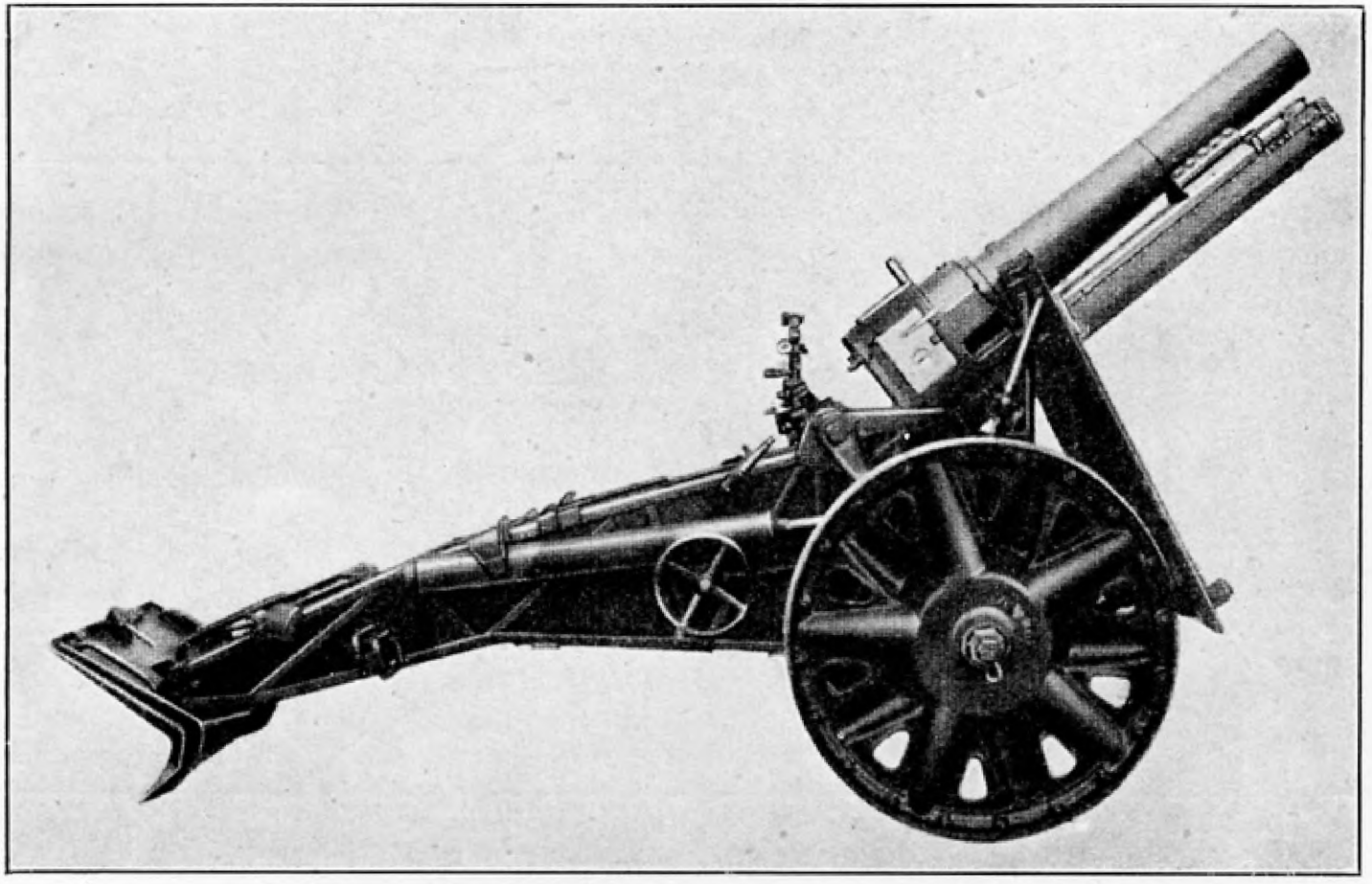

FIG. 29.—15 CM. (5·91 IN.) HEAVY INFANTRY HOWITZER (15 CM. S.I.G.33)

iii. *The ammunition*

The ammunition is separate. Two types of H.E. shell are fired, the 15 cm. I.Gr. 33 and the 15 cm. I.Gr. 38. These are for all practical purposes identical, except that the former has a screwed-in baseplate. The only other shell that this weapon is known to fire is a smoke shell, 15 cm. I.Gr. 38 Nb. The same percussion fuze, s. I.Gr. Z. 23, which weighs ·75 lb., is used in each case.

(*a*) *H.E. shell.* (15 cm. I.Gr. 33 and 38)

Weight of projectile	38 kg.	83·6 lb.
Weight of H.E. filling	8·3 kg.	18·26 lb.
Packing :—		
One projectile in basket—Weight packed... ...	41 kg.	90 lb.

(*b*) *Smoke shell.* (15 cm. I.Gr. 38 Nb.)

Weight of projectile	38·50 kg.	85 lb.
Weight of chemical filling	2·24 kg.	5 lb.
Packing :—		
One projectile in basket—Weight packed	41·50 kg.	91 lb.

3. The breech mechanism

The breech mechanism is similar to the 10·5 cm. 1.F.H. 18 breech mechanism described in Section III, para. 3.

4. The carriage

i. *The carriage* is of the box trail type. It is fitted with a fixed spade and is also provided with an attachable sand spade. Towards the front are the trunnion bearings which receive the trunnions of the cradle, and there is a spring compensator on each side-piece. The elevating handwheel is mounted on the right of the carriage and the traversing handwheel on the left. A shield is fitted at the front, and a box for spares at the rear.

When travelling the cradle is secured by a clamp to the carriage, to the centre of which the sand spade is also secured.

ii. *The cradle* is trough-shaped and is provided with guide ways in which guides on the gun move as it recoils and runs out. On either side at the front is a pad to receive the unabsorbed force of run-out and between the pads is the expansion chamber, which receives the buffer fluid forced from the buffer by expansion as it becomes heated. Towards the rear are the two cradle arms to which the trunnions are fixed. Each trunnion is provided with a cranked compensator lever which compresses the compensator spring.

The elevating arc is secured underneath and the recoil indicator at the right rear. The latter is marked with graduations from 1,170 to 1,200 and the words ACHTUNG (caution) and FEUER-PAUSE (stop).

iii. *The clamp* is at the front of the carriage, and is operated by a lever secured to the clamp shaft.

iv. *The elevating gear* is operated from the right of the carriage. It consists of a worm gearing, rack, pinion, and shafting.

v. *The traversing gear* is operated from the left by a system of gear wheels and shafting.

vi. *The spring compensators* are fixed longitudinally one on each side of the carriage. They neutralize muzzle preponderance at all angles of elevation.

vii. *The sight* is the Zieleinrichtung 34, which is described in Section IV, para. 6.
The panoramic dial sight, Rbl.F. 32, is described in Section III, para. 6.

5. Recoil system

Both buffer and recuperator are housed in a casing underneath the barrel. The recoil system is similar to that of the 10·5 cm. l.F.H. 18 described in Section III, para. 7.

The only points of difference are :—

i. A greater complexity of the packing at the rear of the buffer cylinder.

ii. The expansion chamber of the buffer is outside the buffer itself, and is connected to it by a pipe.

iii. No cooling cylinder is provided.

APPENDIX A

NOTES ON THE USE OF GERMAN SIGHTS

1. Angles

The angles used are :—

i. The MIL, called in German STRICH (symbol . . .‾‾) of which there are 6,400 to a circle. TAN 1‾‾ = ·001 (this is used in measuring any kind of angle).

ii. The DEGREE, subdivided into sixteenths, which is used for tangent elevations on some equipments, particularly A.A. equipments.

2. Types of dial sights

i. Rundblickfernrohr 32—Rbl.F. 32 (Panoramic telescope 32) used with field and medium equipments as well as the 8·8 cm. multi-purpose gun (for indirect laying).

This has a slipping scale on the dial, graduated in mils, black from 0 to 32 (anti-clockwise) and red from 0 to 32 (clockwise).

The slipping scale on the micrometer is graduated in mils from 0 to 100 anti-clockwise in black, and clockwise in red.

ii. Rundblickfernrohr 16—Rbl.F. 16 (Panoramic telescope 16). This has no slipping scales.

The sight clinometer bubble and the cross-levelling bubble are carried on the dial sight and seen in a mirror.

iii. Rundblickfernrohr 10—Rbl.F. 10.

This obsolescent type has no slipping scales and no levelling bubble.

All German dial sight main scales and micrometer scales are the same. The main scale is graduated anti-clockwise in hundreds of mils, from 0 to 64, numbered every 200 mils. The micrometer scale is graduated in mils from 0 to 100, numbered every 10 (anti-clockwise in black, clockwise in red).

As the black anti-clockwise graduation moves against a fixed index, any increase in deflection moves the gun to the left.

This rule applies to American and to almost all continental equipments.

3. Drill for laying the original line

with any of the above dial sights.

i. Calculate the gun angle in degrees and minutes by any of the usual methods (aiming point, individual angles, T.O.B.).

ii. Convert to mils using one of the simple rules given in Appendix B,

iii. Set the hundreds of mils on the dial using the black graduation.

iv. Set the residue in mils on the micrometer, turning it clockwise from zero and using the black graduation.

4. Switches

Convert to mils.

For the sake of simplicity, in observed shooting, switches of more than 1 degree need only be converted to the nearest 5 mils.

To avoid errors, apply all switches on the micrometer. One full turn equals 100 mils (approximately 6 degrees). Each graduation equals 1 mil (approximately 3½ minutes).

MORE switches turn AWAY (RED graduations).

LESS switches turn TOWARDS (BLACK graduations).

There is one micrometer only.

Take no notice of MEHR (more) and WENIGER (less) as the Germans order MEHR to switch the gun to the left.

5. Angle of sight

The sight carrier usually has a graduation in hundreds of mils on each side of 300 which corresponds to angle of sight zero. Red graduations are for angles of depression.

A micrometer is graduated from 0 to 100. Move the graduation towards TIEFER for angles of depression.

6. Tangent elevations

On field and medium equipments, the range drum is graduated in mils to the left, and in metres for one particular charge. The index slides from one to the other.

Metres equal yards less 10 per cent.

7. Drill for laying with field guns

No **3**—sets the angle of sight and range (in mils or metres) ;
—roughly centres the sight clinometer bubble by turning the half spherical knurled knob, underneath the sight carrier ;
—cross levels, using the knob at front left of sight carrier ;
—lays : accurately for line,
accurately for elevation on the sight clinometer ;
—reports : " Ready."

This process tilts the sight bracket and moves an arm with an index at its extremity. Another arm with a similar index pivots in elevation with the gun.

No. **2**, by means of the elevating handwheel, brings both index marks into coincidence and announces : " Set."

APPENDIX B

GERMAN SYSTEM OF ANGULAR MEASUREMENT

The unit of angular measurement used in most German sights and fire control instruments is the conventional mil, which is a convenient approximation to a mathematical unit known as the radian mil. There are 6,400 conventional mils in a full circle; one conventional mil, therefore, equals 0·0563 degrees or 3·375 minutes.

The mil is a convenient unit for artillery purposes, since 1 mil, at any range, subtends a distance approximately equal to 1/1000 of the range. Fig. 30 shows the relationship of degrees and minutes to conventional mils. It will be seen from this diagram that :—

27 minutes = 8 mils.
9 degrees = 160 mils.
360 degrees = 6400 mils.

Useful slide rule settings can be obtained from the above figures. For example, to find the number of mils equal to 40 minutes, set 27 on scale A of the slide rule opposite 8 on scale B. Move the cursor to 40 on scale A, and read off 12 mils (approximately) from scale B. To find the number of degrees and minutes corresponding to 96 mils, set 9 on scale A opposite 160 on scale B. Move the cursor to 98 on scale B and read off 5·5 degrees (i.e. 5 degrees 30 minutes) from scale A.

Another method of converting degrees to mils, based on the approximation 1 degree = 17·8 mils, is to multiply the number of degrees by 20 and then subtract 11 per cent. in two stages :—

	23	degrees
Multiply by	20	
	460	
Subtract	46	
	414	
Subtract	4·6	
	409	mils

CONVERSION DIAGRAM

(Conv^{l} Mils to Degrees & Minutes)

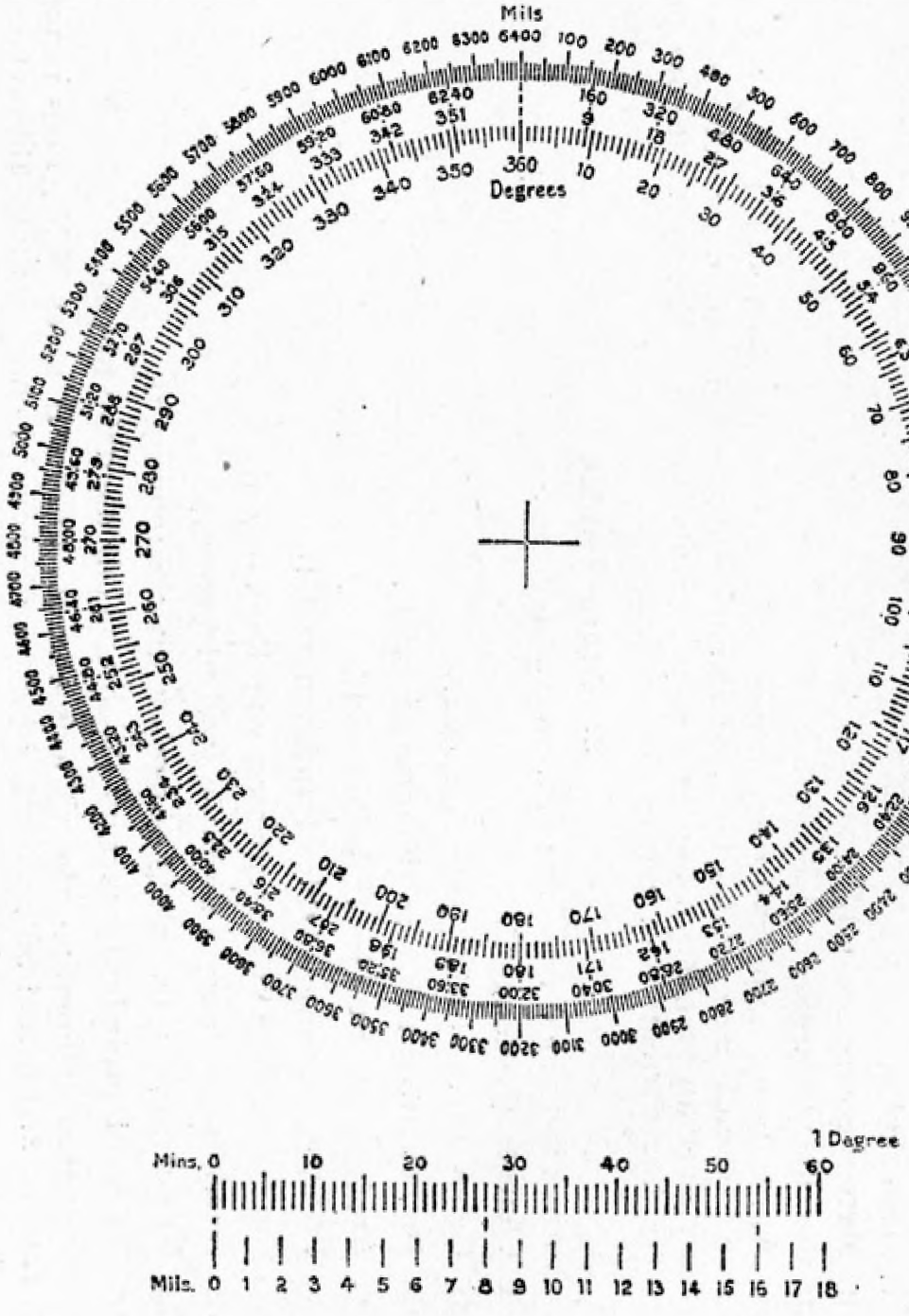

FIG. 30

APPENDIX C

THE USE OF GERMAN RANGE TABLES

1. General

1. German range tables are compiled in four main parts :—

i. Main tables.

ii. Meteor correction tables.

iii. Auxiliary tables.

iv. Appendices ; supplementary range tables for smoke shell and T and P fuze.

The unit of measurement for line and elevation is the mil. M.V. corrections are estimated in a specifically German manner, using the " step " (Stufe) as unit. Special tables are provided giving the corresponding correction in metres.

2. Main Tables

These are subdivided into nine sections, as follows :—

i. Charges (Ladungen).

ii. General data (Allgemeine Angaben).

iii. Immediate firing data (Kommandotafel).

iv. Angle of sight tables (Libellentafel).

v. Position correction tables (Staffelungstafel).

vi. Crest clearance (Überschiessen von Deckungen).

vii. Cover from observation table (Sichtdeckung).

viii. 50 per cent. zone tables (Angaben über Streuungen).

ix. Table of probability factors (Wahrscheinlichkeitsfaktoren).

i. This section enumerates the various charges fired. It gives M.V., map range, T.E., short bracket, time of flight, and 50 per cent. zone for the several charges in an abbreviated form.

ii. This section gives data about the gun and its ammunition, including types and weight of shell, fuzes used, effective areas of burst and details of propellant used with the charges. The final paragraph gives the conditions under which the tables were compiled, including the barometric pressure and charge temperature. These are 1·22 kg/cbm (2·68 lb. per cub. ft.) and plus 10 degrees C. respectively.

iii. This section gives the following information (for each charge) for map ranges every 50 metres :—

Col. 1.—Range (Entfernung) in metres.
Col. 2.—T.E. (Erhöhung) in mils. These take jump into account and are the results of experimental shooting.
Col. 3.—Short bracket (Enge Gabel) in mils—equal to approximately 100 metres.
Col. 4.—Correction for drift (Seitenverschiebung) in mils. German sights do not compensate for drift.
Col. 5.—Fuze setting (Zünderstellung).
Col. 6.—Time of flight (Flugzeit) in seconds.
Cols. 7-9.—Displacement of point of burst for one point setting of fuze key.
Col. 10.—Remaining velocity (Endgeschwindigkeit) in metre-seconds.
Col. 11.—Angle of descent (Fallwinkel).

iv. Angle of sight tables. The angle given is the angle of sight plus non-rigidity of trajectory correction : hence tables are given for each charge. Angles of elevation are given in black, angles of depression in red. (The sight clinometer is graduated from 100 to 500 mils : 300 mils=A/S zero.)

v. Position correction tables. This table gives the necessary correction to range in mils (added to A/S) according to the distance in metres between the pivot gun and the remaining guns *measured in the line of fire.*

vi. Crest clearance. This table gives the minimum elevation in mils necessary to clear the crest. The left-hand column gives distance from gun position to crest. The six centre columns give the elevation in mils to be added to the angle of sight to crest for the various charges when

safety of own troops is in question. The extreme right-hand column gives necessary additional elevation when there is no question of endangering own troops.

vii. Cover from observation (of gun position). This section gives for charges 1 to 4 the minimum height of cover under which smoke by day and flash by night will be invisible to enemy. A chart for calculation of " cover figure " (in metres) is appended at end of range tables. Data required are :—

1. Range from enemy occupied crest to crest before gun position DE.
2. Difference in height between enemy occupied crest and gun position crest FE.
3. Height of gun position crest DH (=AG).
4. Horizontal distance from gun position crest to gun position.

The required formula is BG=DH (=AG)−AB.
AG is known, AB is found from the two charts in the manner shown in an example in red in the range tables. If BG is less than figures given, then gunfire may be reckoned as visible to enemy.

viii. 50 per cent. zone data. This table gives the 50 per cent. length, breadth, and height zone for the various charges at different ranges.

ix. Table of probability factors.

3. Tables giving corrections for meteorological conditions and abnormalities in shell and propellent

These tables fall into three parts with an introductory note on graphic wind analysis.

Introductory note. (This gives a rough and ready method of converting compass bearings into " wind figures.")

i. Wind analysis (Windzerleger).

ii. Calculation of air pressure (Luftgewichtsberechnung in kg/cbm).

iii. Correction figures for each charge. (Verbesserungswerte für Ladungen 1–6).

i. *Wind analysis.*—This table breaks up the wind into its ballistic components. The data necessary are (*a*) the velocity of the wind in metre-seconds (*see* 4 centre columns) (*b*) the difference between the bearing of the wind and the bearing of the line of fire in " wind figures " (*see* right and left-hand columns). The results given are the wind velocities in metre-seconds as they effect line (Querwind—crosswind) and range (Längswind—head/following wind). " Wind figures " may be obtained by three methods :—

(*a*) Wind chart in introductory note.

(*b*) Division of bearings in mils by 200.

(*c*) Multiplication of bearings in degrees by 0·09.

Example of wind analysis :—
Bearing of wind in mils=4094.
Bearing of line of fire=4726.
4094+6400−4726=5768 mils.
$\frac{5768}{200}$=29 "wind figure."
From tables : for a wind figure of 29 and a velocity of 6 m.s. :—
Head/following wind= +5 m.s.
Cross wind = +3 m.s.

ii. *Tables for calculation of air density.*—These give the air density in kg. per cubic metre for a known temperature in degrees Centigrade (left-hand column) and a known barometric pressure in millimetres (top headings of centre columns). 1 mm. should be subtracted for every 11 metres difference in height between gun position and mean sea level.

To convert barometric pressure (Luftdruck) from inches to cubic centimetres multiply by 25·4.
Example : BAR 30·60 ins. Height, 125 metres. Air temperature, 14·4° C. (58° F.).
30·60×25·4=777 mm.−11 mm. (for height of gun position).
From tables, air density=1·23 kg./cbm.

iii. *Additional corrections for each charge*

Table A.—Left-hand column gives range, top headings centre columns give head/following wind component (*see* (i) above) correction in metres.

Table B.—Left-hand column gives range, top headings give cross-wind component ; correction given in mils.

Table C.—First table here gives the figure, according to shell weight class, by which air density must be altered (by addition or subtraction). The second table gives the correction for air density in metres. Left-hand column is range, top headings are calculated air density (*see* (ii) above and first table here).

Table D.—The first three tables give corrections in " steps " for charge temperature (top headings), shell weight class, flash eliminating compound ; the final table converts these steps into metres. Final T.E. (map range plus corrections) found from Part I, Section 3, Col. 2 of the German range tables.

4. Auxiliary tables

These are subdivided into seven sections as follows :—

i. Angular conversion table (Winkeltafel).

ii. Slope factor (Hangfaktor) for 50 per cent. zone.

iii. Flank observation angle (Schiessen mit seitlicher Beobachtung).

iv. Influence of humidity of charge on M.V. (Einfluss der Pulverfeuchtigkeit auf die Anfangsgeschwindigkeit).

v. Calculation of " steps " from measured M.V. (Ermitteln der Grundstufe).

vi. Table of rough penetration figures (Uberschlägigen Eindringungstiefen).

vii. Additional angle of sight corrections (Zusatzlibellenwerte).

i. *Angular conversion table.*—This is a useful table giving the tan, sine and degree equivalents of mils from 10 to 1,200.

ii. *Slope factor for* 50 *per cent. zone.*—This is a table for determining the length of the 50 per cent. zone on a rising or falling slope. On the table, the left-hand column gives distances in metres between adjacent contour lines (i.e. 20 m. difference in height) on the map; the right-hand column, subdivided into nine sections, gives angles of descent from 100 to 900 mils (5° 37′ to 50° 33′). Black figures are for rising slopes, red for falling slopes. For example, if the distance between two adjacent 20 m. contour lines is 150 m., the angle of descent is 200 mils, and the 50 per cent. is 30 m., then the 100 per cent. zone on a rising slope is $0{\cdot}60 \times 30 = 18$ m., on a falling slope $3{\cdot}06 \times 30 = 91{\cdot}8$ m.

iii. *Flank observation.*—This table gives the alteration of deflection in mils required for an alteration of 100 metres in elevation during O.T. ranging.

iv. *Table for the influence of humidity of charge on M.V. in "steps."*—This table shows the differences in M.V. brought about by varying degrees of humidity in the charge. The normal humidity of Digl. P. and Ngl. P. is given as ·4 per cent.

v. *Calculation of M.V. corrections in "steps" from measured M.V.*—Table A gives for each charge the basic "step" for calculating the correction for loss of M.V. Table B gives the M.V. correction in "steps" to be added to angle of sight :—

e.g. Charge V. Measured M.V. at 50 metres 385·5 m.s.
Addition (table A) ... ... 2·7

Measured M.V. ... ... 388·2
Loss of M.V. from normal $391 - 388{\cdot}2 = 2{\cdot}8 = 3$.
M.V. correction (*see* table B) = 2.

(Right-hand column of table B gives differences between measured and range table M.V.)

vi. *Rough penetration figures.*—This table gives rough penetration figures of concrete, earth, etc., according to striking velocity of rounds.

vii. *Additional angle of sight corrections.*—This table shows for each charge the correction to angle of sight corresponding to the " steps " (referred to in sub-para. v above) for every 100 mils increase of T.E. After calibration a table is fixed to the shield on which are entered data from this table ; these corrections are then added by the layer to the A/S ordered.

5. Appendices

i. Data for firing with smoke shell (F.H.Gr.Nb.).

This appendix is divided into three parts as follows :—

(*a*) General data concerning smoke shooting with F.H.Gr.Nb. (smoke shell).

(*b*) Table of corrections to T.E. given in para. 2, column 2.

(*c*) Table of T.E. for smoke shooting with fuze A.Z. 23 Nb. (percussion fuze).

ii. Data for firing with T and P fuze Dopp. Z. S./60 Fl.

This appendix falls into two parts :—

(*a*) General data explaining use of tables A and B.

(*b*) Tables A and B for use with fuze Dopp. Z. S/60 Fl.

Time of flight for a given range is found from column 6, para. 2, according to charge used. The correct fuze setting for S/60 Fl. fuze is found by combining table A and table B. In A, correct setting in whole seconds up to 60 secs. is given ; in B, the necessary additions for 1/10 secs.

II. Example showing calculation of " special and meteor " corrections

The following example may prove useful in illustrating the method of consulting German range tables ; the meteorological corrections are worked out on the basis of figures taken from British measurements in order to exemplify the various conversion factors.

1. Data

Charge	V	Air temperature... ...	58°F.
Bg. of line of fire ...	265° 30′	Bar, pressure	30·€0
Range	5,000 m.	Bg. of wind	230°
Height of gun posn.	125 m.	Velocity of wind ...	6 m.s.
Height of target ...	180 m.	Charge temp.	72°F.
Measured M.V. ...	385·5 m.s.	Shell class	Class IV
Humidity of charge	30 per cent. less than normal (dry)	Flash eliminating charge	

2. Immediate or uncorrected data for laying

T.E. = 240 mils.

A/S = 312 mils. (N.B.—this is the setting on the sight clinometer, including non-rigidity correction = actual angle of sight = 12 mils (40′)).

3. Corrections

i. *Meteor.*

(*a*) Wind figure. 230° + 360° − 265° 30′ = 324° 30′

324° 30′ × ·09 = 29·8 = wind figure.

Wind velocity = 6 m.s.

Therefore wind components (p. 120) = +6 m.s. head wind.
+2 m.s. cross wind.

(*b*) Air density.

Air temp. = 33°F. = 58–32 × $\frac{5}{9}$ = 14·4°C.

Bar press. = 30·60 in. = 30·€0 × 25·4 = 777 mm.

Correction for height of gun position = 11 mm.

Therefore air density (p. 125) = 1·23 kg/cbm.

(*c*) Range correction for head wind (p. 141).
Range of 5,000 m. head wind+6 m.s. give **+80 m.**

(*d*) Line correction for cross wind (p. 142).
Range of 5,000 m. cross wind+2 m.s. give **more 1 mil.** (i.e. gun traverses to left).

(*e*) Air density correction.
Alter air density figure in 3 (ii) above by −0·02 kg./cbm. for shell weight IV (p. 143).
Therefore final air density=1·23−·02=1·21 kg./cbm.
Therefore correction for air density in metres (p.143)= **−10 metres.**

ii. *Non-meteorological corrections.*

1. Charge temperature=72°F.=72−32×$\frac{5}{9}$=22·9°C.
Correction in " steps " **−2** (p. 144 top table).

2. Shell weight class correction.
Class IV gives +3 " steps " (p. 144 second table).

3. Flashless charge table gives **+2 " steps."**

To these we must add two further corrections in " steps " :—

4. Charge humidity. Table on p. 156 gives for 30 per cent. diff. from normal (dry) **−2 " steps."**

5. M.V. corrections. Measured M.V.=385·5=" basic " correction (table (*a*) p. 157)=2·7.
Therefore corrected measured M.V.=388·2 m.s.
Range table M.V. Charge V (p. 17)=391 m.s.
Difference between corrected measured M.V. and Range Table M.V.=2·8 i.e. 3.
Therefore correction in " steps "= **+2** (table (*b*) p. 157).
Therefore total correction in " steps "= −2+3+2−2+2 = +3 " steps."
Convert steps to metres= +55 metres (final table p. 144).

Range : Total corrections in metres = +80 −10+55=125.
Corrected map range = 5,125 metres.
Corrected T.E. = 248 mils.
Line : Total corrections in mils=original line +1+6 (for drift)= +7.

III. Comparative table of British and German range tables

Part in G.R.T.	Table or Subject	Location British	Location German
I	Range	Part I, cols. 9 and 17	Part I, sect. 3, col. 1
	T.E. (A. of P. in British)	Part I, col. 8	Part I, col. 2
	Short bracket...	—	Part I, col. 3
	Drift correction	Part I, col. 18	Part I, col. 4
	Fuze setting	—	Part I, col. 5
	Time of flight...	Part I, col. 10	Part I, col. 6
	Remaining velocity	Part I, app. 1	Part I, col. 10
	Angle of descent	Part I, app. 1	Part I, col. 11
	Angle of sight	Part II, sect. 2e	Part I, sect. 4
	Position correction tables	Part II, sect. 2e	Part I, sect. 5
	Crest clearance	Part I, app. 5	Part I, sect. 6
	Cover from view	Part II, sect. 4	
		—	Part I, sect. 7
	50 per cent. zones	Part I, cols. 1 and 2.	Part I, sect. 8
	Probability factor	Part II, sect. 6	Part I, sect. 9

Part in G.R.T.	Table or Subject	Location British	Location German
II	Wind correction table	Part I, app. 2	Part II, sect. 1
	Air density	—	Part II, sect. 2
III	Angular conversion table	Part II	Part III, sect. 1
	Slope factor (50 per cent. zone)	—	Part III, sect. 2
	Flank observation corrections	Part II, sect. 5	Part III, sect. 3
	Influence of humidity on M.V.	—	Part III, sect. 4
	M.V. corrections	Part I, app. 4	Part III, sect. 5
	Rough penetration figures	—	Part III, sect. 6
	A/S corrections (for table on shield) ...* ...	—	Part III, sect. 7
IV	Corrections for smoke shell	Part I, Suppl. R.T.	Part IV, app. I
	Corrections for T and P fuze	—	Part IV, app. II

Notes.—Although these notes have been compiled on the basis of range tables for the German 10·5 cm. gun-howitzer, the 10·5 cm. 1.F.H.18, it will be found that the general principles and layout are similar in range tables for other equipments.

IV. Conversion factors

i.	Mils to degrees	Multiply by	·05625
	Mils to minutes	,, ,,	3·375
ii.	Degrees to mils	,, ,,	17·7778
	Minutes to mils	,, ,,	·2963

iii. To obtain " wind figures " : these are actually two hundreds of mils, and may be found in three ways :—

(*a*) from wind chart (range tables—prefix Part III) ;

(*b*) if bearing is given in mils, divide by 200 ;

(*c*) if bearing is in degrees, multiply by ·09.

iv. Barometer pressure from inches to mm., multiply by 25·4.

v. Fahrenheit to Centigrade, subtract 32 multiply by $\frac{5}{9}$.

vi. Feet seconds to metre seconds, multiply by ·305.

vii. Metre seconds to feet seconds, multiply by 3·28.

APPENDIX F

Ground Range Table for 8·8 cm (3·46 in.) Multi-Purpose Gun firing A.P. Shell with base fuze (8·8 cm. Pzgr. mit Bd. Z)

M.V.=2657 f.s. Weight of shell=20 lb. 12 oz.

Range		T E. (16ths degree)	Time of flight secs.	50 per cent. zone		Remaining velocity ft./sec.
M.	yds.			Height ins.	Width ins	
100	109	0^{1}	0·12	—	—	2625
200	219	0^{1}	0·25	7·9	3·9	2592
400	437	0^{3}	0·49	11·9	7·9	2526
600	656	0^{4}	0·74	15·7	7·9	2467
800	875	0^{6}	1·00	19·7	11·9	2405
1000	1094	0^{7}	1·25	27·6	15·7	2349
1200	1312	0^{9}	1·52	31·5	19·7	2297
1400	1531	0^{11}	1·80	39·4	19·7	2241
1600	1750	0^{12}	2 08	47·3	23·6	2192
1800	1969	0^{14}	2·37	55·1	27·6	2139
2000	2187	1^{0}	2·68	63·0	31·5	2090
2200	2406	1^{2}	2·98	70·9	35·4	2044
2400	2625	1^{4}	3·30	78·7	35·4	1995
2600	2843	1^{6}	3·62	86·6	39·4	1952
2800	3062	1^{8}	3·96	94·5	43·3	1906
3000	3281	1^{10}	4·31	106·2	47·2	1867
3200	3500	1^{12}	4·67	122·0	51·1	1827
3400	3718	1^{15}	5·05	137·8	55·1	1785
3600	3937	2^{1}	5·44	153·5	59·0	1749
3800	4156	2^{3}	5·84	173·2	63·0	1709
4000	4374	2^{6}	6·25	196·9	66·9	1673

NOTE.—Correction for drift :—± 0 mils. from 100–1700 m.; + 1 mil from 1800–3800 m.; + 2 mils from 3900–4000 m.

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To face page 65

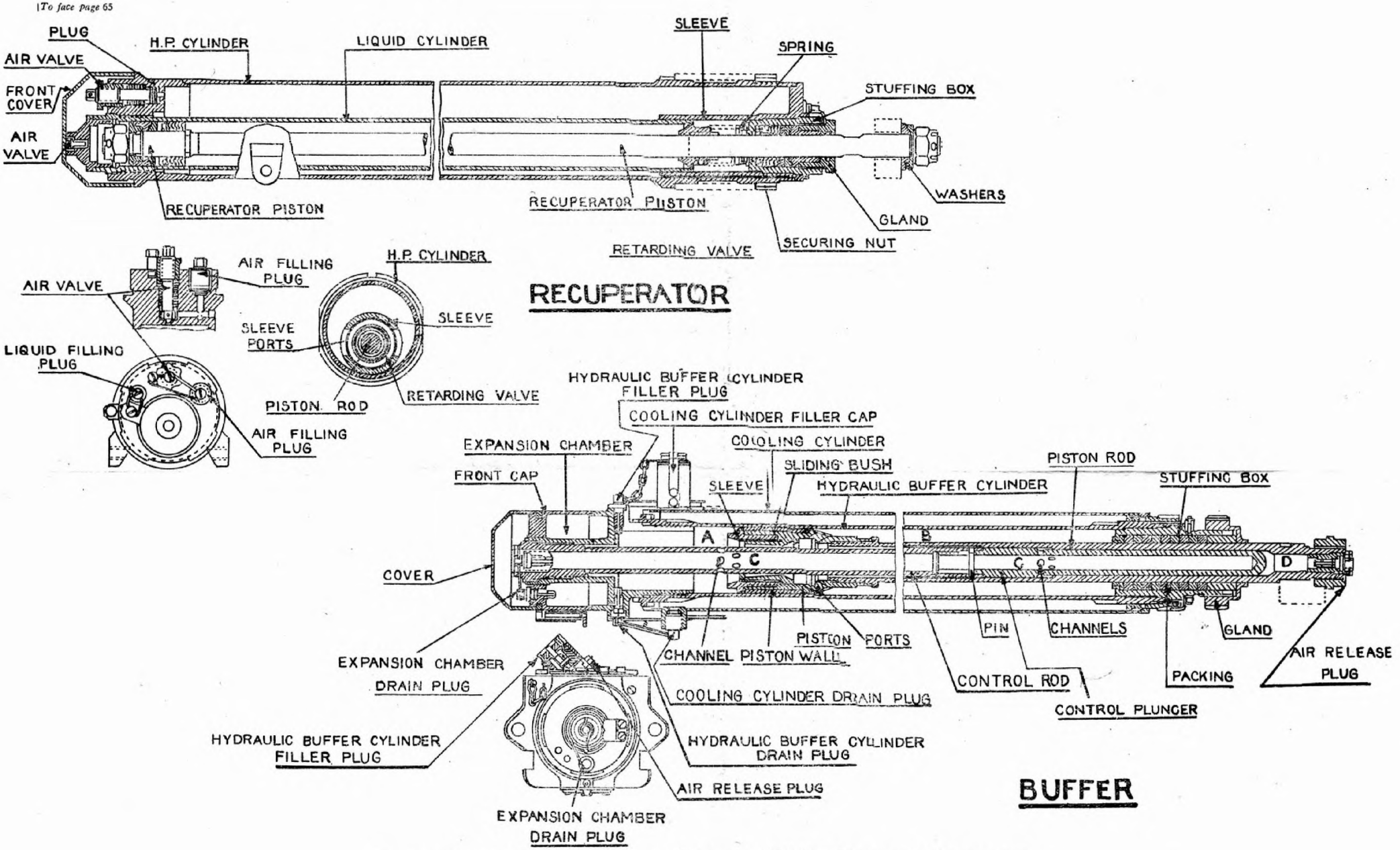
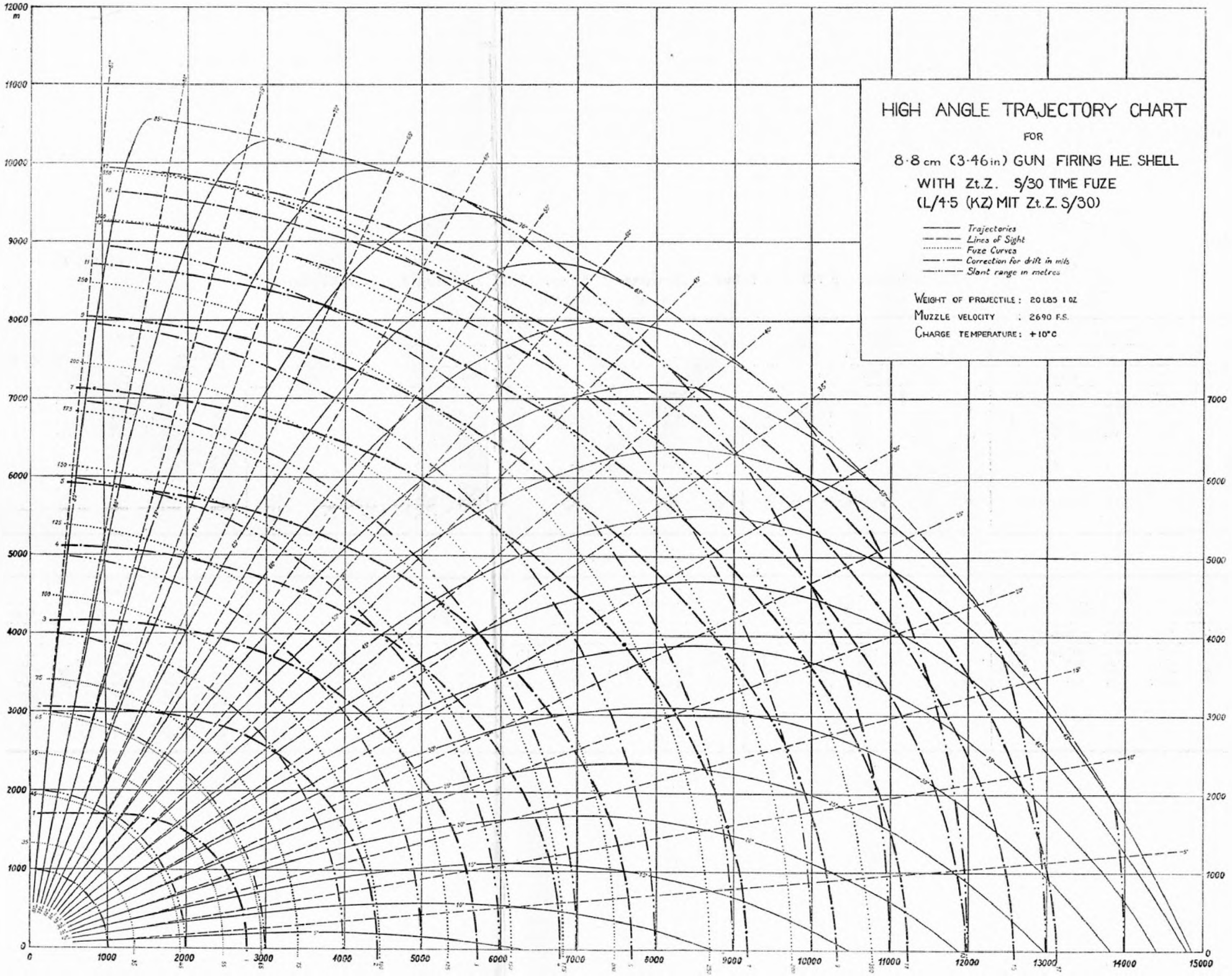


FIG. 26.—10·5 CM. (4·14 IN.) GUN-HOWITZER 10·5 CM. (I.F.H.18).—BUFFER AND RECUPERATOR


HIGH ANGLE TRAJECTORY CHART
FOR
8·8 cm (3·46 in) GUN FIRING H.E. SHELL
WITH Zt.Z. S/30 TIME FUZE
(L/4·5 (KZ) MIT Zt.Z. S/30)
Trajectories
Lines of Sight
Fuze Curves
Correction for drift in mils
Slant range in metres
WEIGHT OF PROJECTILE : 20 LBS 1 OZ
MUZZLE VELOCITY : 2690 F.S.
CHARGE TEMPERATURE : +10°C
m
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
13000
14000
15000

Range Table for 7·5 cm. Infantry Howitzer (7·5 cm. I.I.G. 18) firing 12 lb. H.E. Shell

LOWER REGISTER

Charge 1					Charge 2					Charge 3					Charge 4					Charge 5				
Range		T.E.		Fuze	Range		T.E.		Fuze	Range		T.E.		Fuze	Range		T.E.		Fuze	Range		T.E.		Fuze
Met.	Yds	Mils.	Degs.		Met.	Yds.	Mils.	Degs.		Met.	Yds.	Mils.	Degs.		Met.	Yds.	Mils.	Degs.		Met.	Yds.	Mils.	Degs.	
200	218·5	110	6°	24	200	218·5	77	4° 30′	23	200	218·5	52	3°	—	200	218·5	29	1° 30′	—	1400	1531	160	9°	—
400	437·5	238	13° 30′	38	400	437·5	165	9° 30′	33	400	437·5	113	6° 30′	29	400	437·5	67	4°	25	1600	1750	186	10° 30′	—
600	656	386	21° 30′	52	600	656	260	14° 30′	44	600	656	177	10°	38	600	656	105	6°	32	1800	1968·5	214	12°	—
800	875	598	33° 30′	71	800	875	367	20° 30′	57	800	875	244	13° 30′	48	800	875	143	8°	40	2000	2187	243	13° 30′	70
850	929·5	704	39° 30′	79	1000	1093·5	505	28° 30′	72	1000	1093·5	316	18°	58	1000	1093·5	183	11°	47	2200	2406	274	15° 30′	77
					1150	1257·5	690	39°	90	1200	1312·5	400	22° 30′	70	1200	1312·5	224	12° 30′	55	2400	2624·5	307	17° 30′	85
										1400	1531	509	28° 30′	83	1400	1531	268	15°	63	2600	2843·5	344	19° 30′	92
										1600	1750	762	43°	110	1600	1750	317	18°	71	2800	3062	387	22°	101
															1800	1968·5	372	21°	80	3000	3281	437	24° 30′	111
															2000	2187	437	24° 30′	91	3200	3499·5	498	28°	123
															2200	2406	518	29°	103	3400	3718·5	579	32° 30′	138
															2400	2624·5	643	36°	121	3550	3882·5	688	38° 30′	156
															2450	2679	702	39° 30′	128					

UPPER REGISTER

Charge 1					Charge 2					Charge 3					Charge 4					Charge 5				
Range		T.E.		Fuze	Range		T.E.		Fuze	Range		T.E.		Fuze	Range		T.E.		Fuze	Range		T.E.		Fuze
Met.	Yds.	Mils.	Degs.		Met.	Yds.	Mils.	Degs.		Met.	Yds.	Mils.	Degs.		Met.	Yds.	Mils.	Degs.		Met.	Yds.	Mils.	Degs.	
500	547	1274	71° 30′	116	700	765·5	1255	70° 30′	134	1000	1093·5	1228	69°	147	1400	1531	1240	70°	178	2000	2187	1259	71°	222
600	656	1194	67°	112	800	875	1199	67° 30′	130	1200	1312·5	1147	64° 30′	143	1600	1750	1190	67°	176	2200	2406	1230	69°	219
800	875	980	55°	100	1000	1093·5	1064	60°	122	1400	1531	1038	58° 30′	137	1800	1968·5	1138	64°	174	2400	2624·5	1197	67° 30′	216
850	929·5	871	49°	93	1150	1257·5	867	49°	107	1600	1750	802	45°	119	2000	2187	1082	61°	171	2600	2843·5	1160	65° 30′	213
															2200	2406	1017	57° 30′	165	2800	3062	1117	63°	209
															2400	2624·5	909	51°	154	3000	3281	1065	60°	205
															2450	2679	860	48°	148	3200	3499·5	1000	56° 30′	199
																				3400	3718·5	912	51° 30′	190
																				3550	3882·5	801	45°	179

Range Table for 10.5 cm. (4·14 in.) Gun-Howitzer (1.F.H.18) firing H.E. Shell

(Weight 32·6 lb.)

Charge 1					Charge 2					Charge 3					Charge 4					Charge 5					Charge 6				
Range		T.E.		Fuze setting	Range		T.E.		Fuze setting	Range		T.E.		Fuze setting	Range		T.E.		Fuze setting	Range		T.E		Fuze setting	Range		T.E.		Fuze setting
M.	Yds.	Mils.	Degs.		M.	Yds.	Mils.	Degs.		M.	Yds.	Mils.	Degs.		M.	Yds.	Mils.	Degs.		M.	Yds.	Mils.	Degs.		M.	Yds.	Mils.	Degs.	
500	547	58	3° 30′	27	*500	547	43	2° 30′	25	*500	547	33	2°	24	*500	547	22	1°	22	*500	547	13	0° 30′	21	5,500	6,015	205	11° 30′	109
1,000	1,094	125	7°	42	*1,000	1,094	92	5°	38	*1,000	1,094	71	4°	35	*1,000	1,094	49	3°	32	*1,000	1,094	31	1° 30′	29	6,000	6,562	234	13°	120
1,500	1,640	197	11°	57	1,500	1,640	144	8°	51	*1,500	1,640	110	6°	47	*1,500	1,640	77	4° 30′	41	*1,500	1,640	52	3°	37	6,500	7,108	264	15°	132
2,000	2,187	275	15° 30′	74	2,000	2,187	198	11°	65	*2,000	2,187	152	8° 30′	58	*2,000	2,187	106	6°	51	*2,000	2,187	74	4°	46	7,000	7,655	297	16° 30′	144
2,500	2,734	364	20° 30′	93	2,500	2,734	258	14° 30′	79	2,500	2,734	196	11°	71	*2,500	2,734	137	8°	62	*2,500	2,734	97	5° 30′	56	7,500	8,202	332	18° 30′	157
3,000	3,281	478	27°	115	3,000	3,281	325	18° 30′	96	3,000	3,281	242	13° 30′	84	*3,000	3,281	169	9° 30′	72	*3,000	3,281	123	7°	66	8,000	8,749	370	21°	170
3,500	3,828	670	37° 30′	150	3,500	3,828	401	22° 30′	113	3,500	3,828	292	16° 30′	98	3,500	3,828	202	11° 30′	84	*3,500	3,828	149	8° 30′	76	8,500	9,296	411	23°	185
3,575	3,910	752	42° 30′	163	4,000	4,374	497	28°	135	4,000	4,374	349	19° 30′	114	4,000	4,374	238	13° 30′	95	*4,000	4,374	178	10°	86	9,000	9,843	456	25° 30′	201
					4,500	4,921	651	36° 30′	166	4,500	4,921	415	23° 30′	130	4,500	4,921	276	15° 30′	108	4,500	4,921	208	11° 30′	97	9,500	10,389	508	28° 30′	219
					4,625	5,058	754	42° 30′	184	5,000	5,468	496	28°	150	5,000	5,468	318	18°	121	5,000	5,468	240	13° 30′	109	10,000	10,936	573	32° 30′	241
										5,500	6,015	611	34° 30′	177	5,500	6,015	364	20° 30′	135	5,500	6,015	274	15° 30′	120	10,500	11,483	673	38°	271
										5,750	6,288	747	42°	208	6,000	6,562	416	23° 30′	150	6,000	6,562	309	17° 30′	133	10,675	11,674	767	43°	298
															6,500	7,108	475	26° 30′	168	6,500	7,108	347	19° 30′	146					
															7,000	7,655	550	31°	189	7,000	7,655	390	22°	161					
															7,500	8,202	676	38°	222	7,500	8,202	439	24° 30′	176					
															7,600	8,311	738	41° 30′	239	8,000	8,749	495	28°	194					
																				8,500	9,296	563	31° 30′	215					
																				9,000	9,843	669	37° 30′	244					
																				9,150	10,007	742	42°	265					

* The different charges are only used for the ranges thus marked in exceptional circumstances.

Range Table for 1.F.H.18 firing 10 cm. Gr. 39 rot (Hollow charge)

(Charge 5. M.V.—420 m/s (1,378 f.s.))

Range		T.E.		Time of flight	50 per cent. zone						Beaten zone Target height—2 m.		Remaining Velocity	
					Length		Width		Height					
m.	yds.	mils.	degs.	secs.	m.	ins.	m.	ins.	m.	ins.	m.	yds.	m. s.	f. s.
100	109	1	0 3·4′	0·24	10	394	0·1	3·9	0	0	0– 100	0– 109	407	1,335
200	219	4	0 13·5′	0·49	10	394	0·1	3·9	0·1	3·9	0– 200	0– 219	394	1,292
300	328	7	0 23·6′	0·75	10	394	0·2	7·9	0·1	3·9	0– 300	0– 328	382	1,253
400	437	11	0 37·1′	1·02	10	394	0·2	7·9	0·1	3·9	0– 400	0– 437	371	1,217
500	547	14	0 47·3′	1·30	10	394	0·3	11·9	0·2	7·9	0– 500	0– 547	361	1,184
600	656	18	1 0·8′	1·58	10	394	0·3	11·9	0·2	7·9	480– 600	525– 656	352	1,155
700	766	21	1 10·9′	1·86	10	394	0·4	15·8	0·3	11·8	610– 700	667– 766	343	1,125
800	875	25	1 24·4′	2·15	10	394	0·5	19·7	0·3	11·8	730– 800	798– 875	335	1,099
900	984	29	1 37·9′	2·44	10	394	0·5	19·7	0·3	11·8	840– 900	919– 984	328	1,076
1,000	1,094	33	1 51·4′	2·74	10	394	0·6	23·7	0·4	15·8	950–1,000	1,039–1,094	322	1,056
1,100	1,203	37	2 4·9′	3·05	10	394	0·7	27·6	0·4	15·8	1,055–1,100	1,154–1,203	316	1.037
1,200	1,312	41	2 18·4′	3·36	10	394	0·7	27·6	0·5	19·7	1,160–1,200	1,269–1,312	311	1,020
1,300	1,422	46	2 35·2′	3·68	10	394	0·8	31·5	0·6	23·7	1,265–1,300	1,383–1,422	306	1,004
1,400	1,531	50	2 48·7′	4·01	10	394	0·9	35·4	0·6	23·7	1,370–1,400	1,498–1,531	302	991
1,500	1,640	55	3 5·6′	4·34	10	394	0·9	35·4	0·7	27·6	1,470–1,500	1,608–1,640	298	978

Range Table for 1.F.H.18 firing 10 cm. Gr. 39 rot H1/A or B (Hollow Charge)

(Charge 6)

Range		T.E.		Range		T.E.	
m.	yds.	mils.	degs.	m.	yds.	mils.	degs.
400	437	7	0° 23′	1,100	1,203	24	1° 21′
600	656	11	0° 37′	1,200	1,312	27	1° 31′
700	766	14	0° 47′	1,300	1,422	30	1° 41′
800	875	16	0° 54′	1,400	1,531	33	1° 51′
900	984	19	1° 4′	1,500	1,640	36	2° 2′
1,000	1,094	22	1° 14′				

Range Table for 15 cm. (5·9 in.) Medium Howitzer (s.F.H. 18) firing H.E. shell (15 cm. Gr. 19)

Charge 1 (M.V. = 689 f.s.)

Range		T.E.		Fuze setting
m.	yds.	mils.	degs.	
25	27	0	0°	—
200	219	20	1°	18
400	437	43	2° 30′	23
600	656	66	3° 30′	29
800	875	90	5°	34
1,000	1,094	114	6° 30′	40
1,200	1,312	139	8°	46
1,400	1,531	165	9° 30′	51
1,600	1,750	191	11°	57
1,800	1,969	219	12° 30′	63
2,000	2,187	247	14°	70
2,200	2,406	276	15° 30′	76
2,400	2,625	306	17°	83
2,600	2.843	338	19°	90
2,800	3,062	372	21°	97
3,000	3,281	408	23°	105
3,200	3,500	448	25°	113
3,400	3,718	492	27° 30′	122
3,600	3,937	544	30° 30′	132
3,800	4,156	610	34° 30′	145
4,000	4,374	725	41°	165

(Note.—Correction for drift :—
+ 4 mils at 1,000 m.
+ 9 mils at 2,000 m.
+16 mils at 3,000 m.
+30 mils at 4,000 m.)

Charge 2 (M.V. = 755 f.s.)

Range		T.E.		Fuze setting
m.	yds.	mils.	degs.	
3,000	3,281	327	18° 30′	95
3,200	3,500	355	20°	101
3,400	3,718	385	21° 30′	108
3,600	3,937	418	23° 30′	115
3,800	4,156	452	25° 30′	123
4,000	4,374	490	27° 30′	131
4,200	4,593	533	30°	140
4,400	4,812	585	33°	151
4,600	5,031	657	37°	166
4,725	5,167	748	42°	183

(Note.—Correction for drift :—
+13 mils at 3,000 m.
+19 mils at 4,000 m.
+31 mils at 4,725 m.)

Charge 3 (M.V. = 820 f.s.)

Range		T.E.		Fuze setting
m.	yds.	mils.	degs.	
3,500	3,828	327	18° 30′	101
3,600	3,937	339	19°	104
3,800	4,156	364	20° 30′	110
4,000	4,374	390	22°	117
4,200	4,593	418	23° 30′	123
4,400	4,812	447	25°	131
4,600	5,031	480	27°	139
4,800	5,249	517	29°	147
5,000	5,468	561	31° 30′	157
5,200	5,686	614	34° 30′	168
5,400	5,906	686	38° 30′	184
5,500	6,015	786	44°	201

(Note.—Correction for drift :—
+13 mils at 3,500 m.
+15 mils at 4,000 m.
+23 mils at 5,000 m.
+34 mils at 5,500 m.)

Charge 4 (M.V. = 919 f.s.)

Range		T.E.		Fuze setting
m.	yds.	mils.	degs.	
4,000	4,374	298	17°	103
4,200	4,593	317	18°	108
4,400	4,812	336	19°	113
4,600	5,031	356	20°	119
4,800	5,249	378	21° 30′	125
5,000	5,468	400	22° 30′	131
5,200	5,686	424	24°	138
5,400	5,906	449	25° 30′	144
5,600	6,124	476	27°	151
5,800	6,343	506	28° 30′	159
6,000	6,562	540	30° 30′	168
6,200	6,780	579	32° 30′	177
6,400	6,999	628	35° 30′	189
6,600	7,218	697	39°	205
6,675	7,300	748	42°	217

(Note.—(1) Minimum range = 25 m. (27 yds.)
(2) Correction for drift :—
± 0 mils at 25 m.
+ 3 mils at 1,000 m.
+ 5 mils at 2,000 m.
+ 8 mils at 3,000 m.
+12 mils at 4,000 m.
+16 mils at 5,000 m.
+22 mils at 6,000 m.
+33 mils at 6,675 m.)

Charge 5
(M.V. = 1,050 f.s.)

Range		T.E.		Fuze setting
M.	Yds.	Mils.	Deg.	
5,000	5,468	299	17°	114
5,200	5,686	315	17° 30′	119
5,400	5,906	331	18° 30′	124
5,600	6,124	347	19° 30′	130
5,800	6,343	364	20° 30′	135
6,000	6,562	382	21° 30′	140
6,200	6,780	400	22° 30′	146
6,400	6,999	420	23° 30′	152
6,600	7,218	440	25°	158
6,800	7,437	461	26°	164
7,000	7,655	484	26° 30′	171
7,200	7,874	509	28° 30′	178
7,400	8,093	536	30°	186
7,600	8,311	567	32°	194
7,800	8,530	603	34°	204
8,000	8,749	648	36° 30′	215
8,200	8,968	718	40° 30′	234
8,250	9,022	754	42° 30′	242

(NOTE.—Correction for drift :—
+10 mils at 5,000 m.
+13 mils at 6,000 m.
+17 mils at 7,000 m.
+24 mils at 8,000 m.
+30 mils at 8,250 m.)

Charge 6
(M.V. = 1,230 f.s.)

Range		T.E.		Fuze setting
M.	Yds.	Mils.	Deg.	
6,000	6,562	304	17°	127
6,200	6,780	318	18°	131
6,400	6,999	332	18° 30′	136
6,600	7,218	346	19° 30′	141
6,800	7,437	361	20° 30′	146
7,000	7,655	376	21°	151
7,200	7,874	392	22°	156
7,400	8,093	408	23°	161
7,600	8,311	425	24°	167
7,800	8,530	443	25°	173
8,000	8,749	461	26°	179
8,200	8,968	481	27°	185
8,400	9,186	502	28° 30′	191
8,600	9,405	524	29° 30′	198
8,800	9,624	548	31°	206
9,000	9,842	574	32° 30′	214
9,200	10,061	604	34°	223
9,400	10,280	639	36°	233
9,600	10,499	686	38° 30′	246
9,775	10,690	765	43°	267

(NOTE.—(1) Minimum range = 25 m. (27 yds.)
(2) Correction for drift :—
± 0 mils at 25 m.
+ 1 mils at 1,000 m.
+ 2 mils at 2,000 m.
+ 4 mils at 3,000 m.
+ 6 mils at 4,000 m.
+ 7 mils at 5,000 m.
+ 9 mils at 6,000 m.
+12 mils at 7,000 m.
+15 mils at 8,000 m.
+19 mils at 9,000 m.
+27 mils at 9,775 m.)

Charge 7
(M.V. = 1,427 f.s.)

Range		T.E.		Fuze setting
M.	Yds.	Mils.	Deg.	
7,000	7,655	302	17°	138
7,200	7,874	315	17° 30′	142
7,400	8,093	328	18° 30′	147
7,600	8,311	341	19°	152
7,800	8,530	354	20°	157
8,000	8,749	368	20° 30′	162
8,200	8,968	382	21° 30′	167
8,400	9,186	397	22° 30′	172
8,600	9,405	412	23°	177
8,800	9,624	427	24°	182
9,000	9,842	443	25°	188
9,200	10,061	459	26°	194
9,400	10,280	477	27°	199
9,600	10,499	495	28°	206
9,800	10,717	514	29°	212
10,000	10,936	535	30°	219
10,200	11,155	557	31° 30′	226
10,400	11,374	581	32° 30′	234
10,600	11,592	609	34° 30′	243
10,800	11,811	641	36°	253
11,000	12,030	681	38° 30′	265
11,200	12,248	743	42°	282
11,275	12,331	800	45°	300

(NOTE.—(1) Minimum range = 5,000 m. (5,468 yds.)
(2) Correction for drift :—
+ 6 mils at 5,000 m.
+ 8 mils at 6,000 m.
+10 mils at 7,000 m.
+13 mils at 8,000 m.
+16 mils at 9,000 m.
+19 mils at 10,000 m.
+25 mils at 11,000 m.
+31 mils at 11,275 m.)

Charge 8
(M.V. = 1,706 f.s.)

Range		T.E.		Fuze setting
M.	Yds.	Mils.	Deg.	
8,500	9,296	298	17°	154
8,600	9,405	304	17°	156
8,800	9,624	315	17° 30′	161
9,000	9,842	327	18° 30′	165
9,200	10,061	339	19°	170
9,400	10,280	351	20°	175
9,600	10,499	364	20° 30′	179
9,800	10,717	377	21°	184
10,000	10,936	390	22°	189
10,200	11,155	404	22° 30′	194
10,400	11,374	418	23° 30′	200
10,600	11,592	432	24° 30′	205
10,800	11,811	447	25°	210
11,000	12,030	462	26°	216
11,200	12,248	478	27°	222
11,400	12,467	495	28°	228
11,600	12,686	513	29°	234
11,800	12,905	531	30°	241
12,000	13,123	550	31°	248
12,200	13,342	571	32°	255
12,400	13,561	592	33° 30′	263
12,600	13,779	616	34° 30′	271
12,800	13,998	644	36° 30′	281
13,000	14,217	677	38°	292
13,200	14,436	723	40° 30′	306
13,325	14,572	778	44°	323

(NOTE.—Correction for drift :—
+12 mils at 8,500 m.
+13 mils at 9,000 m.
+16 mils at 10,000 m.
+19 mils at 11,000 m.
+23 mils at 12,000 m.
+29 mils at 13,000 m.
+34 mils at 13,325 m.)

Range Table for s.I.G. 33 firing 83·6 lb. H.E. Shell

LOWER REGISTER

Charge 1				Charge 2				Charge 3				Charge 4				Charge 5				Charge 6			
Range		T.E.		Range		T.E.		Range		T.E.		Range		T.E.		Range		T.E.		Range		T.E.	
M.	Yds.	Mils.	Deg.	M.	Yds.	Mils.	Deg.	M.	Yds.	Mils.	Deg.	M.	Yds.	Mils.	Deg.	M.	Yds.	Mils.	Deg.	M.	Yds.	Mils.	Deg.
25	27	2	0° 7′	800	875	175	10°	1,950	2,133	322	18°	2,625	2,871	350	19° 30′	3,450	3,773	412	23°	3,925	4,293	450	25° 30′
200	219	58	3° 30′	1,000	1,094	226	12° 30′	2,000	2,187	333	18° 30′	2,800	3,062	383	21° 30′	3,600	3,937	441	25°	4,000	4,374	465	26°
400	437	125	7°	1,200	1,312	280	16°	2,200	2,406	379	21° 30′	3,000	3,281	424	24°	3,800	4,156	484	27°	4,200	4,593	509	28° 30′
600	656	195	11°	1,400	1,531	339	19°	2,400	2,625	430	24°	3,200	3,500	472	26° 30′	4,000	4,374	536	30°	4,400	4,812	564	32°
800	875	271	15° 30′	1,600	1,750	405	23°	2,600	2,843	491	27° 30′	3,400	3,718	530	30°	4,200	4,593	606	34°	4,600	5,031	647	36° 30′
1,000	1,094	355	20°	1,800	1,969	483	27°	2,800	3,062	568	32°	3,600	3,937	607	32°	4,375	4,785	726	41°	4,700	5,140	740	41° 30′
1,200	1,312	457	25° 30′	2,000	2,187	596	33° 30′	3,000	3,281	710	40°	3,750	4,101	726	41°								
1,400	1,531	610	34° 30′	2,125	2,324	755	42° 30′																
1,475	1,613	733	41° 30′																				

UPPER REGISTER

Charge 1				Charge 2				Charge 3				Charge 4				Charge 5				Charge 6			
Range		T.E.		Range		T.E.		Range		T.E.		Range		T.E.		Range		T.E.		Range		T.E.	
M.	Yds.	Mils.	Deg.	M.	Yds.	Mils.	Deg.	M.	Yds.	Mils.	Deg.	M.	Yds.	Mils.	Deg.	M.	Yds.	Mils.	Deg.	M.	Yds.	Mils.	Deg.
925	1,012	1,241	70°	1,325	1,449	1,242	70°	1,850	2,023	1,244	70°	2,300	2,515	1,244	70°	2,675	2,925	1,242	70°	2,850	3,117	1,243	70°
1,000	1,094	1,208	68°	1,400	1,531	1,218	68° 30′	2,000	2,187	1,211	68°	2,400	2,625	1,226	69°	2,800	3,062	1,223	69°	3,000	3,281	1,222	69°
1,200	1,312	1,104	62°	1,600	1,750	1,148	64° 30′	2,200	2,406	1,164	65° 30′	2,600	2,843	1,188	67°	3,000	3,281	1,191	67°	3,200	3,500	1,192	67°
1,400	1,531	954	53° 30′	1,800	1,969	1,066	60°	2,400	2,625	1,111	62° 30′	2,800	3,062	1,148	64° 30′	3,200	3,500	1,157	65°	3,400	3,718	1,161	65° 30′
1,475	1,613	834	47°	2,000	2,187	954	53° 30′	2,600	2,843	1,048	59°	3,000	3,281	1,104	62°	3,400	3,718	1,121	63°	3,600	3,937	1,127	63° 30′
				2,125	2,324	800	45°	2,800	3,062	967	54° 30′	3,200	3,500	1,054	59° 30′	3,600	3,937	1,080	61°	3,800	4,156	1,090	61° 30′
								3,000	3,281	827	46° 30′	3,400	3,718	994	56°	3,800	4,156	1,034	58°	4,000	4,374	1,049	59°
												3,600	3,937	915	51° 30′	4,000	4,374	980	55°	4,200	4,593	1,003	56° 30′
												3,750	4,101	799	45°	4,200	4,593	910	51°	4,400	4,812	947	53° 30′
																4,375	4,785	789	44° 30′	4,600	5,031	867	49°
																				4,700	5,140	771	43° 30′