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ARMOURED CAR HUMBER MARK IV

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SERVICE INSTRUCTION BOOK

This publication has been produced to the instructions of the Chief Inspector of Fighting Vehicles, to whom all communications should be addressed

1ST EDITION **Publication No. 1300** 8/43

IMPORTANT

Where periodical maintenance quoted throughout this publication differs from the "Lubrication Chart," the Chart must be followed

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FOREWORD

The Armoured Car, Humber, Mark IV is a development of the preceding Marks I, II and III and differs mainly in armament. It is a four-wheeled vehicle with its engine, clutch and main gearbox disposed at the rear. The drive from this point is transmitted through a transfer gearbox to the front and rear axles, thereby assuring satisfactory operation over difficult ground.

The chassis frame supports, on four flexible mountings, the hull and rotatable gun turret, which are constructed from welded armour plate and afford full protection for the chassis, power unit, transmission and crew of three.

Main armament consists of a 37 m/m gun and a 7.92 m/m Besa. gun co-axially mounted in the turret. Supplementary armament includes a Bren Gun, carried in the centre stowage rack, for use with a high angle mounting against aircraft attack, and a "Thompson" sub-machine gun, stowed in the fighting compartment, for action at close range. Two smoke generator dischargers are fixed to the turret.

For clarity, the book is divided into three main sections :—

Section "A" Operation, preventive maintenance and adjustment of the vehicle by the crew.

Section "B" Detailed description of the various units and equipment of the vehicle.

Section "C" Detailed instructions for the use of Workshops covering the removal, replacement, overhaul and repair of assemblies and equipment.

From this it will be seen that the crew are particularly interested in "A" and "B." Schools will work mainly from "B," while Workshops will be more closely concerned with "C" than "A" or "B."

Section "A" and "B" are issued to all personnel. The complete volume, section "A," "B" and "C" is issued to Workshop personnel and those on the distribution list of W.S.5 (b).

Mechanical Maintenance must be carried out as laid down in the R.A.O.C. Permissive Repair Schedule, Chilwell Catalogue No. 62/335 of March, 1941.

FOR FROST PRECAUTIONS SEE PAGE 14

BEFORE DRIVING THE VEHICLE AWAY SEE PAGE 11

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DRIVING AND MAINTENANCE

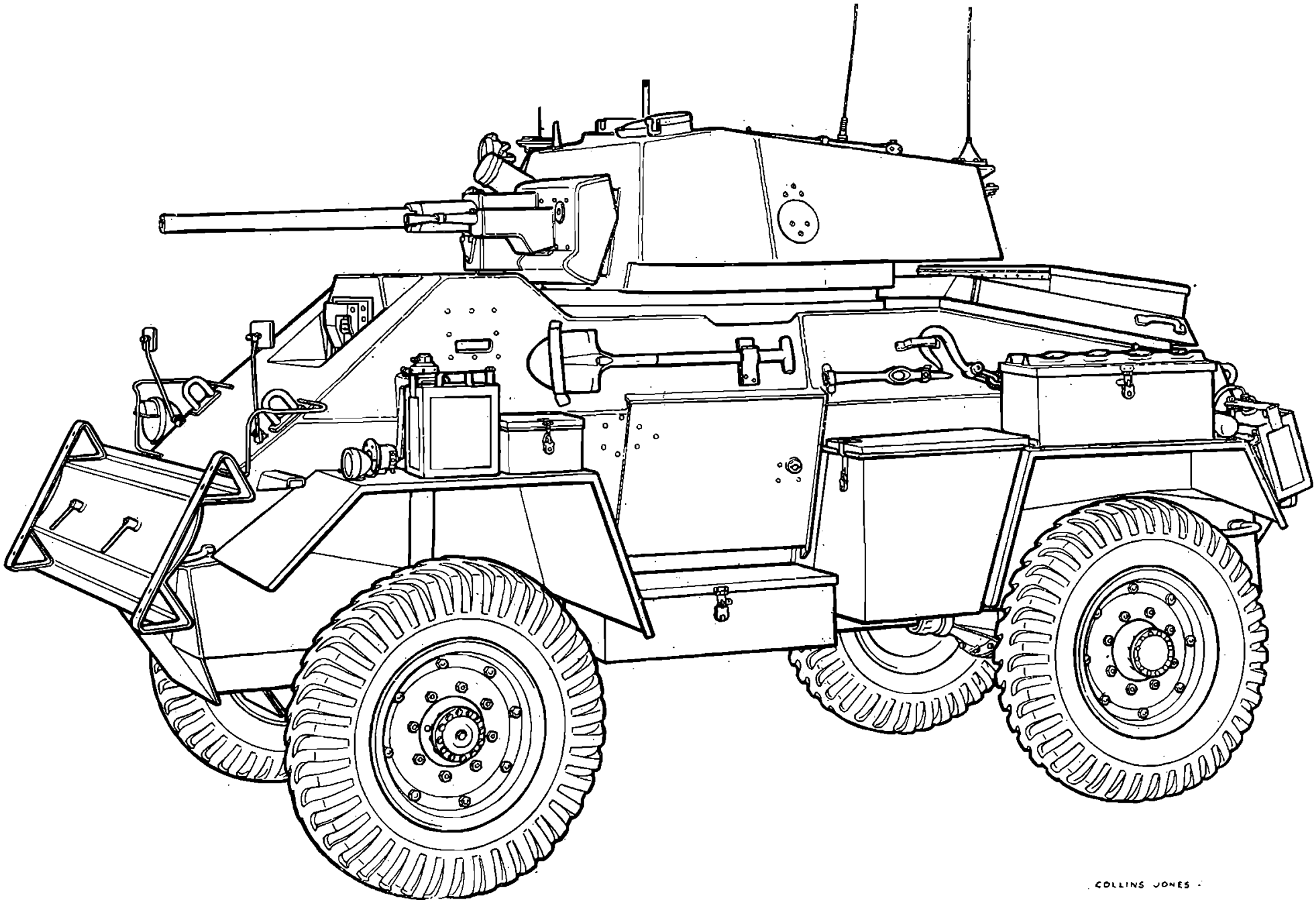


Plate 1. Three-quarter view of Armoured Car, Humber, Mark IV—Front

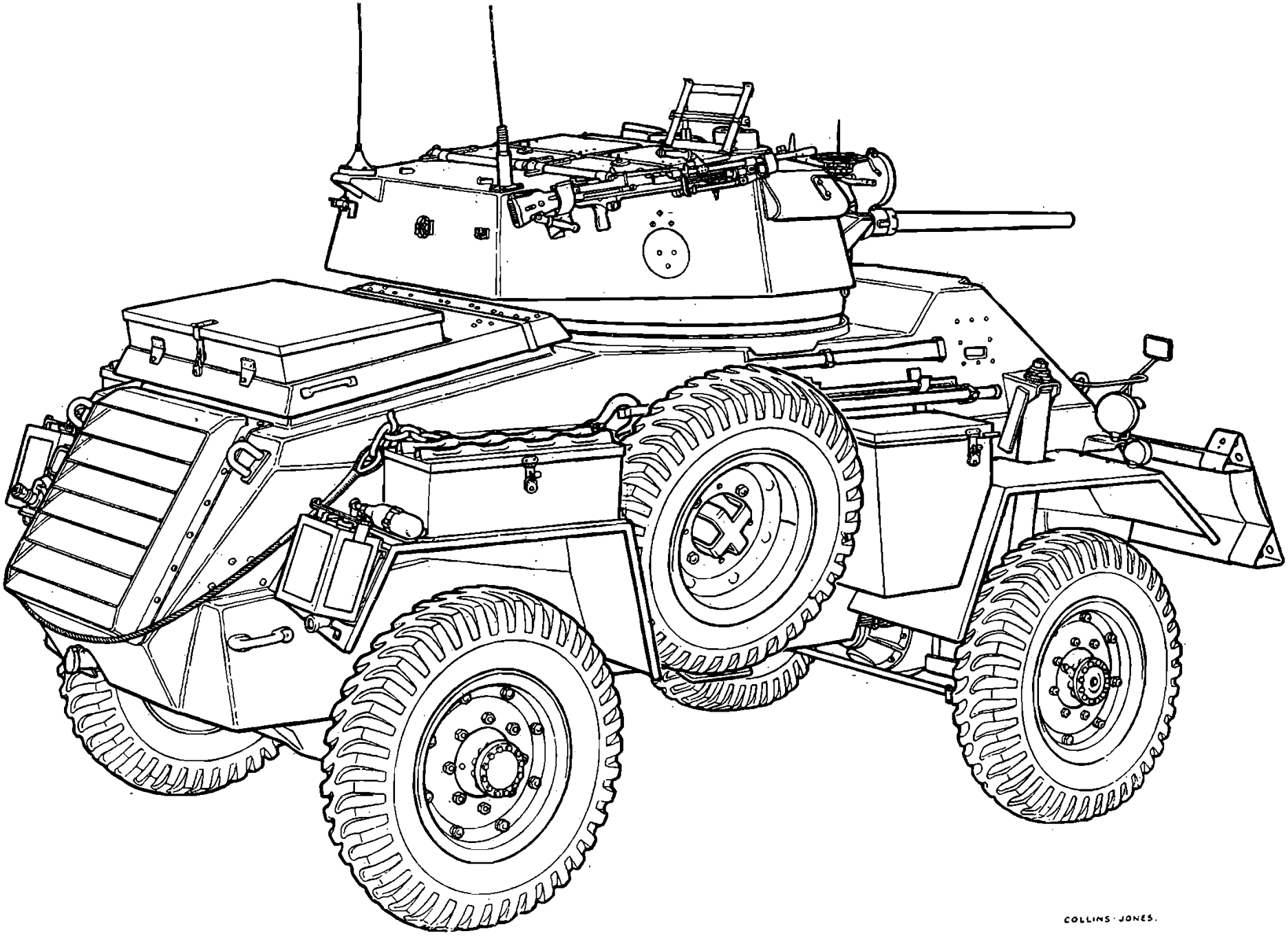


Plate 2. Three-quarter view of Armoured Car, Humber, Mark IV—Rear

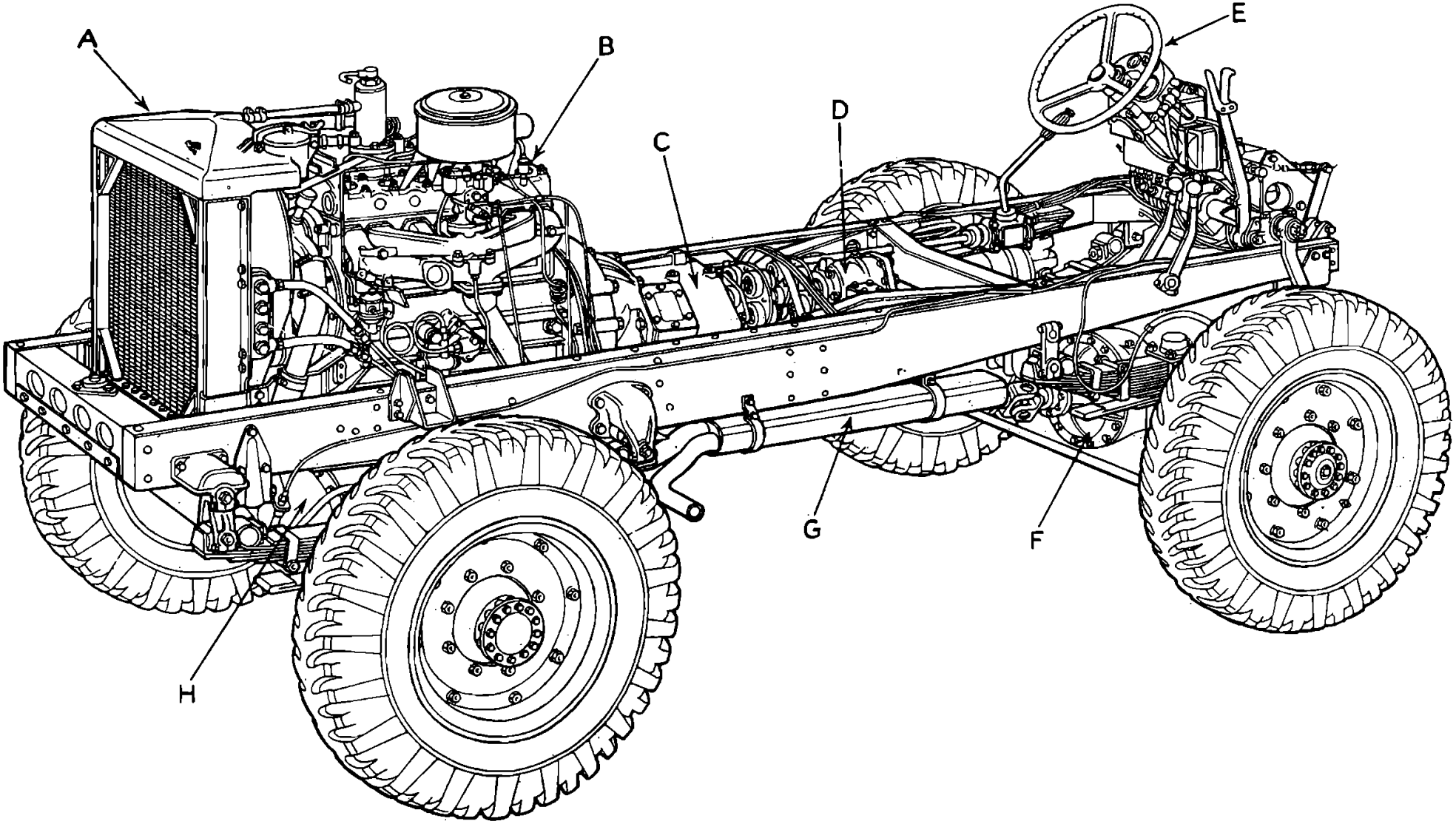


Plate 3. Three-quarter view of Armoured Car, Humber, Mark IV—Chassis

A—Radiator and Oil Cooler
B—Engine at rear of chassis
C—Gearbox fitted with tyre pump
D—Transfer box and declutch
E—Steering Wheel set amidship
F—Front driving axle
G—Silencer
H—Rear driving axle

GENERAL DESCRIPTION

The Armoured Car, Humber, Mark IV consists of a hull and turret made of bullet-proof nickel chrome molybdenum steel mounted on a four wheeled chassis.

The vehicle will accommodate three men—Commander/Loader, Gunner and Driver.

Entrance or exit, when no spare wheel is carried, is by two closely fitting doors, one on each side of the hull. These doors are provided with suitable splinter protection strips to prevent injury to the personnel from bullet splash. In cases where the spare wheel is fitted, only the left hand door is available, as the right hand door is rendered inoperative and is covered by the bracket carrying the spare wheel.

Chassis.

The vehicle is powered with a six cylinder water cooled engine constructed as a unit with the clutch and gearbox. This is mounted at the rear of the vehicle.

The power of the engine is transmitted through a single dry plate clutch to the gearbox which has four forward speeds and one reverse. The gearbox is then coupled to a transfer box by means of a short propeller shaft with large flexible rubber couplings. The transfer box, which has two speeds, relays the drive to the front and rear axles via tubular propeller shafts fitted with needle roller universal joints.

The drive is normally taken through the rear axle only, the front axle being engaged to provide traction through all four wheels for severe conditions.

The combination of a four speed gearbox and two speed transfer box gives the vehicle a total of eight forward speeds and two reverse.

The front and rear axles are of the fully floating type and the front axle is fitted with constant velocity universal joints to enable the front wheels to be turned in steering.

The foot brake is hydraulically operated and acts on all four wheels. The hand brake is mechanically operated and acts on the rear wheels only quite independently of the foot brake.

The chassis and hull are mounted on the axles on semi-elliptic leaf springs of special design, having universal anchorages allowing the maximum articulation of the axles without straining the springs.

The whole suspension is adequately controlled by large capacity hydraulic shock absorbers.

Hull and Turret.

The hull is flexibly mounted on the chassis at four points, one at the front, one at the rear, and one on each side. In addition to these mounting points are four snubbers, one on each corner to control any tendency of excessive body movement over rough terrain.

The driver is provided with a window which can be opened to improve his vision when conditions permit, and a protective visor is incorporated which can be operated at will. A bullet-proof glass block, or alternatively an emergency screen, can be affixed to the window and these give protection consistent with maximum vision. Spare blocks and screens are carried for use when required.

The turret is mounted on top of the hull on a large diameter ball bearing and is rotated by a single speed traversing gear conveniently placed for the gunner's left hand. The main armament is mounted in the front plate and rotates with the turret.

Two revolver ports are provided, one on the right-hand side and the other on the left-hand side.

Separate observation flaps for commander and gunner are provided in the top of the turret, and two adjustable type periscopes are also fitted.

TABULATED SPECIFICATION

ARMOURED CAR, HUMBER, MARK IV.

BRIDGE CLASSIFICATION DATA

Weight of vehicle ready for the road with crew	Between 5 and 8 tons
Overall length of vehicle	15′ 0″
Overall width of vehicle ..	7′ 2″
Height to top of turret cover (laden)	7′ 8″
Wheelbase	8′ 6¼″
Wheel track	
Front ..	6′ 4″
Rear	6′ 0″
Ground clearance (under axles)	12″
Fording depth	2′ 6″ in still water

CREW

Number ..	Three
Designation	One Commander/Loader
	One Gunner
	One Driver

ARMAMENT

Ordnance	37 m/m Gun, M6
Machine Guns	7.92 m/m Besa Mk. III
	.303″ Bren Mk. II
	"Thompson" Sub-machine Gun
Smoke weapons	Dischargers, Smoke, 4″ No. 2, Mk. II (2)
Signal weapons ..	Pistol, Signal, No. 1, Mk. III or IV

AMMUNITION

Ordnance	69 Rounds
Machine guns	
7.92 m/m	11 boxes, S.A.H. 29, Mk. I or Belt, Besa, 7.92 m/m
.303″ Bren	5 Magazines, Bren, .303″ M/G Mk. I (Drum type 100 rounds each)
"Thompson" Sub-Machine gun	10 Magazines, Thompson Sub-machine gun (20 rounds each)
Smoke weapons .	8 rounds, Generators, Smoke, No. 8, Mk. II or III
Signal weapons ..	12 Cartridges, Signal (4 red, 4 green, 4 white)

W/T SET

Type	No. 19

ENGINE

Number of cylinders	6
Bore (Nominal) ..	85 m/m (3.35″)
Stroke	120 m/m (4.72)
R.A.C. Rating	26.88
B.H.P. ..	90 @ 3430 R.P.M. (without fan)
Firing order	1, 5, 3, 6, 2, 4

ENGINE (continued)

Sparking Plugs	
Size	14 m/m ¾" Reach (Screened)
Gap ..	.018"/.020"
Valve tappet clearances	
Inlet ..	.012" } Engine cold
Exhaust ..	.014" } Engine cold
Cooling system (total) ..	6 gallons
Sump oil capacity	21 pints
Measured by	Dipstick
Oil pressure (normal)	10 lbs. per sq. in. with engine idling. 40 to 50 lbs. per sq. in. at normal running speed. Engine warm.

FUEL CAPACITY

Main tank	25 gallons
Reserve Tank	5 gallons
Total ..	30 gallons
Measured by	Dipstick

GEARBOX

Type ..	Four speed and reverse
Oil capacity	7 pints
Measured by	Dipstick

TRANSFER GEARBOX

Type ..	Two speed with front axle declutch
Oil capacity	5 pints
Measured by	Level plug

AXLES

Type ..	Spiral bevel
Oil capacity	4 pints (each axle)
Measured by	Level plug

BRAKES

Type	Progressive
Operation	Hydraulic
Fluid	Fluid, Brake, Hydraulic, No. 3

STEERING

Type ..	Cam and roller
Turning circle	
Front axle driving	46' 6"
Front axle free	45' 0"

TYRES

Type	" Run flat "
Size	10.50" × 20" (singles)
Pressure	
Front	28 lbs. per sq. in.
Rear ..	31 lbs. per sq. in.

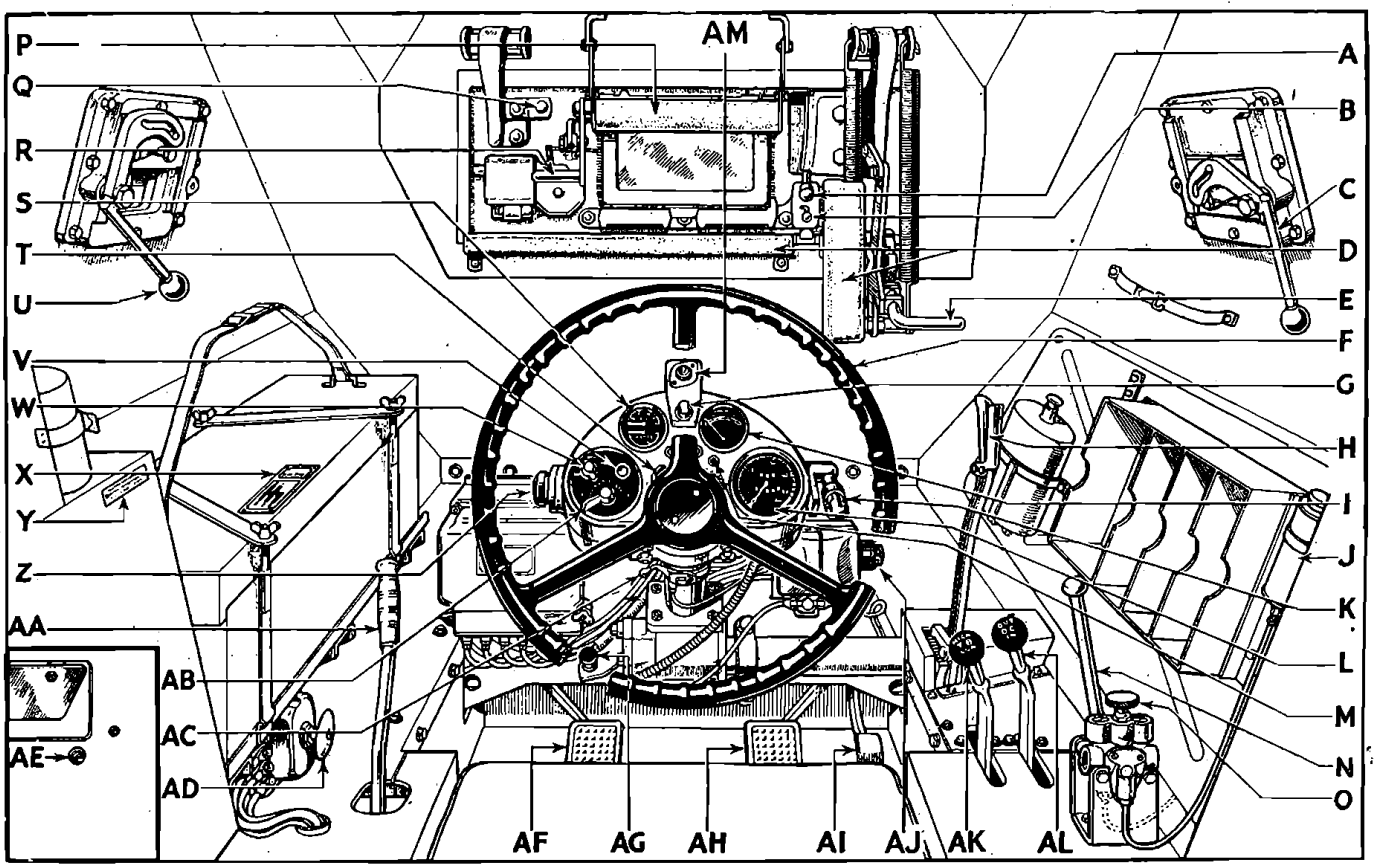


Figure 1. Instrument Panel and Driver's Controls

Key to Reference Letters

A Operating Handle—Driver's safety visor.
B Window lock bolt.
C Lever operating side lookout shutter on right-hand side. Shutter closed.
D Driver's head protection pads.
E Handlever operating driver's window.
F Steering wheel.
G Switch for panel lights.
H Handlever operating brakes on rear wheels.
I Ammeter.
J Feed tank for engine access door jack hand pump.
K Festoon lamp on panel.
L Speedometer.
M Sockets for inspection lamp plug.
N Handle on hand pump for engine access door jack.
O Valve on hand pump for engine access door jack.
P Driver's brow pad in ready position.
Q Windscreen wiper motor switch.
R Operating handle—Triplex block release.
S Combined oil pressure gauge and water temperature thermometer.
T Starter motor switch.
U Lever operating side look-out shutter on left-hand side. Shutter open.
V Ignition warning light.
W Ignition switch.
X Diagram of gear positions.
Y Auxiliary carburettor instruction plate.
Z Horn push.
AA Gear change lever.
AB Switch for driving lights.
AC Throttle control lever.
AD Battery master switch.
AE Commander's independent ignition switch on rear bulkhead.
AF Clutch pedal.
AG Auxiliary carburettor control.
AH Brake pedal.
AI Accelerator pedal.
AJ Convoy light switch.
AK Lever operating gears in transfer box for "high" and "low" speeds.
AL Lever operating front axle declutch.
AM Oil warning light.

STARTING AND DRIVING INSTRUCTIONS

STARTING UP AND DRIVER'S CONTROL

The illustration on page 8 (Fig. 1) shows the instrument panel and driver's controls, the position of the commander's independent ignition switch being shown on the inset in the bottom left-hand corner. A diagram of the gear positions will be seen on the battery cover situated at the driver's left-hand side, and it will be found that to engage reverse gear the resistance of a spring loaded plunger must be overcome.

As these machines are fitted with fully automatic ignition advance and retard, no hand control is fitted, and the driver has only to determine that oil (*See page* 29), petrol (*See page* 25) and water supplies (*See page* 31) are adequate, that the gear change lever is in neutral position and then to proceed as follows :—

WHEN COLD

Close main throttle by pushing lever (AC).

Pull out knob (AG) **controlling auxiliary self-starting carburettor** to its first stop in normal weathers including light morning frost. In the event of *severe frost* pull knob out to the first stop, turn left and pull again.

Turn battery master switch (AD) to the " on " position.

Switch on ignition (W) and the red warning light (V) shows up.

There is also an independent ignition switch (AE) for the use of the commander, fitted on the rear bulkhead of the fighting compartment. This switch automatically remains in the " on " position unless otherwise operated.

Press starter motor control button (T) until engine fires, then release immediately. In this connection it should be remembered that on no account must the accelerator pedal be agitated when starting engine.

Should the engine be very cold and stiff, the starter motor and batteries will be relieved of considerable strain if the engine be cranked over several times by hand before the ignition is switched on and the starter motor brought into action.

A loose starting handle is carried in the tool kit and is brought into use by being inserted through the outboard bearing situated at the rear of the vehicle. A cap to prevent the entry of missiles is fitted on to the end of the outboard bearing and must, obviously, be lifted up before the handle can be placed in position.

It is also possible that when the engine has been left stationary for a prolonged period, the petrol in the carburettor may have evaporated thus requiring the operation of the petrol pump to re-fill the float chamber. The petrol pump is driven at half engine speed, and it will therefore be appreciated that the re-filling of the carburettor must take some little time if this operation is carried out entirely by revolving the engine with the starter. To save the batteries it is advisable in these circumstances to use the hand primer on the petrol pump which is shown on Plate 4, page 26.

Allow the engine to run on the auxiliary starter jet *only so long as is necessary for it to warm up enough to change over to the main carburettor.* This should be done *as soon as possible* by pushing the control knob fully in from whatever position it has been in use and slightly opening the throttle at the same time.

After starting from cold the engine should be allowed to run at fair speed (*not raced*) for a few minutes in order to allow the oil to warm up and circulate thoroughly (See also section " Warming up ").

WHEN HOT

Slightly open throttle.

Switch on ignition.

Press starter motor control button until engine fires, then release immediately.

Return main throttle to normal idling position.

WARMING UP, USE OF TRANSFER BOX AND DRIVING AWAY

WARMING UP

Oil temperature. It is important that the engine should be run at a fair speed (*not raced*) until the normal working temperature has been attained in order that the oil circulation may reach the correct running pressure in the shortest possible time.

The reason for this is that after an engine has been standing for some time the whole of the oil has drained back into the sump ; furthermore, the actual operation of starting tends to wash the cylinder bores with petrol so that when efficient lubrication is most necessary the bores are practically devoid of oil.

In addition to the foregoing is the fact that the jet of oil from the bearings (*on which the pistons rely for their lubrication*) is below normal owing to the higher viscosity of the oil ; hence the necessity for speedily warming up the engine.

The correct oil pressure shown by the gauge (S) is 40-50 lbs. per square inch when the engine is new and warm at normal running speed. This may drop as low as 10 lbs. per square inch when the engine is idling, or rise considerably higher with a cold engine.

A warning light (AM) provides a safeguard additional to the gauge, mentioned in the preceding paragraph and the word " oil " will become illuminated immediately the ignition is switched on. As the oil pressure rises the current is switched off, but should the pressure become dangerously low, the light will come into operation again, in which case switch off immediately and investigate.

It must be clearly understood that neither pressure gauge nor warning light registers the quantity of oil in the sump ; they only indicate whether the oil pressure is satisfactory or not.

When the engine is idling the oil pressure may drop so low as to permit the current to be switched on and in that case the word " oil " will become illuminated again. This does not mean that oil circulation has stopped and this can be proved, either by reference to the gauge or by accelerating the engine when the light will cut out immediately.

The warning light should be checked immediately the ignition is switched on, to ensure that the light bulb has not failed, although such a failure should not lead to any complications owing to there being an additional indication of pressure in the gauge.

Water temperature. A thermostat fitted in the cylinder head prevents the flow of water through the radiator until a certain predetermined temperature has been reached. This ensures the rapid warming up of the engine and correspondingly reduces the amount of cylinder wear.

It should be noted that the fitting of this unit may cause the water in the radiator to freeze in very cold weather if the vehicle is driven away immediately after starting the engine. This danger can, however, be avoided by the use of an anti-freeze compound or by always ensuring that the water has commenced to warm up before driving away.

An indicator (S) with a range of 90° to 212° Fahrenheit and working on the vapour pressure principle, is fitted in the instrument panel and the driver can thus see at a glance the temperature of the water in the cooling system ; that is to say the engine operating temperature. This, under normal operating conditions, will read between 170° and 180° Fahrenheit, and if there be any considerable deviation, the cause should be investigated.

USE OF TRANSFER BOX

Choice of high or low gear should be made before the machine is driven away, for although it is permissible to change gear while the vehicle is in motion, yet it is a practice which, if unskilfully done, may damage the transmission and on this account should not be adopted.

The gear ratios with transfer box in high, make the use of this gear possible on all surfaced roads and it can also be employed for fairly severe cross-country conditions provided the front axle is engaged as instructed below, so that all four wheels are driving. Low is provided mainly as an emergency gear to be used in extreme cases when traversing rough ground and should be treated as such.

It is impossible to lay down any hard and fast rule covering the application of these gears but the importance of using " High " in all cases where circumstances permit is emphasised.

There are two operating levers on the driver's right-hand side and the inner one (AK) of these controls the transfer box, the positions of the lever being right back for low, the central position for neutral and fully forward for high.

A de-clutch unit fitted to the transfer box allows the machine to be used in high gear with or without the front axle driving, and a decision governed by circumstances will have to be made as to whether the amount of traction required can be provided by the two rear wheels only. Obviously, the vehicle should be operated whenever possible with the front axle free, *i.e.* outer lever (AL) on the right-hand side of driver pushed forward to disengage the de-clutch.

No choice, however, is permitted in low gear, for this lever is interconnected with that operating the gears in such a way as to prevent low gear being engaged unless the front axle is driving.

It will be seen, therefore, that if the low range of gears is necessary, the de-clutch lever must be moved back to bring all four wheels into drive before the inner lever can engage low gear.

The declutch lever may be operated with the vehicle in motion, merely by pressing the clutch pedal and moving the lever in the desired direction.

DRIVING AWAY

Use of gears. The gear lever (AA) is on the left-hand side of the driver, the positions (X) being indicated on a plate fitted to the battery lid and both initial engagement and changing are carried out in the orthodox manner.

The gearbox gives four forward speeds and one reverse and it is essential in order not to over-run or damage the engine through excessive " revving," that the following speeds in the intermediate gears be not exceeded :—

	Speeds in M.P.H.			*Speeds in M.P.H.*	
	Transfer Box	*Transfer Box*		*Transfer Box*	*Transfer Box*
Gears	*in High*	*in Low*	*Gears*	*in High*	*in Low*
Top	46.	29.75	Second	13.7	8.8
Third	25.8	17.1	First	7.25	4.62

All the above speeds are given at the governed engine speed at 3430 R.P.M. and should certainly not be indulged until the engine is well run-in, say after a month in service. At all times remember that high road speeds (*which can be attained in certain circumstances even though the engine is governed*) are uneconomical both in cost of fuel and wear and tear.

Maintenance of good average speeds is the soundest method, coupled with intelligent use of the gearbox. " Over-revving " in gears is wasteful.

The driver's window, operated by lever (E), cannot be opened until the driver's safety visor has been locked in the closed position by moving lever (A) to the upper notch on the quadrant ; this allows the window lock bolt (B) to be released by lifting the lockbolt handle and turning it to the left so that the bolt is held in the released position. The window can now be opened by lifting lever (E) either to the first slot in the quadrant to give a half open position or by allowing the lever to go up to the top quadrant stop when the window will be held in the maximum open position by the two springs on the operating lever.

Incorporated in the window is a bullet proof visor and glass block, or, as an alternative to the latter, an emergency screen. A windscreen wiper actuated by button (Q) keeps the glass block or the emergency screen clear.

Should the glass block be rendered opaque by the impact of a missile, the damaged block in its container may be

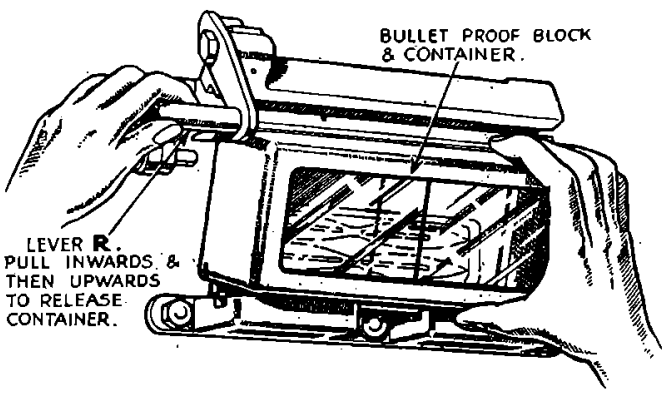


Figure 2. Changing Glass Block Container

removed by pulling the lever (R) towards the driver until the lever disengages from the eccentric pin (See Fig. 2). The lever may then be lifted vertically and this, in turn, raises the top slide and allows the glass block to be removed and replaced by a spare which should be locked in position by a reversal of the above procedure.

Side vision is provided by shutters actuated by levers (C and U, Fig. 1).

Reversing. A field of view for driving in reverse is obtained by operating the hydraulic pump at the right of the driver.

After screwing down the valve (O) in the centre of the pump and operating the handle (N) to and fro, the jack will lift the engine access door as well as the observation door in the centre of the rear bulkhead of the fighting compartment, the observation door being coupled to the access door by means of a chain.

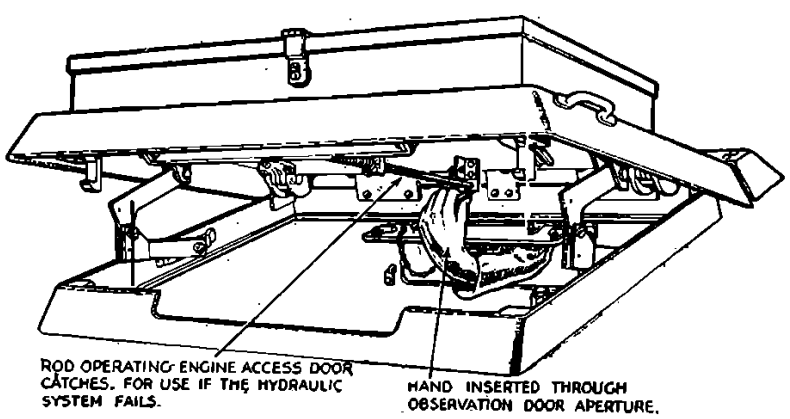


Figure 3. Engine Access Door Hand Operating Rod

To shut the doors, it is only necessary to open the valve on the top of the pump.

Should the hydraulic system fail, a hand operating rod has been fitted to bring the two catches at the rear of the engine compartment out of engagement.

This can be operated through the observation door aperture, the rod being pulled towards the operator and held there whilst the access door is lifted from outside (see Fig. 3).

FOUR WHEEL DRIVE IS ONLY FOR USE IN SEVERE CONDITIONS

RECEPTION OF A NEW VEHICLE

When a new vehicle is received it is **MOST IMPORTANT** to make a full and careful examination of the machine, because once the vehicle is handed over **YOU ARE RESPONSIBLE** ! It is, therefore, your responsibility to ensure that the vehicle is in perfect mechanical condition and that all equipment, tools and stowage are complete in every detail.

TAKING DELIVERY

For guidance the following points must be checked immediately on delivery :—

1. Examine oil level in sump to ensure that the engine has **NOT** been run short of oil.
2. Check water level in radiator, and examine water connections and hoses for leaks.
3. Check over engine for external oil leaks.
4. Start up the engine by the procedure given on page 9.
   Note : This is a new engine : Do not race it.
5. With the engine running, check oil pressure. When engine has properly warmed up, satisfy yourself that it runs smoothly and regularly without undue noise or vibration.
6. Examine generator charging rate which should read from 1 to 10 amps. according to the condition of the batteries.
7. Remove battery covers and vent stoppers and check the electrolyte level, which should be at least $\frac{1}{4}$" above top of the plates.
8. Check over the hand traverse and turret locking device.
9. Test all lights and electrical equipment.
10. Check gear lever engagement and clutch movement and operation. The clutch engagement should be smooth and progressive.
11. The steering should be sensitive and accurate.
12. The brakes should be powerful and progressive.

Make a report of any mechanical fault, damage or breakage which may be found during examination.

RUNNING IN

During the first month of service the engine should not be driven hard. Do not " labour " the engine in top gear, and avoid excessive " revs " in any gear.

At the end of the first day's service and twice during the first week *the spring holding down bolts should be tightened.*

Tighten the cylinder head nuts in the order shown in figure 4 at the end of the first and second day's work, *while the engine is hot.* Check these nuts again at the end of the first week.

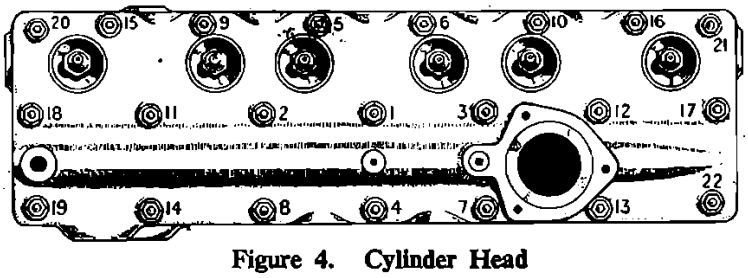


Figure 4. Cylinder Head
(Shewing order of tightening head nuts)

Check and if necessary re-adjust tappet clearances (*see* " *Engine* " *page* 35).

Tighten sump and timing cover screws.

Test clutch pedal for free movement and adjust if necessary to a minimum of 1" (*see Pedal Adjustment, page* 38).

After the first week clean petrol filters in petrol pump and carburettor.

Drain oil from engine, gearbox, transfer box and front and rear axles and refill with new oil.

After the first three months decarbonize the engine and grind in the valves.

Remember this is a new vehicle ! The first 500 miles are the most important. Look after it. It is your responsibility.

FROST PRECAUTIONS

It is most important that precautions be taken to prevent freezing of the liquid contained in the engine cooling system during cold weather.

The efficiency of this system depends upon circulation, as the heat must be conducted from the engine to the radiator. It is therefore disastrous if the coolant, which should be circulating, is frozen.

Furthermore, water expands as it freezes, and in consequence will crack the radiators, cylinder jackets or pipes. Then, when the ice is melted, the system will leak badly and need a major overhaul to right it. To prevent such trouble, one of the following methods can be adopted :—

(1) Use an anti-freeze solution.
(2) Drain the cooling system completely.
(3) Run the engine periodically.

It is not sufficient to cover the system with muffs.

(1) USE OF ANTI-FREEZE

The coolant is made into an anti-freeze solution by adding ethylene-glycol (*it should be noted that commercial glycerine must in no circumstances be used*) to the water ; the greater the proportion of ethylene-glycol, the lower the freezing point. Therefore the proportion of ethylene-glycol to water is varied up to 60% maximum according to the atmospheric temperature prevailing, as shown below :—

ATMOSPHERIC TEMPERATURE	COOLANT
Tropical Summer (above 90F°)	Water
Normal	Water
Severe Cold (32°F to -4F°)	66.6% Water 33.3% Ethylene-Glycol
Extreme Cold (-4°F to -40°F)	40% Water 60% Ethylene-Glycol

Ethylene-Glycol has a much greater searching action than water and it is most important, therefore, to keep all joints in good condition. Inspect all hoses for condition and joints and clips for tightness before inserting anti-freeze coolant.

To fill up with anti-freeze coolant, first drain the cooling system by **opening the radiator filler cap** and the two drain cocks, one provided in the bottom water pipe of the radiator (*shown in the shut position in Fig.* 5) and the other positioned towards the rear of the cylinder block on the nearside (*shut position shown on Fig.* 6). It will be realised that access to the radiator drain cock is obtained underneath the skirt at the right-hand side rear of the hull, while the cylinder drain cock can be reached after the engine access door has been opened.

The cocks must be tested at frequent intervals by inserting a piece of wire to ensure that they are clear. This should be done immediately after they have been opened, so that any obstructions freed by the wire may be flushed out by the water.

When draining, do so with the vehicle on level ground and when the engine is hot.

Do not leave the vehicle until the water has ceased to run from both cocks.

Prepare the solution in separate containers using the proportions stated in the table and mix thoroughly.

Close the drain cocks and pour the coolant into the header tank until the bottom is just covered.

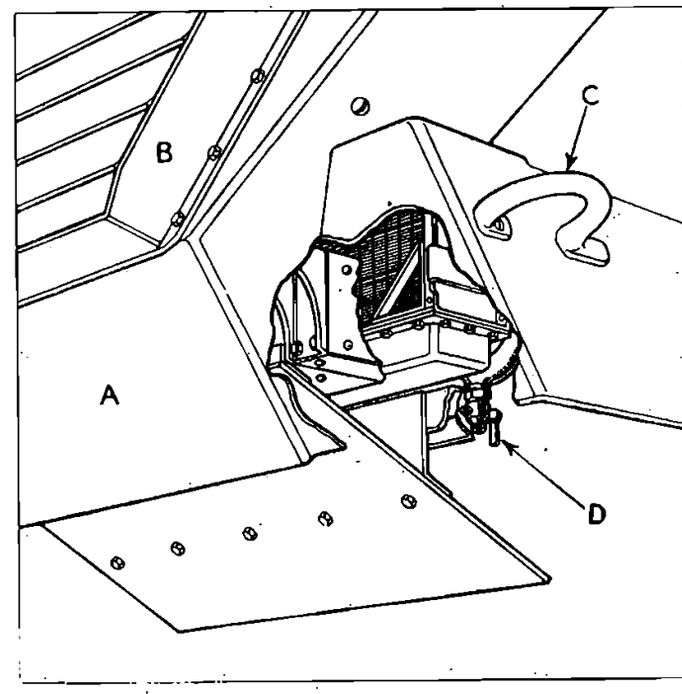
Start the engine as described in " Starting and Driving Instructions " and run it (*without racing*) until the coolant is warm. Then top up to the correct level (see Chapter 1A) so avoiding waste by overflow due to expansion. Never top up cold.

After the system has been filled with anti-freeze, the strength of the solution must be maintained by topping up, when necessary, with anti-freeze solution. The system **must not** be topped up with water only, as this reduces the degree of protection afforded.

When the cooling system has been filled with anti-freeze solution, a blue circle must be painted on the header tank and it is preferable that this blue circle should be superimposed on a square, painted white for easy recognition. This mark will be painted out if the cooling system is drained and not refilled with anti-freeze.

When using anti-freeze, do not drain the cooling system in cold weather.

Should it become necessary to drain the cooling system for repairs, the anti-freeze solution must be collected in suitable containers for subsequent refilling of the system.



A Hull Rear Skirt Plate
B Radiator Air Outlet
C Rear Towing Loop O.S.
D Radiator Drain Cock

Figure 5. Radiation Drain Cock

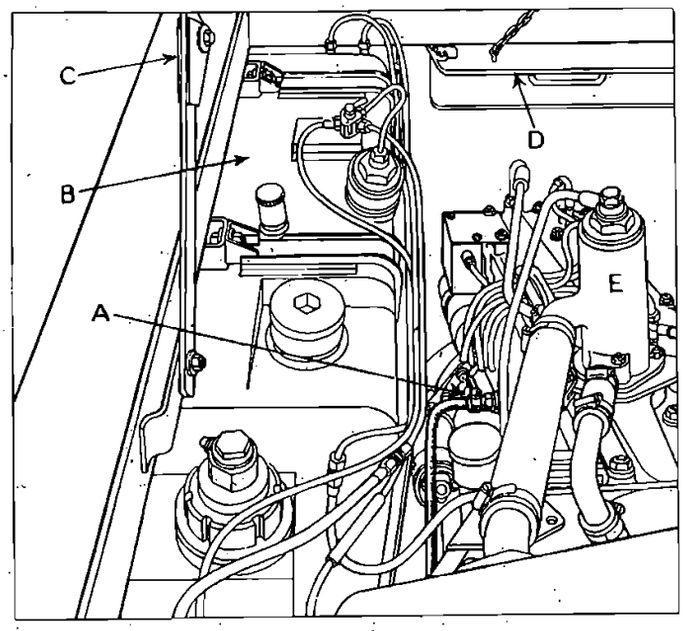
(2) DRAINING THE COOLING SYSTEM

When anti-freeze is not available, **drain the cooling system completely** as instructed in (1) above.

If there is no water supply near, collect and keep the drained off water.

When all water has been drained off, run the engine for one minute with both cocks open, and stop.

Leave a notice on the tank that the cooling system is empty. Should this be overlooked, and the engine started up, seizure will quickly occur. If, however, the mistake is discovered before seizing, stop the engine and let it cool down before pouring in coolant.



A Cylinder Drain Tap
B Main Petrol Tank
C Support for Engine Access Door
D Observation Door in Bulkhead
E Thermostat and Pressure Relief Valve Housing

Figure 6. Cylinder Drain Cock

When starting up after the cooling system has been drained, bring the water to the engine, not the engine to the water.

Close the drain cocks, free the engine bearings by hand (*using the loose starting handle in the tool kit*) then start the engine as shown in "Starting and Driving Instructions." Immediately fill the cooling system with warm water if this is obtainable, keeping the flow as continuous as possible.

If warm water is unobtainable and cold water has to be used, the system must be warmed by running the engine at a steady speed (*not racing*). On no account must the vehicle be driven away until the water in the **radiator** has started to warm up.

The reason for this is that the cooling system incorporates a thermostat which prevents the flow of water through the radiator until running temperature has been attained. This ensures the rapid warming up of the engine, but it is possible for the water in the radiator to freeze while the vehicle is in motion.

(3) RUNNING THE ENGINE PERIODICALLY

If it is impossible to secure anti-freeze, and the vehicle must be ready for immediate use, freezing of the coolant can be prevented by periodical running of the engine. To do this, run the engine at a fast speed, but don't race it, for periods of five minutes at intervals dependent upon the severity of the cold.

This also applies to vehicles which are halted temporarily.

Under conditions of severe cold, be sure to change the lubricants as instructed on the lubrication chart.

FIRE PRECAUTIONS

If you keep your vehicle clean, and free from oily dirt, and all ammunition properly stowed, there is less danger of it catching fire.

POSITION OF FIRE EXTINGUISHER

Four fire extinguishers are fitted to the Vehicle :—

Two (2) " Essex " (Methyl Bromide) Extinguishers fitted externally on the rear wings.

Two (2) "Pyrene" (Carbon Tetrachloride) extinguishers fitted internally, one by near side door, and one on bulkhead of fighting compartment.

These two types are illustrated in Figs. 7 and 8.

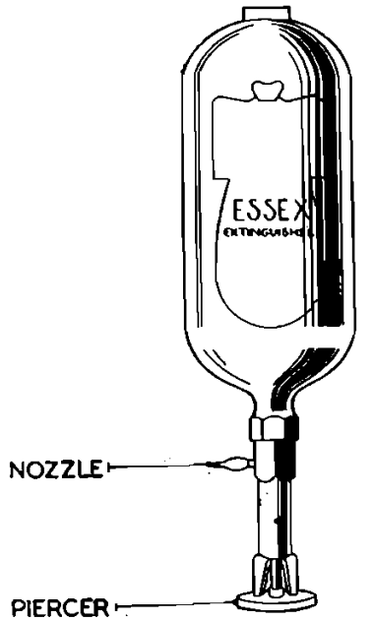


Figure 7. " Essex " Type Extinguisher

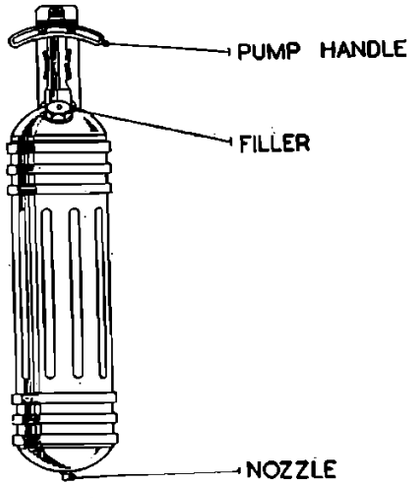


Figure 8. " Pyrene " Type Extinguisher

TO RELEASE FIRE EXTINGUISHERS

" Essex " Type. Grasp neck of the extinguisher in right hand, and lift free of supporting bracket ; **taking care to keep extinguisher upright.**

" Pyrene " Type. Free extinguisher by sharp pull from spring clip holding handle, and lift out of supporting cup.

TO OPERATE EXTINGUISHERS

" Essex " Type. Holding extinguisher by neck in right hand, and taking care to keep it **upright,** approach the seat of fire, then striking the " mushroom " headed plunger on a hard surface, direct jet stream at seat of fire. The extinguisher will continue operation until exhausted.

" Pyrene " Type. Holding extinguisher in left hand, and pointing nozzle at seat of fire, give handle of extinguisher a half turn, which unlocks it, the ordinary pumping action can then be started. Having a double acting pump, the extinguisher operates on the first upward pull.

Avoid inhalation of the fumes given off.

MAINTENANCE OF EXTINGUISHER

" Essex " Type. The carrying bracket is fitted with a safety collar, preventing accidental operation of " mushroom " plunger. Keep discharge nozzle free from dirt. It should be noted that " Essex " type extinguishers must be fully discharged—there being no cut off valve or tap.

" Pyrene " Type. Carrying bracket is fitted with cup at base projecting nozzle. Keep jet nozzle clean and free from dirt or obstruction.

REFILLING

" Essex " Type. There is no provision for refilling. The exhausted " flask " must be returned for replacement.

" Pyrene " Type. Owing to the fact that this pump type Extinguisher, may be partially discharged when only used for a short time, care should be taken before replacing in bracket, to see that it is refilled. A " screw in " filler is provided to fit at the top of the extinguisher for this purpose. (See Fig. 9). Refilling fluid is provided in sealed cans.

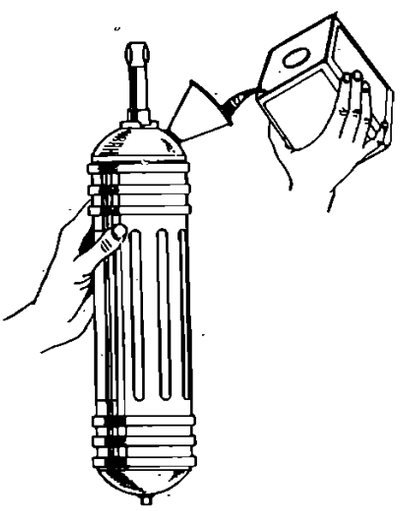


Figure 9.
Refilling " Pyrene " Extinguisher

CHARACTERISTICS

" Essex " Type. The liquid contents of this extinguisher has a decided freezing effect. Its action is to cool surface of burning oil or petrol, preventing further vaporisation of inflammable material.

" Pyrene " Type. The liquid content of this extinguisher has a " blanketing effect," excluding air from the seat of fire.

AVOID INHALING FUMES

MAINTENANCE

The following table has been compiled to show clearly and concisely the attention required to maintain the vehicle in a state of high efficiency under normal conditions of work and climate.

The periods at which the attention is required are shown on both a time and mileage basis and the maintenance should be carried out at whichever is the less, *i.e.*, if the vehicle is doing less than 200 miles in a day then the attention marked " Daily or every 200 miles " will be carried out daily. If the vehicle is doing more than 200 miles in a day then it will be carried out every 200 miles.

It is appreciated that in service the conditions encountered, particularly climatic, will vary between wide extremes and it must therefore, of necessity, be left to the discretion of those on the spot to vary the periods at which this attention is given, to suit actual conditions.

Cleanliness of the lubrication system is of great importance, involving strict adherence to the instruction regarding flushing the engine and changing the oil at the stated intervals.

The need for cleanliness of oil measures and cans used for refilling and of drums used for storing the lubricant is emphasised.

To carry out the operations shown below it will be necessary to refer to the sections of the book which cover the parts or units mentioned, and to assist it will be found that the chapter and part numbers are quoted at the end of each item in the summary.

Finally, it will be found that the lubrication diagram in the cover pocket will be of great assistance in carrying out this work.

DAILY OR EVERY 200 MILES	(1) Check oil level in engine and top up if necessary (see chapter IA, part 4). (2) Check coolant level in radiator and replenish if necessary. If water is being used, soft water should be obtained for topping up providing it is obtainable. In the event of anti-freeze solution being in use (indicated by a coloured disc on the header tank) see instructions in section headed " Frost Precautions " on page 14. (See chapter IA, part 5). (3) Examine tyres for cuts, etc. Test for pressure. (See chapter IIA, part 6). (4) Check all wheel nuts for tightness. Wheel nuts on R.H. have R.H. threads. Wheel nuts on L.H. have L.H. threads. (See chapter IIA, part 6). (5) Clean periscope glasses. (See chapter VIIA, part 2). (6) Clean air cleaner and refill with fresh oil. This should be done every 100 miles when subjected to very dusty conditions. (See chapter IA, part 2). (7) The side door, turret headflaps, revolver ports and vision flaps should be wiped clean and rubbed with an oily rag. The hinges and catches should be lightly oiled and any surplus removed, for otherwise dust and dirt will collect.
WEEKLY OR EVERY 500 MILES	(1) Grease spring and shackle pins—12 points. (See chapter IIIA, part 1). (2) Grease swivel bearings and "Tracta" joints—2 points. (See chapter IIA, part 5). (3) Grease steering joints—track rod, 2 points, side steering rod, 2 points. (See chapter IIA, part 5). (4) Grease universal joints and propellor shaft splines—6 points. (See chapter IIA, part 4). (5) Grease handbrake cable—1 point. (See chapter IVA, part 3). (6) Grease gearbox control—1 point. (See chapter IIA, part 2). (7) Give one turn to cap of water pump greaser. (See chapter IA, part 4). (8) Give one turn to cap of clutch withdrawal bearing greaser. (See chapter IIA, part 1). (9) Grease periscope lower bearings—2 points. (See chapter VIIA, part 2) (10) Grease turret ball race—2 points. (See chapter VIIIA, part 1). (11) Top up steering box—1 point. (See chapter IVA, part 1).

WEEKLY OR EVERY 500 MILES (continued)	(12) Oil moving parts on periscope. (See chapter VIIA, part 2). (13) Oil starting handle chain. (See chapter 1A, part 8). (14) Oil handbrake, transfer box and declutch control lever bushes, yoke pins and all other connections. (15) Oil gun mounting. (See chapter XA, part 1). (16) Top up battery—using distilled water only. (See chapter VA, part 3). (17) Check fluid level in master cylinder and replenish if necessary. (See chapter IVA, part 2). (18) Check tightness of coupling bolt nuts on propeller shaft between gearbox and transfer box. (See chapter IIA, part 4). (19) Check clutch pedal adjustment. (See chapter IIA, part 1). (20) Check valve clearances and re-adjust if necessary. (See chapter IA, part 7). (21) Inspect oil level in gearbox, transfer box and front and rear axles. Replenish if necessary. (See chapter IIA, parts 2, 3 and 5). (22) Test brakes and adjust if necessary. (See chapter IVA, part 3). (23) Grease turret hatches. (See chapter VIIA, part 1). (24) Oil moving parts of driver's window with oil can. (See chapter VIA, part 2).
EVERY MONTH OR EVERY 1,000 MILES	(1) Grease cam and pivots on distributor. (See chapter IA, part 6). (2) Grease wheel hubs—4 points. (See chapter IIA, part 5). (3) Check wheel alignment. (See chapter IIA, part 6). (4) Clean distributor points and check gaps. (See chapter IA, part 6). (5) Replenish distributor oil reservoir. (See chapter IA, part 6). (6) Clean sparking plugs and check gaps. (See chapter IA, part 6). (7) Clean petrol pump sludge chamber. (See chapter IA, part 3A). (8) Clean carburettor float chamber, and banjo union filter. (See chapter IA, part 1). (9) Oil distributor cam bearing. (See chapter IA, part 6). (10) Oil road springs. (See chapter IIIA, part 1). (11) Top up engine access door jack feed tank. (See chapter VIA, part 3). (12) Top up shock absorbers—4 points. (See chapter IIIA, part 2). (13) Drain tyre pump air filter. (See chapter IIA, part 7). (14) Inspect and if necessary renew stockinette in tyre pump air filter. (See chapter IIA, part 7). (15) Grease starting handle shaft. (See chapter IA, part 8). (16) Oil turret traversing gear. (See chapter VIIIA, part 2).
EVERY 3 MONTHS OR EVERY 2,500 MILES	(1) Drain engine sump and refill with fresh oil. (See chapter IA, part 4). (2) Drain gearbox, transfer box, de-clutch and refill with new oil. (See chapter IIA, parts 2 and 3). (3) Drain front and rear axles and refill with new oil. (See chapter IIA, part 5).
EVERY 3,000 MILES	(1) Change engine oil filter. (See chapter IA, part 4).
EVERY 12 MONTHS OR EVERY 5,000 MILES	(1) Drain engine sump, remove, clean, refit and refill with fresh oil. (See chapter IA, part 4). (2) Drain gearbox, transfer box, de-clutch and refill with new oil. (See chapter IIA, parts 2 and 3). (3) Drain front and rear axles and refill with new oil. (See Chapter IIA, part 5).

WHEN AUTHORISATION IS GIVEN BY FORCE HEADQUARTERS TO CHANGE OVER TO H.D. OILS THE FOLLOWING INSTRUCTIONS MUST BE STRICTLY ADHERED TO

(*a*) It is preferable to change over to the new H.D. oils whilst the engine is in a new condition, or as soon after an overhaul as possible. Engines which are nearing overhaul should, if possible, continue to run on the existing mineral grades of oils.

(*b*) When changing over to the new H.D. oils, the engine will be run until the normal working temperature is attained and the existing oil drained off whilst hot.

(*c*) The engine will then be filled with the appropriate grade of H.D. oil and run at a speed of approximately 1,500 r.p.m. for half-an-hour and the oil again drained off whilst hot.

(*d*) All easily removable filter elements, gauzes, pipe lines and relief valves must then be removed and cleaned.

(*e*) The engine will then be refilled with the H.D. oil and a label affixed to the instrument board adjacent to the oil pressure gauge, giving in large letters the grade of H.D. oil used, the date and mileage of the change over ; this information will also be entered in the A.B.413.

(*f*) Normal running will be continued for not less than 300 or more than 500 miles, during which time special notice will be taken for evidence of low oil pressure or overheating of the engine.

(*g*) If a drop in oil pressure or overheating is experienced, the engine will be immediately stopped, the oil drained off and the lubrication system cleaned as in (*d*) above, and replaceable filter elements renewed.

(*h*) If the operation of the engine has been normal during the 300-500 miles, the oil will be drained off whilst hot and the lubrication system cleaned as in (*d*) above, and replaceable filter elements renewed. The label on the instrument board and the A.B.413 will be endorsed to the effect that the second draining of oil has been carried out.

(*i*) Normal oil changes and operation of the vehicle will then be resumed.

TROOP LEADER'S INSPECTION

The following suggestions are put forward to assist troop leaders in the inspection of vehicles. It should be appreciated, however, that such an inspection will only cover the general condition of the machine for it cannot be of sufficiently detailed a character as to confirm on each inspection that every operation of maintenance has been carried out. However, checks of different points on each inspection should reveal any defection and in any event the suggested routine outlined will cover all points of major importance.

A road test may bring forward faults which are not otherwise detectable and it will be seen that some of the suggested points could best be checked after the vehicle has returned from a run, *e.g.* oil leaks are most likely to appear when the oil is warm.

1. Examine for general cleanliness, inside and out.
2. See that the engine compartment is clean and dry.
3. Ensure car is correctly stowed and that water, petrol, oil, rations, ammunition and all other equipment is carried as ordered.
4. Check that filled fire extinguishers are carried.
5. Check that tyres are inflated correctly, that there are no stones or other foreign bodies embedded in the rubber and that the wheel nuts are tight.
6. Check operation of intercommunication system and if not under wireless, silence the wireless set also.
7. Examine all grease nipples to see they are clean, and show obvious signs of recent greasing or oiling.

   Nipples will be found on :—

   (*a*) Spring and shackle pins—12 points.

   (*b*) Front axle swivel bearing and " Tracta " joints—2 points.

   (*c*) Steering joints (track rod—2 points, side steering rod—2 points).

(*d*) Universal joints and propeller shaft splines—6 points.
(*e*) Handbrake cable—1 point.
(*f*) Gearbox control box—1 point.
(*g*) Periscope lower bearing—1 point.
(*h*) Turret ballrace—2 points.
(*i*) Gun mounting.
(*j*) Wheel hubs—4 points.

Screw cap greasers of the " Staufer " type will be found on :—
(*a*) Water pump—1 point.
(*b*) Clutch withdrawal bearing—1 point.

8. Check operation of gun mounting and turret traverse gear.
9. Check operation of periscopes, turret headflaps and revolver ports.
10. Check operation of turret interior lights and ventilating fan.
11. Check operation of driver's window and side lookouts.
12. Check operation of engine access door and rear view flap in bulkhead.
13. Check driver's controls, *i.e.*
    (*a*) Clutch pedal has free movement.
    (*b*) Brake pedal applies brakes positively and does not require pumping.
    (*c*) Steering gear is light and positive.
    (*d*) Gearbox and transfer box hand levers operate gears without undue force and that gears go fully home.

    It will be appreciated that these checks can best be carried out on the road.
14. Check operation of driving lights, horn and windscreen wiper.
15. Have the engine started up and check.
    (*a*) That engine is running smoothly and is free from any unusual mechanical noise or vibration.
    (*b*) That exhaust fumes are lightly tinged with blue smoke. Rich mixture will cause a black or sooty exhaust. Ignore initial moisture emitted immediately after starting, this is from condensation.
    (*c*) That engine accelerates without hesitation on snap throttle opening.
    (*d*) That oil pressure gauge reads 40 to 50 lbs. per sq. in. when engine is new and warm and is running at the normal speed. This may drop to 10 lbs. per sq. in. when engine is idling, or it may rise considerably higher with a cold engine.
    (*e*) That temperature indicator reads between 170° and 180° when engine is thoroughly warm.
    (*f*) That ammeter shews dynamo is charging. This will probably be high when engine is running at normal speed after starting from cold, but will fall to a steady charging rate some time after starting up.
    (*g*) That fan is working correctly. The air stream will be felt coming through the louvres of the radiator grille at the rear of the vehicle.
16. Have engine stopped and examine :—
    (*a*) Engine and oil pipes for oil leaks.
    (*b*) Petrol tanks and pipes for petrol leaks.
    (*c*) Radiator, engine and water pipes for water leaks.
    (*d*) Water pump drain hole. A leak to be reported at once.
    (*e*) Engine oil. Remove dipstick and check level. If oil appears black or carbonized have it changed at once. If there is any suspicion of water report immediately.
17. Examine gearbox, front and rear axles, transfer box and shock absorbers for cleanliness and oil leaks.
18. Check over tools and equipment. Tools must be clean, serviceable and free from rust.

CHAPTER I A

Engine—Operation and Maintenance

Access to the engine is gained after the engine access door has been lifted, and as we have previously indicated under "reversing" on page 12, this door can be lifted sufficiently by means of a jack to permit a field of view. This will not permit enough clearance to carry out any maintenance, but to enable work to be done, the door is so designed that it can be swung completely up on its hinges by man power.

Limit stays are provided to support the door in a fully open position and these are pushed over centre by hand. Care must be taken to see that the turret is facing forward when the door is raised.

It is necessary that the door should be handled by two men when it is being closed, so that the movement is slow and deliberate. This is to ensure that the weight is gently deposited on to the jack, so avoiding the latter being damaged by the shock of a falling door.

PART 1. CARBURETTOR

A single carburettor is fitted to these machines. It is a downdraught dustproof unit and incorporates both a governor and economy device. This latter working under all conditions.

There is a special unit tp facilitate starting the engine in extremely low temperatures and the use of this has already been explained under "Starting and Driving Instructions."

The governor is entirely automatic and needs no attention or lubrication, as it is operated by the air flow past the throttle plate. It is set correctly at the works and the cap is sealed. No attempt must be made to alter the setting.

There are two floats, with the main jet assembly between, and as the floats operate in unison, the gross submerged float volume is constant regardless of gradient.

Maintenance.

Beyond cleaning of the float chambers and filter, together with inspection of the securing nuts and controls, no attention is necessary. In the event of trouble being experienced, it is however, permissible to clean the jets.

The jet settings have been determined by exhaustive tests, and no alteration must be made unless specific instructions are received from the competent authority. Jets can be freed of any obstructions as detailed below.

When cleaning jets, do not ream them or try to remove the obstruction by a piece of wire, or similar material. This action almost invariably ruins the jet by enlarging the orifice. If the obstructions cannot be removed by swilling out with petrol, use air pressure from a compressor, or an ordinary tyre pump.

The float chambers can be drained by removing the main jet carrier. This is a hexagonal nut in the centre of the jet housing cover, immediately above the self starting device. (See Fig. 10).

After removing the main jet carrier, drain and flush the float chambers by operating the hand priming lever and the petrol pump. This removes any sediment or foreign matter.

The filter is located inside the banjo union connecting the petrol pipe to the carburettor and should be cleaned every two months.

Access is gained by unscrewing the banjo bolt. The cylindrical filter can then be withdrawn from its seating.

After the gauze has been cleaned with petrol, reassemble and replace the washers fitted at either side of the banjo. These are necessary to ensure a petrol tight joint.

After cleaning float chamber and filter fill the chamber of the petrol pump, by working the hand primer. No attempt should be made to start the engine until this has been done. This operation will reduce the strain on the batteries.

The main jet is removed for cleaning by unscrewing the main jet carrier (see Fig. 10). The jet itself is screwed into the carrier and is removed with a screwdriver.

The starter (or petrol) jet G.S. is situated along side the main jet carrier and is removed for cleaning in a similar manner (see Fig. 10).

The pilot jet is fitted in the float chamber immediately above the main jet carrier and is removed either by using a screwdriver or spanner. (See Fig. 10).

The pilot air bleed is removed by a screwdriver after the air cleaner has been taken from the top of the carburettor. Its position is clearly shown on Fig. 10 and care should be taken both in removal and replacement, that it is not dropped through the choke and into the engine.

The air correction jet is accessible after removal of the air cleaner. The jet is situated in a tube centrally located in the choke and it will be seen that it can be removed with a screwdriver. (See Fig. 10).

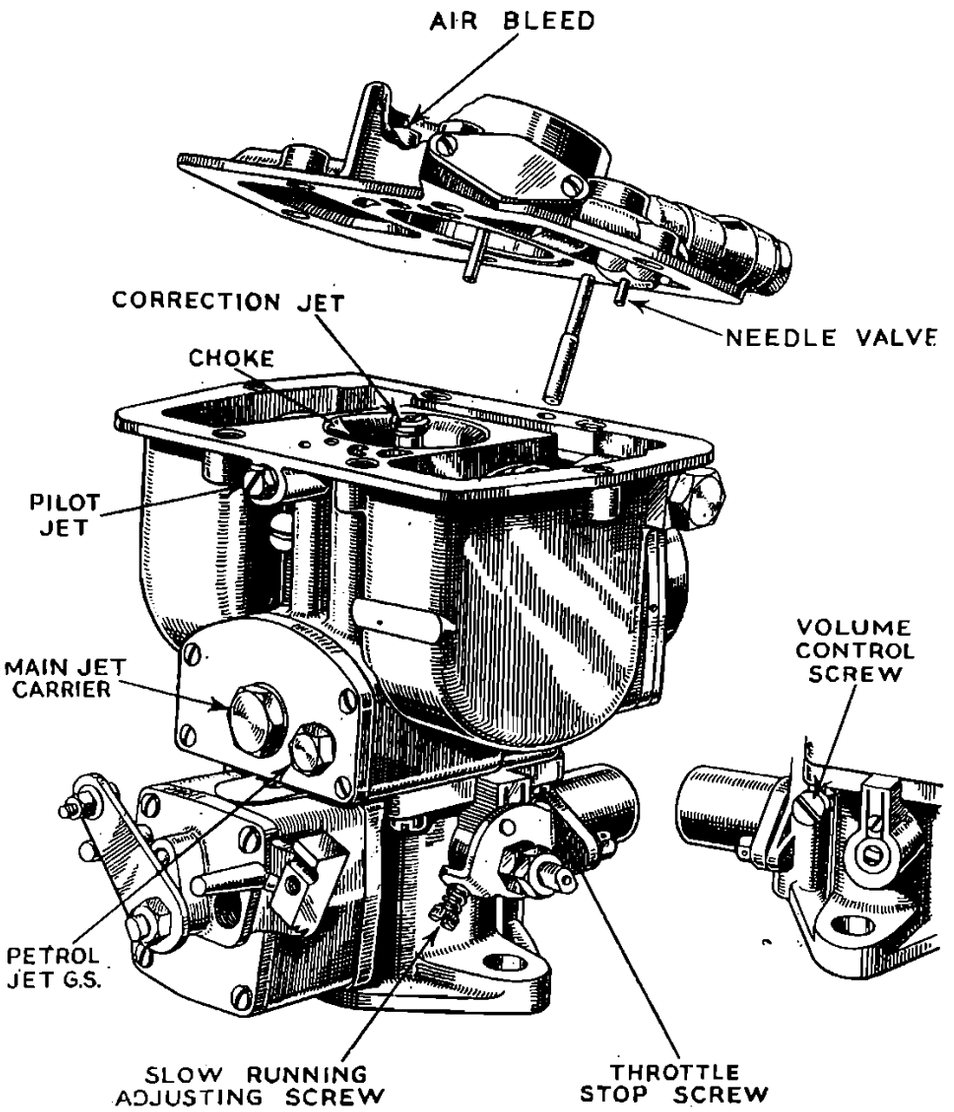


Figure 10. Carburettor shewing jet positions

In removal, care must be taken to see that it is not dropped through the choke and into the engine, for if this should happen, serious damage will be done.

The needle valve is screwed into the float chamber cover and this must be removed before the valve can be screwed out by means of a spanner.

First of all remove the air cleaner and disconnect the petrol pipe by withdrawing its securing banjo bolt. The six setscrews holding the float chamber cover to the float chamber can then be withdrawn and the cover lifted away, giving access to the needle valve.

When replacing, ensure that the gasket between the float chamber and the cover is undamaged and that a good petrol tight joint is obtained. It will also be necessary to ensure that a petrol tight joint is made when reconnecting the petrol pipe. Reference to Fig. 10, will make the above procedure clear.

The speed jet and choke will require no attention, for it is almost impossible for these to get choked. The position of the choke is, however, shown on Fig. 10.

Adjustment.

The only adjustment permissible is to the slow running, and this is carried out by co-ordinating the setting of the slow running screw mounted on the abutment plate of the throttle lever and the volume control screw situated in the throttle chamber immediately adjacent to the governor cap.

The slow running adjusting screw which is shown on Fig. 10 limits the closing of the throttle and fixes the idling speed of the engine. By screwing in this part the engine speed will rise, and vice versa.

If the engine " stalls " when the accelerator pedal is released it generally indicates that the throttle

needs opening, by screwing in this screw, but if a reasonable application does not cure the trouble, a mechanical defect must be sought and the remedy will not be in the adjustment at this point.

The volume control screw permits the richness of the idling mixture to be varied. By turning it in an anti-clockwise direction, enrichment takes place, up to the limit of the pilot jet output and conversely, by clockwise rotation, the mixture is weakened.

Poverty of mixture is recognised by the irregular behaviour of the engine and the tendency to "stall." Over-richness will cause the engine to " hunt " and tend to " stall " when the " hunt " becomes excessive.

In order to perfect the slow-running, adjust first the screw on the abutment plate, to fix approximately the speed of the engine.

Then experiment with the volume control screw until even running is obtained.

As this operation will generally alter the speed, it will be seen that finally a nice adjustment of both the screw on the abutment plate and the volume control screw will determine the results.

Do not try to adjust the idling to too slow a speed, but always ensure that the engine is heated to normal running temperature.

Operation of starting.

On starting from cold in *normal* weather, the dashboard knob is pulled out to its first knob. This in turn pulls the lever on the self-starting device, halfway over its arc of travel to a point located by the spring-loaded steel ball which registers with a small hole in the starting lever, so positioning it for normal weather conditions, including ordinary winter morning frost. Thus a mixture of approximately 10 to 1 air petrol ratio is obtained for easy starting.

For severe frost conditions, the dashboard control knob is pulled out to the first stop, turned half left and pulled again. This double movement pulls the lever to the full limit of its travel.

In this case, the full movement of the self-starting lever brings into line a hole which is of a larger size, enabling petrol to the full capacity of the petrol jet calibration to enter the mixing chamber, at the same time closing off all air. The initial mixture strength is approximately in the ratio of 1 to 1 air-petrol, so it is obvious that the dashboard control must be pushed back to normal position as soon as possible after warming up.

The whole operation of starting has already been explained in " Starting and Driving Instructions" and it will be seen from the above how necessary it is that the instructions given should be closely followed. To run the engine with the starter control out, will have serious effects on the engine, not only from wear caused by washing of the cylinder bores, but also by the damage caused by the dilution of the oil in the sump.

PART 2. AIR CLEANER

The air cleaner employed is of the oil bath type and requires cleaning and re-oiling at the period indicated in the section " Maintenance."

The actual cleaner used, differs from the usual type, in that it is wholly encased in an outer shroud. This enables air to be led to the cleaner from the fighting compartment or the " pre-cleaners," if these latter are fitted.

Maintenance.

The following instructions show how to clean the filter and replenish with oil, and it is emphasised that no hard and fast mileage or time is laid down for the carrying out of this operation. When operating under severe conditions it is almost impossible to carry out this work too frequently. Remember that no damage can be done by over-cleaning, but a great deal can be done if the filter is not kept in effective service.

To remove top cover : Unscrew the knurled nut holding the shroud cover in position. This latter can then be lifted away.

The knurled nut, holding the top cover of the air cleaner, will now be exposed, and, if the nut is removed, the cover can be lifted away. The filter element can be lifted out after removal of the top cover, and it should be cleaned by swishing up and down in a bowl of petrol. Do not replace until it has been thoroughly drained.

To clean base of filter : Empty oil after removal of filter element and scrape out any accumulated mud.

Wash the entire base with petrol and dry thoroughly, making sure that no threads of cloth remain in the base.

In re-oiling filter, use engine oil and fill to level indicated, *i.e.*, to the top of the small shoulder in the base of the filter. (See Fig. 11).

Replace filter element, cover and shroud cover, making sure that the cover gaskets are in good condition and that a proper joint is made.

It should be noted that it is unnecessary to re-oil the filter element, for this is done automatically when the engine is started up.

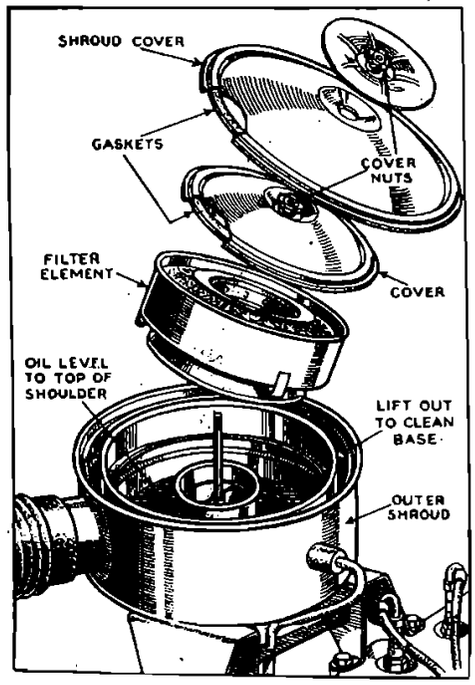


Figure 11. Air Cleaner

PART 3. FUEL SYSTEM

Fuel is carried in two tanks (see Fig. 12) situated in the engine compartment, the larger of the two containing the main supply and the smaller acting as a reserve. Capacities of the tanks are shown in " Tabulated Specification " at the beginning of this book.

The tanks are designed with provision for petrol expansion and no drip pipes are necessary.

To prevent any accumulation of petrol gas in the engine compartment a special system of venting is employed. It will be noted that a pipe is run from the top of the reserve tank into the main and any vapour created in the former through the heat generated by the engine will be exhausted through this pipe line.

To ventilate the main tank, another pipe is led to the outside of the body where the vapour disperses in the atmosphere.

From the foregoing, the importance of these pipes will be appreciated, and, on no account must the vehicle be run unless these pipes are properly coupled.

Ample provision is made for filtration of the petrol, detachable filters being fitted in the tank filling orifices, on the suction pipes, in the petrol pump and in the carburettor.

From each tank, a pipe is run to a 3-position cock mounted on the top of the main tank, and, from this tap, a further pipe carries the fuel to the pump on the side of the engine and from there to the carburettor.

Operation.

Tank replenishment. This must, obviously, be carried out through the engine access door which can be lifted, by the jack, as instructed in the section " Starting and Driving Instructions " on page 9.

The filler caps can be removed after cleaning the surrounding area, and it will be found that filters are provided in the filling orifices of both tanks, but it is still essential that precautions be taken to prevent the entry of any foreign matter when the tanks are being filled.

On no account should the filters be removed during the operation of tank replenishment, but periodically they should be taken out and the gauze cleaned of any impurities which may have accumulated.

Calibrated dipsticks are provided for each tank, and, here again, before their removal, the knob or surrounding flange should be wiped clean.

It is possible that a certain amount of dust, etc., may enter the tank suspended in the fuel but the major portion of this matter will settle to the bottom in the form of sludge. In order that this may be removed, a drain plug is provided and removal of this will allow the tanks to be flushed out.

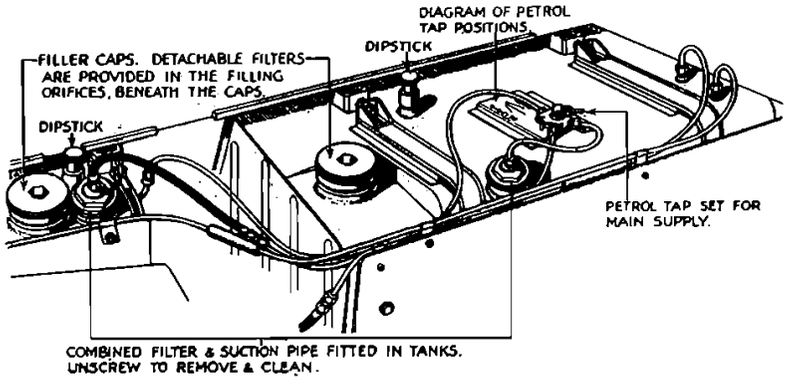


Figure 12. Petrol Tap and Suction Filters

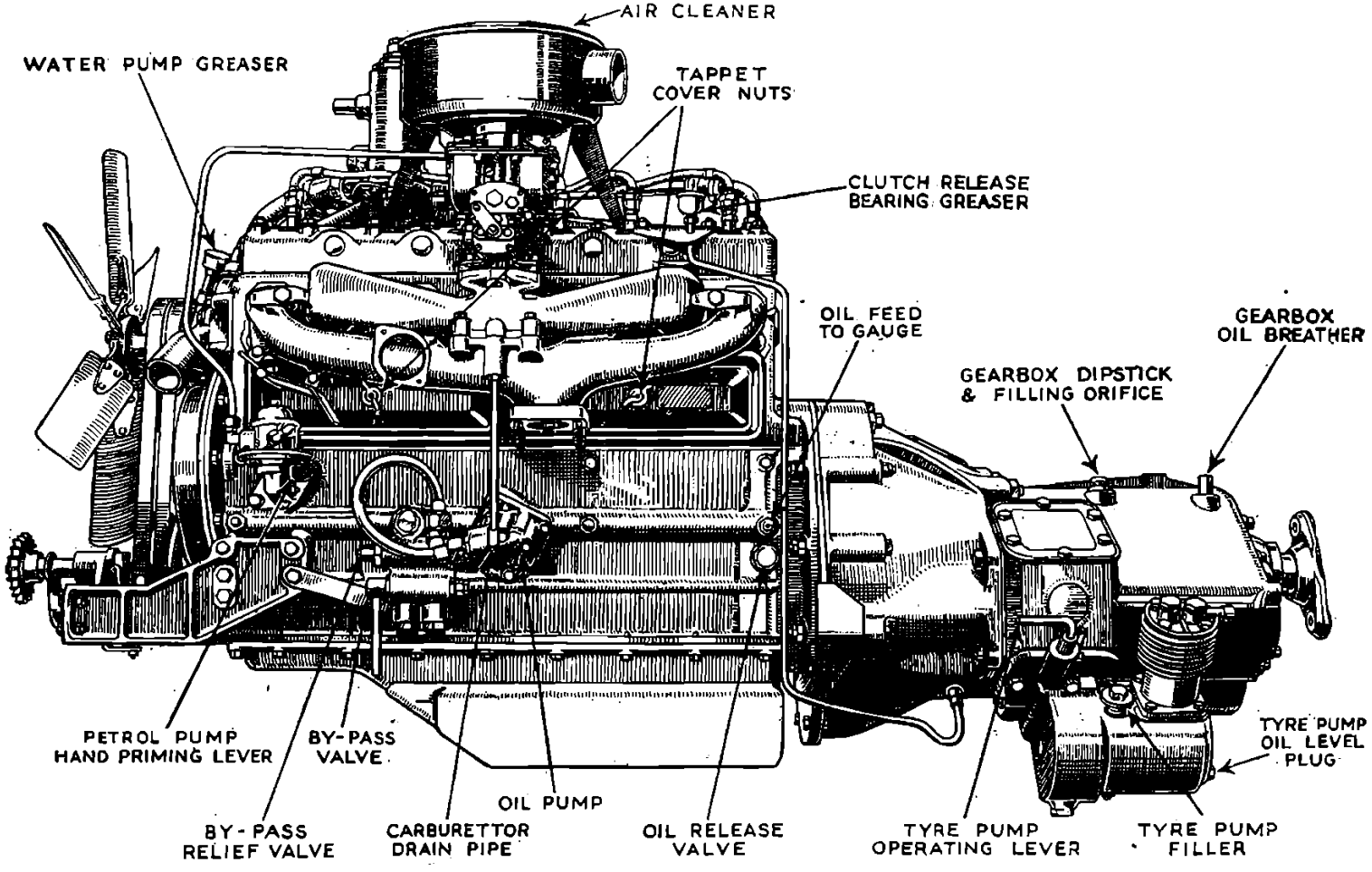


Plate 4. Engine and Gearbox—Manifold Side

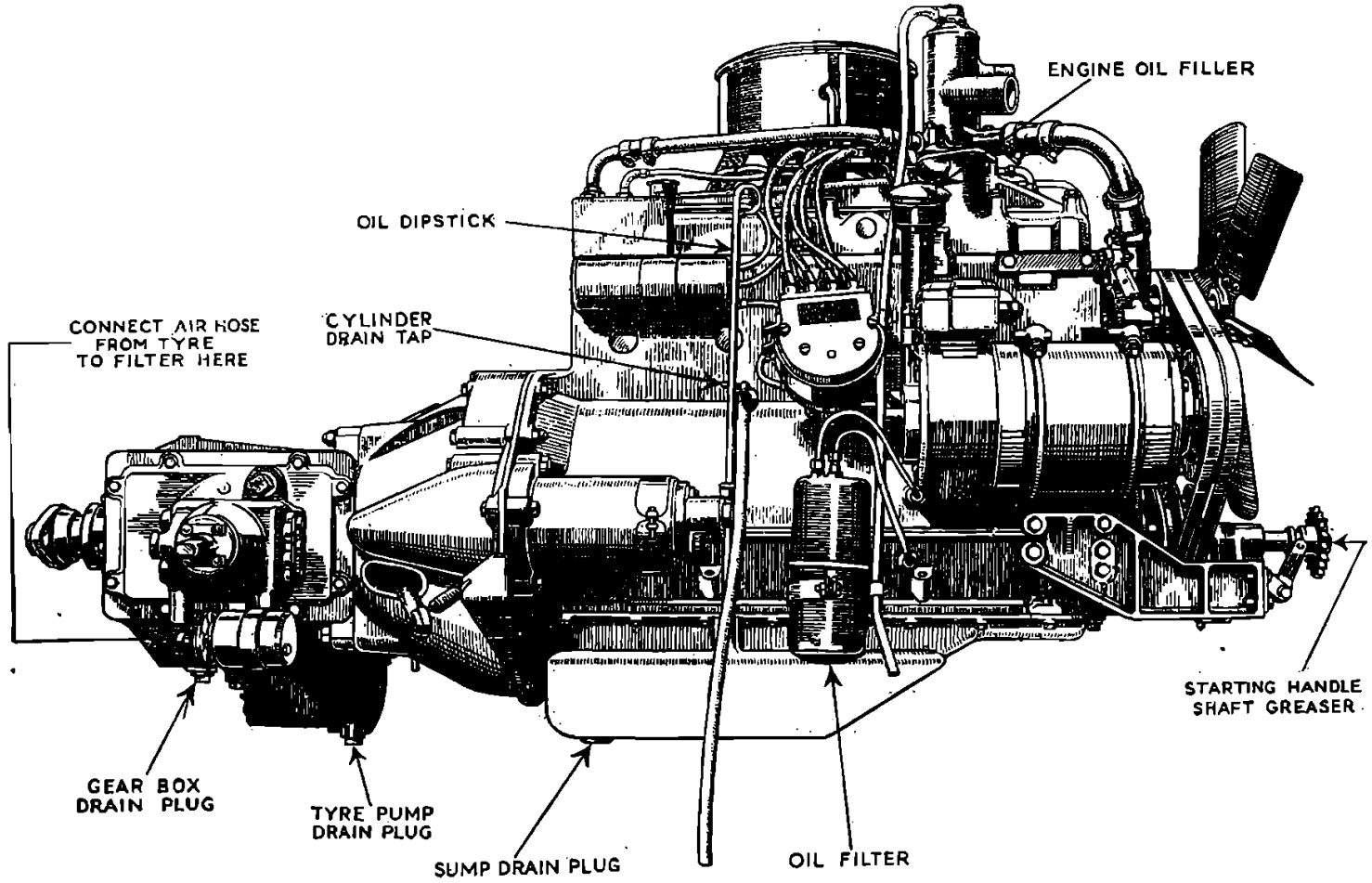


Plate 5. Engine and Gearbox—Dynamo Side

Petrol can be drawn at will from either main or reserve tank by means of the 3-position cock mentioned above, and this fitment also provides a means of cutting off the fuel supply completely.

The illustration shows the position of the tap on the main tank with its operating handle set for main supply. A central position of the handle cuts off the supply completely, whilst when the handle is in line with the reserve pipe, petrol from the reserve tank is being drawn.

The tap can be reached from the fighting compartment by inserting the hand through the hinged flap provided for observation during reversing, thus allowing a change from one tank to another to be carried out without the necessity for raising the engine access door.

Maintenance.

The filters in the tank filling orifices can be removed by inserting the hand and screwing them out. They are held in position by a setscrew fastened to the filter frame and passing through a bar at the bottom of the filling orifices.

The cleaning of the filters can best be done by immersion in clean petrol which is not to be used for fuel. The gauze should not be scraped with a knife or any other similar instrument.

When re-inserting the filters, tighten them by hand just sufficiently for the retaining screw to hold them in position.

The suction filters which are in the form of a combined filter and suction pipe should also be taken out periodically and cleaned. This can be effected by removing the pipes running to the three position tap and unscrewing by means of the spanner flats provided.

Cleaning is carried out in exactly the same manner as detailed above for the filters in the filling orifices, and, when replacing, the units should be tightened securely in order to prevent air leaks.

Additional filters are provided in the petrol pump and carburettor, cleaning of both these being dealt with in the respective sections covering the units.

Before any attempt is made to start the engine after cleaning any part of the filtration system, it will be necessary to re-fill the chamber of the petrol pump by working the hand primer. This operation will reduce the strain put on the batteries.

PART 3A. PETROL PUMP

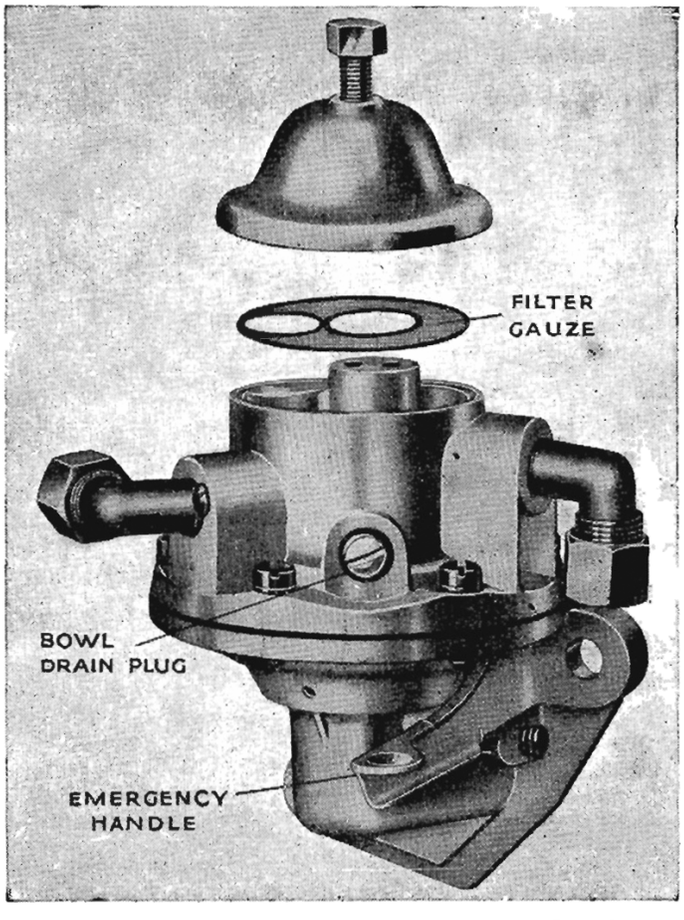


Figure 13. To clean Petrol Pump Sludge Chamber

A suction pump is utilized to lift the fuel from the tanks to the carburettor and no adjustments will be required in service.

It is necessary that the chamber be cleaned from time to time and the driver must be in a position to use the hand priming lever (or emergency handle) should any part of the fuel system have been drained.

Many cases of fuel failure are blamed on the petrol pump, but frequently the trouble is traceable to some other source, or can be simply remedied. A few points which can be usefully checked are given below.

Operation.

The hand priming lever is for use when, for any reason, the carburettor float chamber has become empty.

To use the priming lever (see Fig. 13) work slowly up and down until the petrol has been lifted into the carburettor bowl. It must be remembered that the petrol pump is driven at half engine speed, and the re-filling of the carburettor would take some little time if this operation was carried out entirely by revolving the engine with the starter.

If free movement is felt when operating the priming lever, showing that full pumping action is not taking place, it indicates that the pump operating lever (or rocker arm) is bearing on the toe, instead of on the heel, of the eccentric on the camshaft. The engine in this case, must be turned one complete revolution, so as to obtain full pumping action.

Should the pump fail to deliver petrol, check the following :—

(1) Make sure there is petrol in the tank.

(2) Make sure pipelines are sound and unions tight.

(3) Remove top cover from petrol pump and clean the filter gauze, and the sediment chamber as instructed below.

(4) Make certain that cork gasket of pump cover is unbroken and is properly seated when reassembling and that fibre washer is under head of cover screw.

(5) If there is a leakage of fuel at edge of diaphragm, tighten its screws alternately and securely.

(6) Check that there are no air leaks between the tank and the pump, to delay delivery of petrol to the carburettor.

Maintenance.

To clean the chamber of the petrol pump the top dome cap must be removed, together with the filter fitted below it. The petrol should then be drained from the chamber by the removal of the small plug (see Fig. 13) which will be seen on the outside of the pump. When replacing the top cap it is important that the cork gasket is intact and lies flat on its seat. Whilst it is important that the setscrew must be tightened securely, excessive pressure will serve no useful purpose, but will merely accelerate the deterioration of the cork washer, and tend to strip the threads of the tapped hole in the pump body.

After the petrol pump has been emptied, it is necessary to refill it by working the hand primer before any attempt is made to start the engine. This operation will reduce the strain put on the batteries.

PART 4. LUBRICATION SYSTEM

The engine lubrication is high pressure throughout and visual evidence of satisfactory oil pressure is provided by the fitting of a gauge and warning light.

Circulation is wholly automatic, but the operator can determine whether or not the oil should be passed through the cooler.

In maintaining the system, it must be borne in mind that cleanliness is of primary importance, not only in topping-up and refilling but also in carrying out the instructions regarding changing the oil and the filter.

No adjustments are required in service, the only adjustable relief being situated in the same casting as the by-pass valve. This relief valve permits the oil to return automatically to the main gallery should the cooler become choked, thus ensuring that the oil supply to the engine is maintained.

Correct adjustment is made in initial assembly, and no alteration will be required. In the event of the adjustment being accidentally disturbed, resetting will have to be carried out in R.E.M.E. Workshops.

Operation of by-pass valve.

This valve is provided so that the oil can be by-passed direct from pump to main gallery if the cooler or its connecting pipes are damaged.

The operating handle for the by-pass valve is shown on Plate 4 and is illustrated in the open position, *i.e.* in the position by which the oil is circulated through the cooler.

To feed the oil direct from the pump to the main gallery, turn the handle into a horizontal position.

Maintenance.

Maintain the oil level by daily topping up. At periods laid down in the "Crew Maintenance Book," change oil and oil filter.

To check the oil level in engine a dipstick is situated on the dynamo side and is clearly shown on Plate 5.

The oil level should be kept up to the top mark on the dipstick and should never be allowed to fall below the bottom mark. A reading on the dipstick should never be taken when the engine is running or immediately after it has stopped—*i.e.* a reasonable length of time, at least five minutes, should be allowed to elapse after switching off in order to allow all the oil in the engine to find its way into the sump and thus register its correct level. First of all, withdraw the dipstick, wipe it clean with a rag, re-insert it, and then, after a moment's pause, a correct reading should be obtained. When checking the oil level the vehicle should be standing on a level surface or a false reading may be obtained.

To grease the water pump a grease cup is accessibly provided as shown in Plate 4 and must be given one turn at the stated times.

Do not over-lubricate.

To change the engine oil filter shown on Plate 5 and which is also situated on the dynamo side, it is necessary to unscrew the two oil pipes leading from the top and release the clip which holds it to the crankcase. No attention is required apart from periodical renewal.

The filter must be renewed every 3,000 *miles at least.*

The oil pressure release valve is situated on the manifold side of the engine towards the clutch housing (see Plate 4 on page 26) and if the pressure gauge shows a drop in pressure, or fails to give a steady reading, the trouble may be due to a small particle of carbon lodged beneath the plunger. In this case, the valve which is not adjustable should be removed and cleaned.

To drain the sump remove the drain plug situated in the sump when the oil will drain away. This must be done immediately after a run, when the engine is warm, as the oil will then flow more readily.

To clean engine sump and oil intake remove the sump, and the baffle can be taken out by undoing the six securing bolts and the sump thoroughly washed out with petrol. The oil float (see Fig. 14) should also be removed by extracting the split pin which secures it to the feed pipe. Points to be noted in re-assembly are that all parts must be completely free from petrol, that the oil float is moving freely so as to follow the level of the oil, and *that the exact position of the oil pipe has not been altered, as this will result in the float lodging on the baffle instead of floating on the surface of the oil.*

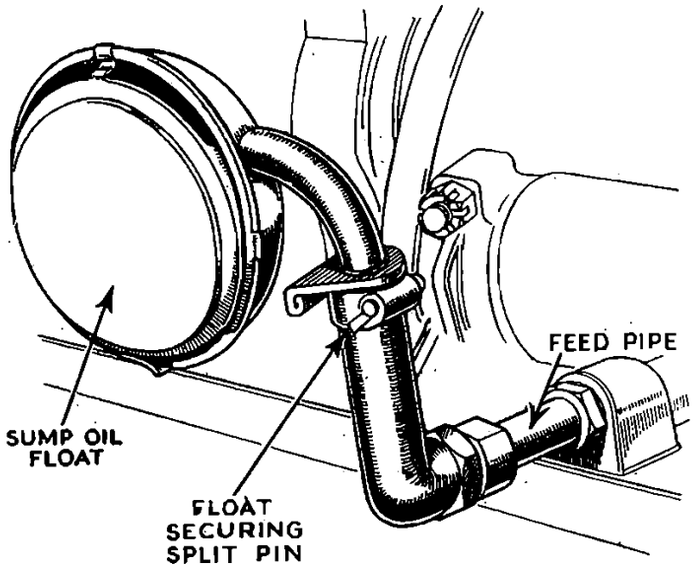


Figure 14. Oil Float

Care must be taken when bolting the sump to the crankcase to ensure that the joint is intact and is not buckled.

Should it ever become necessary, for cleaning or other purposes, to remove the oil intake pipes in the sump, care must be taken in re-assembling that the connecting tubes are screwed hard home to ensure tight joints.

It should also be noted that the valve baffle is correctly situated above the non-return ball in order to prevent this latter being drawn up into the oilways and thereby interfering with the oil circulation.

The adaptor and connecting tube assembly must be fitted to the cylinder block in the correct position, to ensure that oil float moves in a plane corresponding to the centre line of the engine. The assembly must then be firmly secured by the locknut. The oil float must also move freely in the adaptor through its angle of operation.

PART 5. COOLING SYSTEM

Both air and water cooling is employed and all control is automatic. The air is circulated by a six bladed fan, and the water by an impellor type pump, both these being operated by a twin belt drive from a double " Vee " pulley on the crankshaft.

The instructions, given below, cover the attention required to maintain the system at high efficiency

in normal temperatures. When cold weather is experienced, reference should be made to the section " Frost Precautions " on page 14.

Operation.

Efficient operation of the cooling system is shown by the temperature indicator fitted in the instrument panel. This will show an engine temperature of between 170° and 180° under normal running conditions, and this reading must frequently be checked.

It will be appreciated, that a reading showing a much higher temperature, means that the cooling system is not working efficiently, or is being overloaded. In either case, the cause should be investigated and corrective action taken.

A quick superficial check, to ascertain if the fan is working correctly, can be made by setting the engine to run at a fairly fast speed, and then feeling the blast of air coming through the louvres at the rear of the vehicle.

Pump operation can be checked by lifting the filter out of the radiator filling orifice, and, with the engine running at a fair speed, it should be possible to see the water surge caused by the forced circulation.

Maintenance.

Maintenance resolves itself into ensuring the correct level of coolant in the radiator and flushing the water passages occasionally.

To check level of coolant in radiator, raise the engine access door and after undoing the thumb nut swing open the filler cap. The coolant can now be seen and " topped-up " if necessary.

This operation should be carried out when engine is warm and with soft water if this is obtainable. In the event of anti-freeze mixture being in use, then the coolant will be " topped up " with this mixture and not with water.

A filter is provided in the filling orifice and all coolant must be introduced into the system through it. In no circumstances should unfiltered fluid be poured into the system.

It is permissible to remove the filter to inspect the interior of the top tank, or to observe the water surge caused by the pump, but it must be replaced immediately. Cleaning will be necessary occasionally and this can best be done by lifting it out and brushing it in a pail of water. No sharp instrument liable to damage the mesh should be used.

To flush the water passages, drain both radiator and cylinder block as instructed in the section " Frost Precautions " on page 14.

Lead a hose pipe from a pressure system into the radiator top tank, and, with both cocks open, allow the water to run until the passages have been cleaned. During this operation, frequently check that drain cocks are clear of any obstruction.

After using hose pipe, close cocks and fill system ; start engine and allow to run at fair speed (not racing) for a few minutes and drain again. This should remove any sediment disturbed by the circulation.

Finally, re-fill system ready for use.

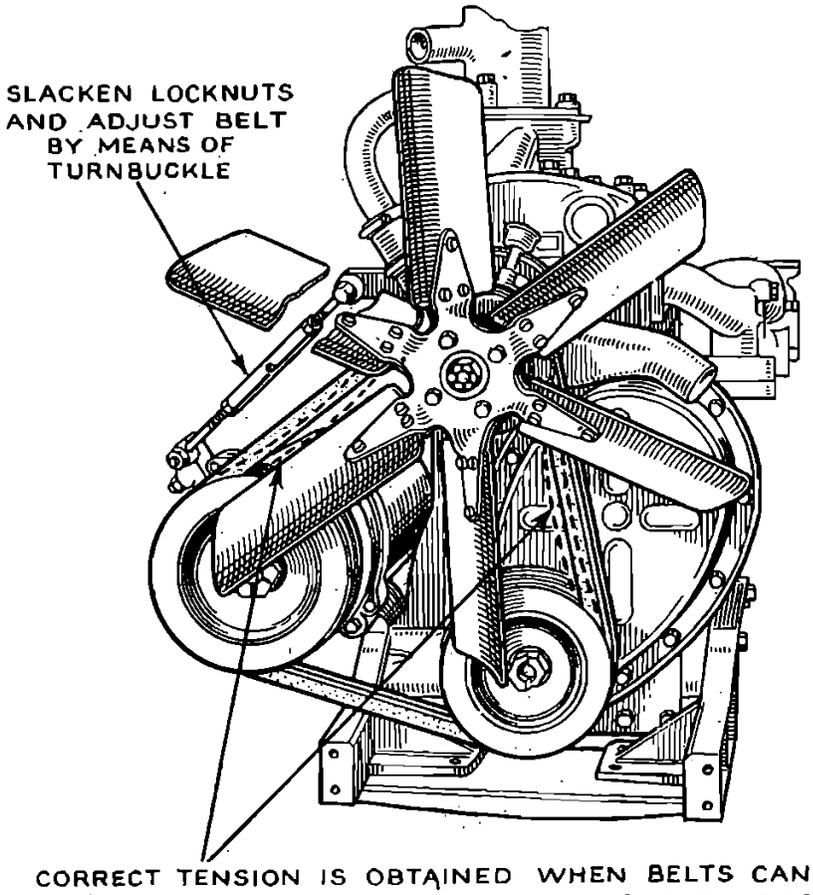


Figure 15. Fan Belt Adjustment

Adjustment.

The only adjustment required is to the belts driving the fan and water pump. These two are formed into one unit and are driven by the same pulley.

Adjustment is made by moving the dynamo which is driven by the same belts and forms part of the three point drive.

In adjusting the belts, it will be found that the dynamo is carried in a cradle, and is supported by a turnbuckle connection to the top of the cylinder block. After slackening the locknuts on the ends of the adjusting pins, the correct tension for the belts can be obtained by means of the turnbuckle.

The correct tension is attained when it is possible to depress belts approximately 1" without undue pressure simultaneously on both of the long runs, *i.e.* on the two lengths running between the crankshaft and fan, and fan and dynamo. When the correct degree of tension is obtained, tighten up the locknuts. Do not tighten the belts excessively as this puts unnecessary load on the bearings and is liable to damage the belts themselves.

PART 6. IGNITION SYSTEM

Coil ignition is fitted, and both distributor and coil are completely screened to prevent interference with wireless reception. The high and low tension cables are of the metal braided type, and, in addition, a filter unit is connected in the ignition primary circuit, between the coil and ignition switch, to prevent radiation from the low tension wiring.

Special spring loaded plunger type connectors are located at the ends of all cables for fitting to the coil and distributor.

The distributor is provided with an automatic timing control which automatically varies the firing points according to the speed of the engine. The mechanism consists of a centrifugally operated governor, housed in the base of the distributor body. The weights move outwards when acted upon by centrifugal forces, and so cause angular motion between the cam and the distributor shaft.

A double contact breaker type is employed ; that is to say, a three lobe cam is used with two contact breakers, one of these being used for cylinders numbers 1, 3 and 5 and the other for cylinders numbers 2, 4 and 6.

Operation is by a switch fitted in the instrument panel and an independent switch fitted in the bulkhead. This latter is to switch off the engine by the commander and is for emergency use only.

In maintaining the set it will be necessary occasionally to clean both coil and distributor ; the latter also needs lubrication at various points.

The adjustments to be done are those required by the contact breaker and sparking plug points.

Operation.

A red warning light is incorporated in the instrument panel to provide an indication when the ignition is switched on. This lights when the engine is stationary or running slowly and goes out when the dynamo commences to charge.

An oil warning light is mounted on a bracket immediately above the instrument panel and this will become illuminated when the ignition is switched on, and the engine is stationary. As the oil pressure rises, the light will cut out, but come into action again should the pressure become dangerously low.

The use of the ignition switch has been fully dealt with in the section "Starting and Driving Instructions," together with both warning lights, and it is only necessary here to emphasize the importance of switching off when the engine is stationary.

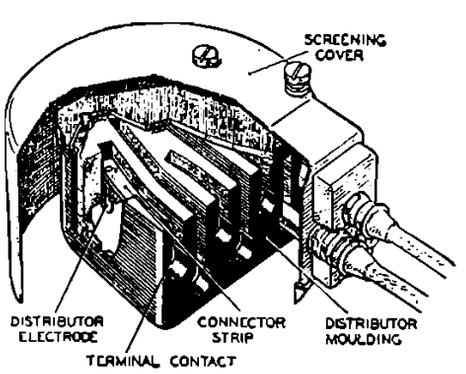


Figure 16. Distributor Cover

Maintenance.

Clean the coil exterior and make sure that the cables to filter unit and distributor are clean and that the braiding is not frayed.

To clean the distributor, slacken the two screws nearest the cable outlets in the distributor screening cover, and remove the cover together with the distributor moulding and leads (see Fig. 17). When replacing the cover, the two screws must be tightened up evenly. Do not attempt to slacken the two screws which are marked "Do not disturb," otherwise the location of the distributor moulding will be altered. Unscrew the high

tension leads from the distributor screening cover, and inspect the contacts in the end of the distributor moulding (Fig. 16). They may be cleaned by means of a cloth moistened with petrol and wrapped round the end of a suitably shaped piece of wood. Take care to refit the leads in their correct positions as indicated on the top of the screening cover (Fig. 17).

The electrodes (Fig. 16) inside the distributor moulding must be clean and free from deposit. If necessary, wipe out the distributor with a dry duster and clean the electrodes with a cloth moistened with petrol. See that the carbon brush is clean and moves freely in its holder.

Examine the contact breaker. The contacts must be kept free from any grease or oil, and, if they are burned or blackened, clean with a very fine carborundum stone or very fine emery cloth. Finish off with a cloth moistened with petrol and remove all traces of dirt and metal dust. (See Fig. 17).

If the surface of the cam is dirty, clean with a cloth moistened with petrol and afterwards give the slightest smear of grease.

Lubrication.

To lubricate cam and contact breaker pivot : give the cam and the pivots on which the contact breakers work, a slight smear of grease. In addition, add one or two drops of engine oil to the cam lubrication wick.

To lubricate distributor cam bearing : Withdraw the moulded rotating arm from the top of the distributor spindle by lifting it off, and add a few drops of thin oil. Do not remove the screw exposed to view, as there is a clearance between the screw and the inner face of the spindle through which the oil passes to lubricate the cam bearing. Take care to refit the arm correctly.

To replenish distributor oil reservoir remove the distributor cover, lift off the rotating distributor arm, and remove the contact breaker base by withdrawing its two securing screws. Lubricate the moving parts of the timing control with engine oil.

Fully tighten the two securing screws when replacing the contact breaker base.

Adjustments.

To adjust the contact breaker. Both contact breaker gaps are carefully set before leaving the works, and, provided that the cam is kept clean and correctly lubricated, the wear on the bakelised fabric heels will be negligible ; consequently, the contact breaker gaps will require adjustment only at infrequent intervals. To check the setting, turn the engine until one pair of contacts is fully opened. Now insert a gauge, having a thickness of .010"—.012", between the contacts. The contacts must be set so that the gauge is just a sliding fit between them.

To make the adjustment, keep the engine in the position to give maximum opening of the contacts, and slacken the two screws securing the contact plate. Then move the plate until the gap is set to the thickness of the gauge. Tighten the locking screws after making the adjustment. Now proceed with adjustment of the second contact breaker in the same way.

Both gaps must be maintained to the gauge, as the contact breaker levers are synchronised at the works with the gaps accurately set. If the contact gaps are not correct, there will be a tendency for the timing of half the cylinders to be slightly different from the rest.

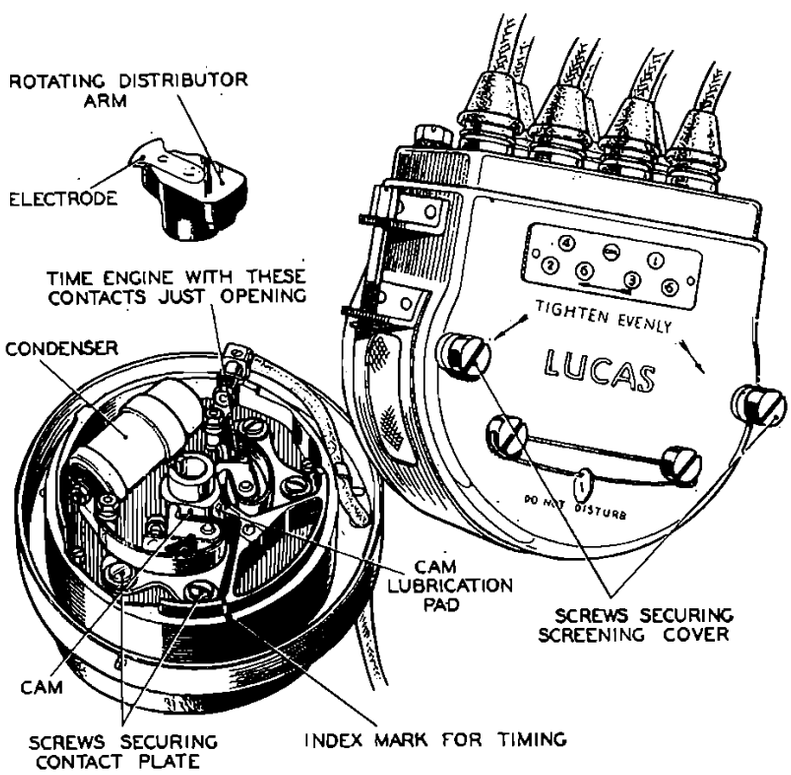


Figure 17. Distributor

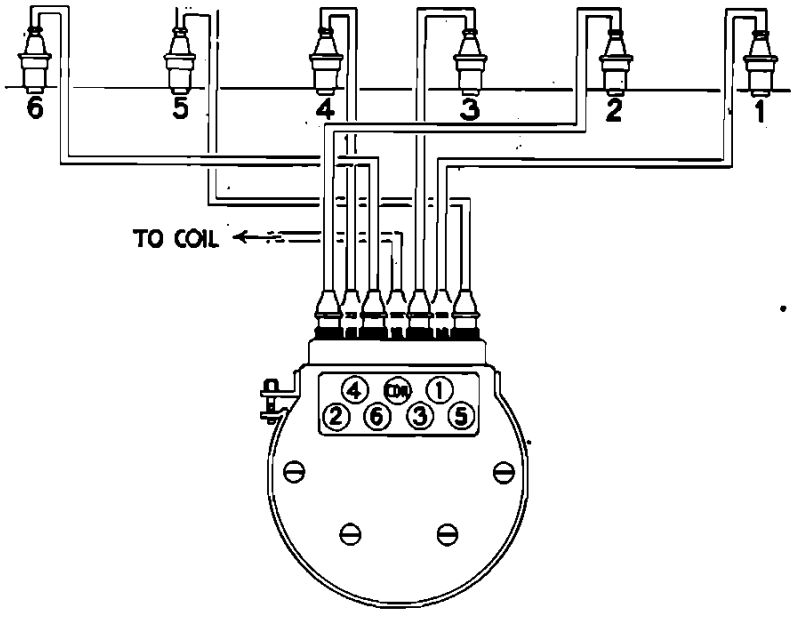


Figure 18. Diagram of High Tension Wiring

To check the sparking plug gap a special gap gauge is included in the tool kit to which the gaps should be set by bending the side electrode.

It is important that no attempt is made to adjust the gap by bending the central electrode as this will cause the insulator to crack.

The correct gap is .018"—.020", and any wider gap is liable to cause misfiring and increase the wear on the central electrode. When the plugs have been replaced ensure that the leads are attached in their correct position as indicated below.

Connecting up high tension wires. The distributor is provided with seven terminals (see Fig. 18); the centre one being connected to the coil. Reference to the drawing above will show the correct wiring, No. 1 cylinder being the one nearest the radiator.

The distributor works in an anti-clockwise direction and the firing order is 1, 5, 3, 6, 2, 4.

PART 7. COMPRESSION

One of the primary points contributing to the efficiency of an internal combustion engine is the compression in the firing chambers and any deviation from the correct ratio will directly affect performance.

As wear of the cylinder bores, rings and pistons takes place, there will be a gradual fall off in power due to losses which can only be rectified by workshop overhaul; but another point at which loss can take place is the inlet and exhaust valves.

Loss of compression past the valves may be caused by incorrect clearance between the valves and tappets or because the valve seats need regrinding. In the case of the former, adjustment of the tappets is required and if the latter is the cause then the cylinder head must be removed and the valves ground to a perfect seating, by the workshop.

Serious damage will result if an engine is run with compression being lost past the valves. The flame of the explosion, and the hot gases rushing between the seat of the valve and the seat in the cylinder block, will act like a blow flame doing irreparable harm to the valves and seriously burning the seat in the block.

There is also the possibility of compression being lost through a blown cylinder head gasket, and, if this be the case, it may indicate damage to the cylinder head.

The importance of making a frequent check of the compressions will be appreciated and instructions upon how to do this are given below.

It is not intended that the driver should carry out any other operation than that of checking compression and tappet adjustments.

Operation.

When a direct hand starting handle drive is used on a six cylinder engine, there are three compressions to each revolution of the handle so that the complete engine sequence is covered in two revolutions. This fact is so universally accepted that, to save any query in the mind of the operator, it is felt desirable to point out that an offset drive with a reduction of 1.5 to 1 is used on this vehicle.

In consequence only two compressions will be felt in one revolution of the starting handle and three complete turns of the handle will be required to cover the full engine sequence.

To check compressions turn engine by hand and in three complete revolutions of the starting handle six even compressions should be felt. The ignition must be switched off and the movement should be continuous throughout the whole of this operation.

Should the feel of the compressions be uneven listen at the side of the cylinder head, for if the gasket is leaking escaping gas can usually be heard. Frequently an indication is the presence of water at the leak.

In any case if any trouble is suspected report the matter immediately.

Adjustment.

The tappets will normally only require adjustment at infrequent intervals and the monthly recommendation to check clearances which is given under " Maintenance " Section does not necessarily mean the carrying out of the following operation.

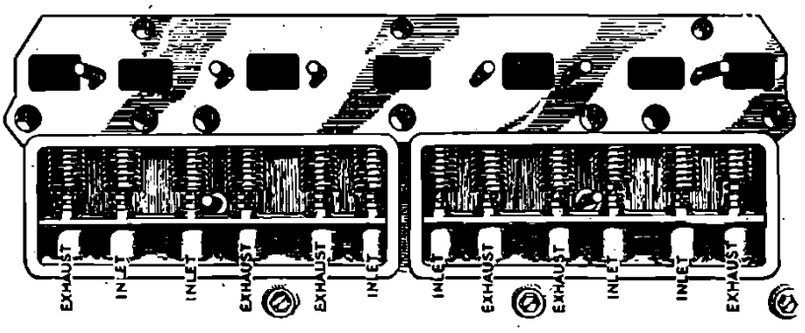


Figure 19. Tappet and Valve Arrangement

Provided the check and re-adjustment called for after the first day's service (See " Reception of new vehicle ") is carried out, it will be sufficient to take action only if trouble is shown by the check under " Operation " above.

To adjust tappets remove the two tappet covers from the manifold side of the cylinders and turn the engine by means of the starting handle until the same valve on the corresponding cylinder is at full lift, the corresponding cylinders being 1-6, 2-5 and 3-4 (see Fig. 19). To take an example, if it is desired to adjust No. 1 inlet valve tappet see that No. 6 inlet valve is fully open before making adjustments. Slacken the locking nut (see Fig. 20), adjust the top screw to the correct clearance and lock the screw to this position.

Correct clearances are given in the section " General Description " and on the tappet cover and should be set with the engine cold.

When the clearances have been set, it is advisable to check them, as tightening of the lock nuts will occasionally alter the position of the adjusting screw.

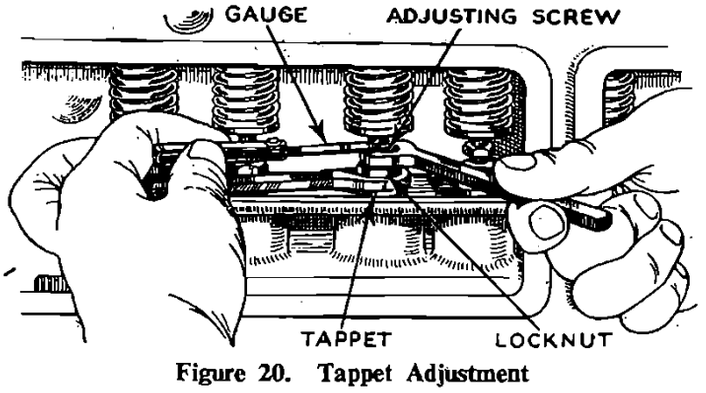


Figure 20. Tappet Adjustment

Care must be exercised when refitting the tappet covers not to damage the cork joints. An oil tight seal is essential, otherwise great waste of oil can occur.

The tappet adjustment can be carried out without the removal of the carburettor, exhaust pipe and inlet manifolds. *This is a workshop operation.* Should the circumstances necessitate the removal of these components, great care must be taken, and the sequence of operations is as follows :—

1. Disconnect pipe to petrol pump and controls at carburettor.
2. Release exhaust pipe and take off nuts and two clamping setscrews holding the exhaust pipe, inlet manifold and carburettor.
3. Remove exhaust pipe, inlet manifold and carburettor as a unit.
4. Replace, adopting the reverse procedure.

PART 8. HAND STARTING GEAR

Owing to the design of the hull, a direct starting handle on the crankshaft cannot be employed and the difficulty is overcome by fitting, immediately behind the radiator and in line with the crankshaft, a shaft which is connected to a further and lower shaft by means of a driving chain operating on two sprockets. This latter shaft is situated below the radiator and secured to the radiator support by two brackets. (See Fig. 21).

Operation.

The tool kit contains a loose starting handle, which is brought into engagement with the dog on the lower shaft through an outboard bearing, easily accessible from the rear of the car.

The starting dogs on the upper shaft and on the crankshaft are brought together by a sliding link and lever, the latter being put in motion by a control rod, which, in turn, is operated by a lever mounted between two friction washers on the lower shaft. The action of turning this shaft pushes the lever over, thereby causing the rod and upper lever to bring the two dogs into engagement.

So long as the lower shaft is revolved, the grip of the friction washers on the lower lever will be sufficient to hold the dogs in mesh, but when the shafts become stationary, a spring operating on the upper shaft dog will force the latter out of engagement.

The remaining operation of the gear is simple in the extreme. As the dogs are in engagement, the drive is transmitted via the lower shaft, chain and upper shaft to the engine.

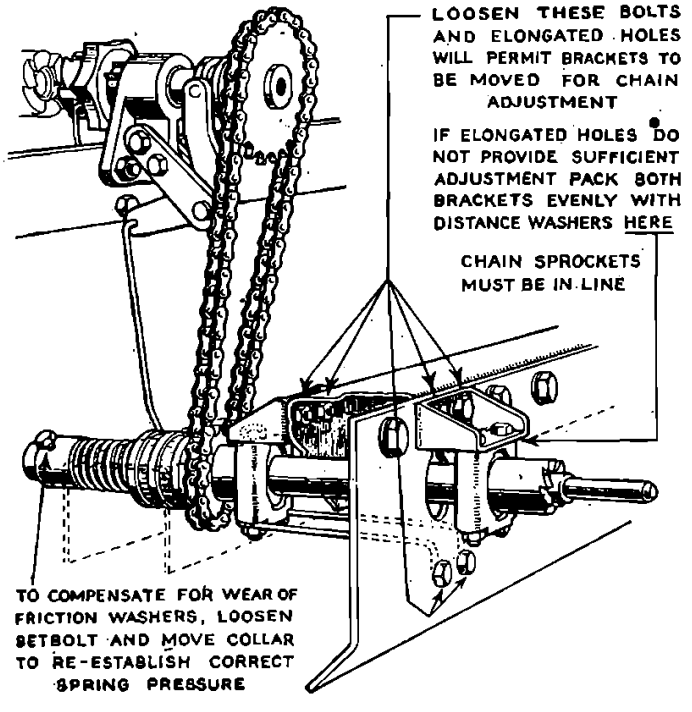


Figure 21. Hand Starting Gear

Lubrication.

A few drops of oil must be given to the starter chain at the interval shown in "Periodical Attention" and it is necessary to wash the chain occasionally with paraffin oil and re-oil with engine oil. This operation is best carried out with the chain revolving.

Adjustment.

In order to adjust the chain tension, loosen the four bolts (in elongated holes) which secure the lower shaft support brackets to the radiator support, as well as the two bolts holding the stiffeners to the support. Move the whole assembly up or down until the correct chain tension is obtained, then ensure that the sprockets are in line and retighten bolts.

If the movement permitted by the elongated holes should prove insufficient to compensate for the chain wear, further adjustment can be obtained by fitting packing washers between the lower shaft support brackets and the bearing housing. The packings should be so arranged as to ensure the sprockets are in line, and the whole operation will be made perfectly clear by reference to the accompanying illustration.

As the friction washers on the lower shaft wear, pressure on the lever will be lost, but this can be regained by slackening the setbolt (see Fig. 21) and moving the collar towards the spring sufficiently to re-establish the correct pressure. Retighten setbolt on collar in new position.

CHAPTER II A

The Transmission—Operation and Maintenance

The transmission consists of those parts of the vehicle through which the power of the engine is carried and in the case of the Armoured Car, Humber, Mark IV it covers clutch, gearbox, transfer box, propeller shafts and axles.

Apart from the engine, more attention is required by the transmission than any other part of the vehicle and neglect will certainly lead to serious consequences. These will be all the more serious because it is quite likely that the damage caused by neglect will not be apparent until it has become extensive.

The need for observing the care detailed in the following pages will be appreciated.

PART 1. CLUTCH

A clutch of the single dry plate type is used and the only lubrication required is to the release bearing.

The clutch itself is adjusted in original assembly and no alteration in service will be required. An adjustment is, however, provided to maintain free movement of the pedal and this will have to be attended to from time to time.

Operation.

It is not intended, in this publication, to deal with the use of the clutch pedal so far as initial gear engagement and subsequent changing is concerned, for this will have been covered in the elementary driver's course.

The importance of not driving with the foot resting on the pedal is emphasised, for this practice causes clutch slip resulting in excessive wear and damage which will necessitate a major overhaul to put right. Similarly the practice of " coasting " with the clutch held out is strictly forbidden.

The action of operating the clutch pedal should be firm and decisive giving a positive clean release or a smooth progressive engagement. The type of clutch employed and the design of the release mechanism is such that very little practice will be required to attain proficiency.

Lubrication.

A ball bearing is fitted in the release mechanism and this requires lubricating at the periods shown in " Maintenance " Section.

The greaser is of the " Staufer " type and is situated in a bracket on the rear of the cylinder head as shown on Plate 4.

When greasing, give one turn only to the cap, for too much grease may cause just as much trouble as too little. If an excessive amount is introduced the surplus will be flung out of the bearing on to the clutch lining.

Adjustments.

As wear of the friction linings on the driven plate takes place the pressure plate will move towards the flywheel taking the outer ends of the release levers with it. These levers are pivotted on the clutch cover and it normally follows that the inner ends will move away from the flywheel, thereby forcing the release bearing into closer contact with the release lever fork.

This will tend to " bring the pedal back " thereby reducing the amount of free movement (see Fig. 22). When this occurs adjustment must be carried out to restore correct conditions.

In addition movement of the clutch pedal beyond the point at which the clutch is released, serves no useful purpose, and only imposes undue stress on the internal parts of the clutch.

The clutch pedal should be adjusted so that it comes to rest on its forward stop at the moment when the clutch " stops," *i.e.* is fully disengaged and the driven plate ceases to spin.

From this point to full clutch engagement the release bearing requires a movement of $\frac{1}{2}$" and this is represented by a pedal travel rearwards of $5\frac{1}{8}$" (see Fig. 22).

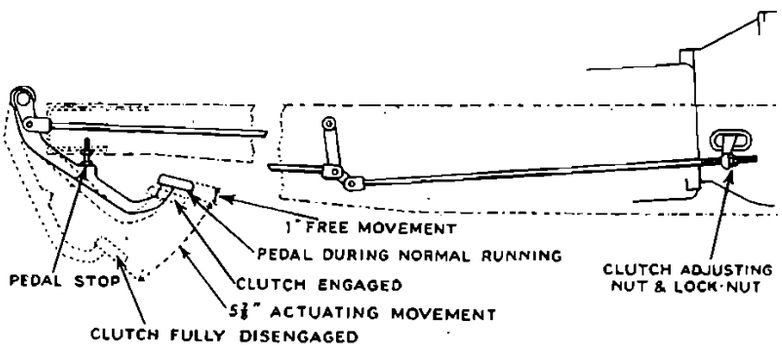


Figure 22. Clutch Pedal Adjustment

Beyond this point the clutch pedal should be free to move back a further 1" to $1\frac{1}{2}$" (*in no case less than* 1") before it comes to rest on its rearward stop in order to ensure that there is a clearance of not less than $\frac{1}{16}$" between the withdrawal lever and the release bearing assembly.

Actually, the pedal movement, as controlled by its adjustable stops, is fixed at the factory and should require no further attention.

Free movement of the pedal is controlled by the adjusting nut on the operating rod (see Fig. 22). The locknut holding this should be slackened and adjustment carried out to give the required movement.

Upon completion ensure that the locknut is correctly tightened so that there is no possibility of the adjusting nut " creeping."

PART 2. GEARBOX

The gearbox has four forward speed positions and one reverse. Remote control being necessary owing to the position of the driver's compartment.

Attention required in service is very small, amounting only to maintaining the oil at its correct level and periodically changing this lubricant at the intervals shown in " Maintenance " Section.

Operation.

The use of the gearbox has been dealt with under " Starting and Driving Instructions " while the position of the gear lever is shown on Fig. 1.

Gear positions are shown on a plate affixed to the battery lid immediately to the driver's left hand. It will be noted that the resistance of a spring loaded plunger has to be overcome when moving the change speed lever into a position to engage reverse.

The practice of " crashing " the gears when changing must not be indulged.

Maintenance and Lubrication.

To inspect oil level remove small plate in centre of " fighting " compartment floor and pull out the dipstick, wipe this with a clean rag and re-insert so that a correct reading may be obtained.

The oil should be kept up to the top mark on the dipstick and if it is below this level replenish through the dipstick orifice with the correct grade (see Plate 4).

To drain gearbox remove the drain plug at the bottom of the gearbox and then, after replacing the plug fill up to the correct level shown on the dipstick.

Oil breather. Situated on the top of the gearbox is a breather consisting of an open ended plug with a split pin, spring and ball, which prevents pressure building up in the gearbox. This may become choked, causing oil to be forced out through the end covers of the gearbox.

Remove the plug, and after taking out the split pin ease out the spring and ball, thoroughly washing them in clean petrol.

Do not use any sharp instrument to remove the spring or ball as this may damage the seating inside the plug and so prevent the correct working of the breather.

A greaser is provided for lubrication of the gearbox control, and this will be found fitted to the box in which the gear change hand lever moves. This should be attended to by means of the gun, and a fair quantity of lubricant should be inserted.

PART 3. TRANSFER BOX

The transfer box is a two speed unit incorporating a front axle " declutch " and is controlled by two hand levers situated at the driver's right hand side.

Provided the oil is maintained at its correct level and periodically changed at the intervals shown on page 19 no further attention in service will be required.

Operation.

Instructions upon how to use the transfer box are given on page 10 and the position of the hand levers can be seen by reference to Fig. 1.

Lubrication.

To inspect oil level, a level plug (see Fig. 23) is provided on the near-side and this should always be removed when the transfer box is being filled or topped up. The oil should be kept up to the level of this orifice by removing the small cover plate in the flooring, and also the filler plug from top of box, and pouring in amount of oil required.

A filler plug is also provided on the declutch, but need only be used when the transfer box is being refilled after draining, at which time approximately one pint should be poured in as an initial supply.

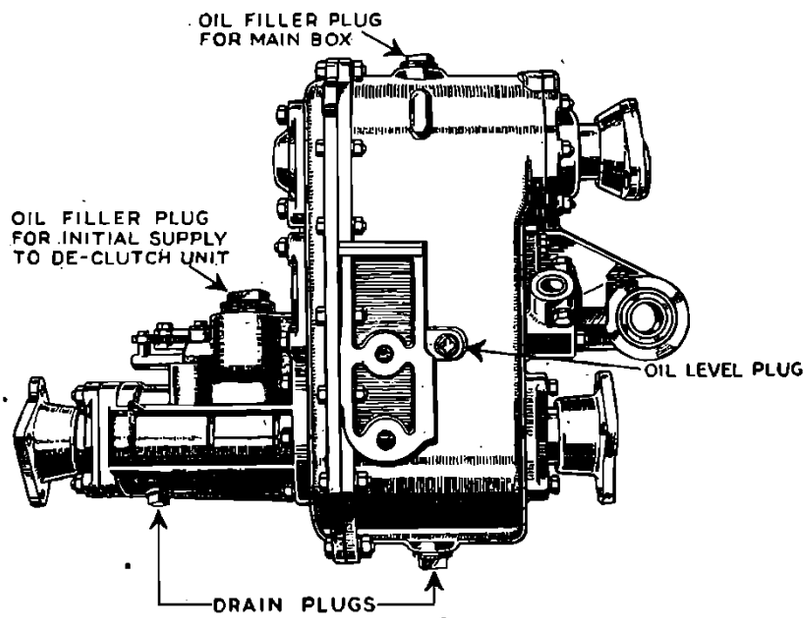


Figure 23. Transfer Box

Drain plugs are fitted and their positions are indicated in Fig. 23, together with the filler and level plugs. Both drain plugs must be removed to completely drain the unit.

Finally, take care to replace and securely tighten all plugs.

PART 4. PROPELLER SHAFTS

A propeller shaft of the " Layrub " type is used between the gearbox and transfer box, while shafts with needle roller universal joints are employed between transfer box and axles.

Care and maintenance of the two types of shafts are entirely different and in order to avoid confusion they are dealt with separately in the following sections.

Maintenance of the " Layrub " propeller shaft.

The couplings used in this type of shaft require no lubrication, but it is necessary that they be kept free from oil during service, for oil, if allowed to remain, would have a detrimental effect on the live rubber incorporated in their construction.

To remove oil from the couplings, wipe them with a rag soaked in petrol. Use the petrol sparingly, there is no need to have the rag dripping and after cleaning remove any residue with a dry cloth.

The bolts and nuts securing the couplings to the companion flanges must be kept tight.

From Fig. 24 it will be noted that the steel trunnion through which the assembly bolt passes is spigotted and registered to the companion flange to take the drive. The bolts are of high tensile steel and are only lightly loaded. If there is a slackness in the bolt assembly the spigotted portion of the trunnion will be free to move in the registered recess in the companion flange. This will result in worn spigots, elongation of bolt holes in the flange, and possible damage to the rubber blocks.

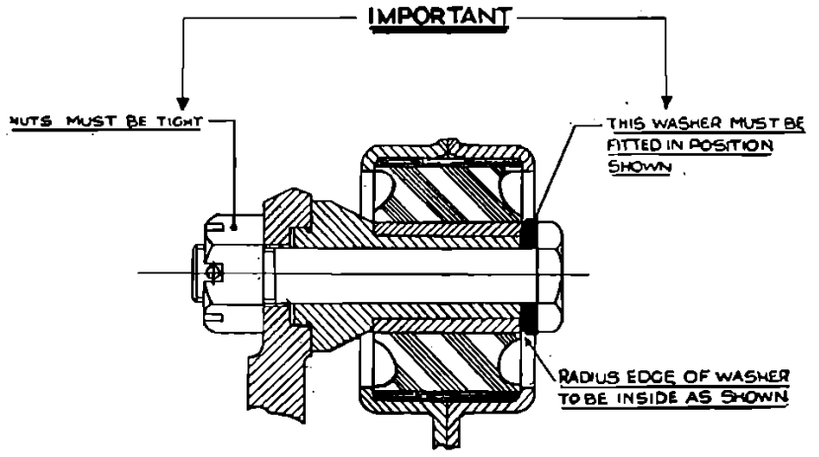


Figure 24. Propeller Shaft Coupling—" Layrub " type

The illustration (Fig. 24) shows a castellated nut located by means of a split pin, but on the vehicles under review this is superseded by a self locking (Simmonds) nut. The illustration, is however, included because while not being completely accurate in detail it clearly shows the points made in the foregoing paragraph.

The nuts should be checked for tightness and if there is any suspicion of slackness then tighten with the spanner provided in the tool kit. It is recommended that after the nut has been drawn up as tightly as possible by means of the standard spanner, then it should be further tightened to a distance equivalent to one of the hexagon flats by means of a spanner with extended leverage.

It is also necessary when tightening to see that the shoulder of the trunnion is tight up against the face of the companion flange, *i.e.* that the spigot is fully home in the flange.

The needle roller propeller shaft.

Lubrication is the only attention required in service and this is carried out by means of the grease gun.

There are six grease nipples in all. Three being positioned in each propeller shaft. They will be found in the yoke ends and at the driving end of the shaft tube.

An ample supply of lubricant should be pumped into each nipple and an indication of enough oil having been inserted into the roller bearings is provided. This is in the form of a relief valve situated in the centre of each journal (or trunnion cross) and when oil is discharged from this relief valve the bearings are completely filled.

PART 5. FRONT AND REAR AXLES

The axles are of the fully floating type and the drive of the front axle can be engaged at will.

In service it is necessary to maintain the oil at its correct level and to periodically drain and refill with fresh oil. The hubs and swivels, together with the steering joints of the track rod and drag link, will also have to be greased with the gun.

Operation.

The rear axle is in permanent drive, but as already explained the drive can be transmitted through the front axle at will. Under the heading " Use of Transfer Box " on page 10, the use of the declutch unit, so far as it applies to the utilization of the drive of the front axle, has been dealt with and it is only necessary here to reiterate that four wheel drive is only for use when the amount of traction required cannot be provided by the two rear wheels only.

Lubrication.

When inspecting level or replenishing the oil, the vehicle should be standing on a level surface and if any kind of force pump is used for topping up, care must be taken to see that an excess is not introduced.

To inspect level and replenish oil remove the combined filler and level plugs provided. On the front axle this will be found in the casing itself, but on the rear axle it is fitted into a neck on the axle casing cover. Reference to Figs. 25 and 26 show the position of these two plugs.

The oil should be kept up to the level of the plug orifice by the introduction of fresh oil as required.

To drain the axle, plugs are situated in the bottom of the axle casing and these are also shown on Figs. 25 and 26. They are readily accessible and care must be taken to replace them securely after use.

The front and rear hubs are greased by means of the grease gun and the position of the greasers is shown on Figs. 25 and 26. Do not overgrease or some will work pass the oil seals into the brakes and thereby spoil their efficiency.

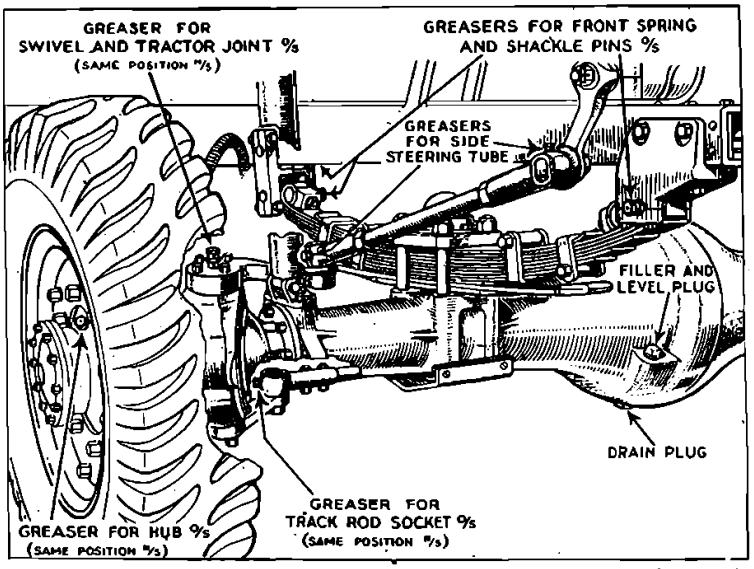


Figure 25. Front Axle and Spring Shackle Lubrication

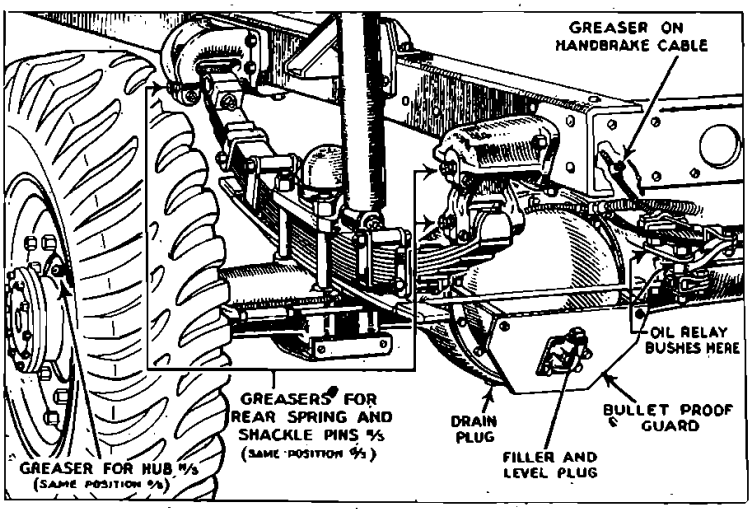


Figure 26. Rear Axle and Spring Shackle Lubrication

Grease the swivel bearings and " Tracta " joints on the front axle, using a fair quantity of lubricant. There are two greasers, the one on the offside being shown on Fig. 25.

Grease steering joints by means of the gun at intervals indicated on page 18. Greasers are provided for each of the joints of the track rod and the drag link (or side steering tube) the positions being indicated on Fig. 25.

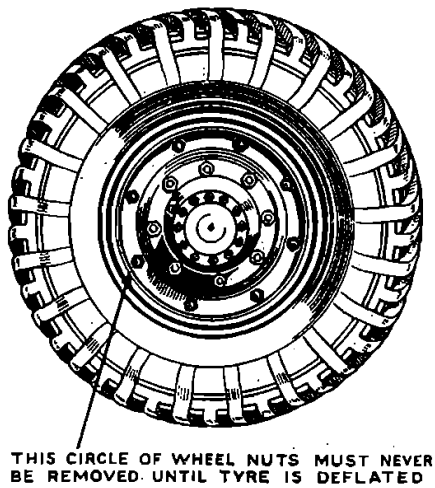


Figure 27. Wheel and Tyre

PART 6. WHEELS AND TYRES

Two-piece wheels are fitted to these vehicles and, for removal of the wheel, only the inner circle of wheel nuts must be removed. The outer circle of nuts, which are painted red, must never be disturbed until the tyre has been deflated. (See Fig. 27).

Failure to observe this precaution is highly dangerous.

Maintenance required by the tyres is detailed below an the correct method of mounting the wheels is also detailed.

Maintenance.

A large proportion of premature tyre failures are due to causes within the control of the user. Neglect or indifference is costly and the small amount of time spent in giving attention to the tyres is well repaid.

The following points must be observed.

(1) Maintain the correct inflation pressure.
(2) Remove flints and stones from the tyre and fill any holes with suitable compound.
(3) Prevent oil getting on to the tyres. If any should do so, remove with petrol used sparingly.
(4) Avoid driving at high speeds over bad surfaces.
(5) Avoid hard braking, which tends to skid the wheels.
(6) Do not bump kerbs or other obstacles.
(7) Badly cut casings should be reported immediately to L.A.D.
(8) Valve caps, whether of the ordinary or " Dublechek " type form the secondary seal and should always be fitted. It is advisable to replace the valve core or " inside " annually.
(9) Even tyre wear is promoted by changing the position of tyres round at monthly or two monthly intervals.
(10) The alignment of the front wheels should occasionally be checked by workshops, for if this is incorrect it will result in excessive tyre wear.

When wheels are removed for any reason, grease the wheel register and wheel studs before replacing. This will prevent rusting up.

Mounting Wheels. The correct procedure when tightening wheel nuts is to give each a few turns only at a time. This should be performed when the wheel is jacked up clear of the ground. The nuts should be tightened diametrically opposite in turn. The object is to enable the wheels gradually to seat themselves evenly on the faces of the studs and nuts.

It is extremely bad practice to screw one dome nut fully tight before moving to the others.

When a vehicle is new, or when the wheels have been changed, the nuts should be tightened daily until it is found that the wheel has " bedded-down."

PART 7. TYRE PUMP, AIR FILTER AND HOSE

A mechanical tyre pump driven from the gearbox is fitted and the filter through which the air is pumped before being forced into the tyres is fitted on the gearbox tower. The flexible hose is stored in one of the containers on the outside of the hull as shown on the stowage lists issued to cover this vehicle.

There is little maintenance required, but a great deal of care is necessary in the operation of this unit.

Operation.

The operating handle for the pump is accessible through the detachable plate on the floor of the hull on the right-hand side of the gearbox cowling.

When engaging or disengaging the pump the clutch should be withdrawn.

It will be noted that when the handle is pointing towards the rear of the chassis, the pump is out of operation, engagement being effected by moving the handle through an arc of 180° to point towards the front of the vehicle.

Maximum efficiency is obtained with the pump running at 1,000 R.P.M., this being attained when the engine is at slightly above normal idling speed. No advantage will be gained by racing the engine : in fact this is very definitely detrimental, for there is a tendency to overheat and deliver warm or hot air to the tyre.

Maintenance.

Lubrication of the pump is automatically carried out by oil from the gearbox. An unlimited amount is permitted to the gears but the flow to the compressor sump is restricted in quantity and only allowed when the pump is running.

At each revolution of the crankshaft, drillings come into line with ports in the end and main bearing bushes, a small quantity of oil being allowed to pass from the main body in the gearbox via end bearing bush, crankshaft and main bearing bush to the sump.

The drillings in the crankshaft are so arranged that when the pump is stationery one or other is out of line with the holes drilled in the bushes. In order to prevent any excess in the sump, an overflow vent, marked " M " on Fig. 28, is provided and it may be found that a small quantity of oil flows when the pump is running.

Initially, the pump must be filled with oil and for this purpose a filler plug marked " A," together with an oil level plug " B," are fitted.

Dust and dirt should not be allowed to accumulate round the suction valve plug " C " which should be cleaned occasionally.

Both the suction and delivery valves " C " and " D " are held in position by springs, and if these valves are taken out care must be taken in replacing them to see that they are seated properly before the valve plugs are screwed down.

The air filter (Fig. 29) acting additionally as a cooler, is located on the gearbox tower and clamped in position with a clip.

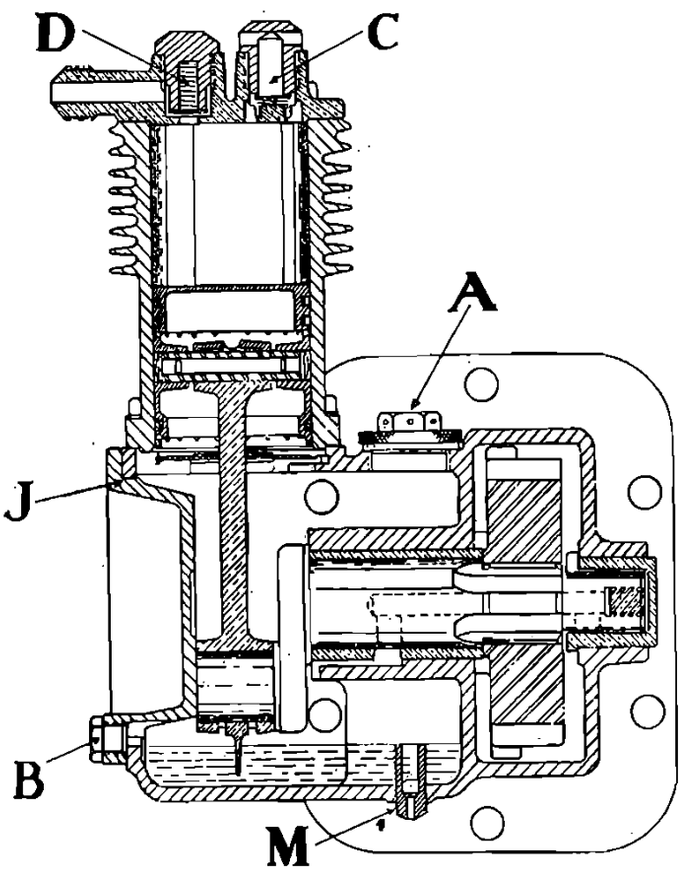


Figure 28. Tyre Pump

To clean the air filter the small hexagon drain plug " E " should be removed, preferably while the pump is in operation so that any condensed oil vapour may be blown out.

It is advisable to test periodically the air supply at the outlet " H " by holding a clean white paper about one inch away. Any trace of oil on the paper will indicate that the central filter tube " F " should be repacked with clean white stockinette. When replacing the head see that the perforated disc " K " is in position.

It will be found that renewal of the stockinette is only necessary if removal of the drain plug at regular intervals has been neglected.

It is important that great care be exercised in the storage of the flexible tubing when not in use, and it should not be thrown carelessly into its container or allowed to come in contact with oil or accumulator acid.

It will be readily understood that the most efficient pump is quite ineffective if connected up to the tyre with a leaking pipe line.

The wing nut supplied, fitted to the end of the pipe, should also be taken particular care of, as damage to this fitment will prevent an air-tight joint being made, and consequently impair the efficiency of the pump.

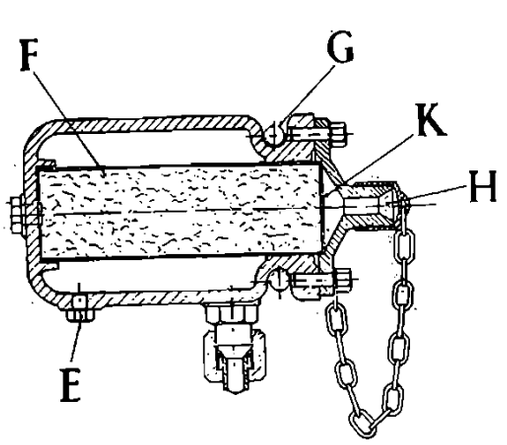


Figure 29. Air Cooler and Filter

It cannot be too strongly emphasised that any falling off in the efficiency of this pump is, in practically every case, attributed to faulty connection between the pump and tyre.

Before connecting hose to filter it is advisable to let the air be discharged for about half-a-minute until any small deposit of oil has been dispersed.

Similarly, before connecting up flex to tyre, the air should be allowed to free itself into the atmosphere for two or three seconds in order to clear any foreign matter which may have found its way into the pipe line while the latter has been out of use.

CHAPTER III A

Suspension—Operation and Maintenance

The chassis and hull are mounted on the axles on semi-elliptic leaf springs having universal anchorages allowing the maximum articulation of the axles without straining the spring leaves.

The whole suspension is adequately controlled by large capacity direct acting shock absorbers.

PART 1. SPRINGS

Both front and rear springs are of special design, allowance being made for them to swivel about the shackles, thus relieving the chassis of any sudden stresses.

The springs are made of silicon manganese steel and have steel bushes in the spring eyes.

The shackles will require lubrication in service and it will also be necessary to insert oil between the spring leaves.

Lubrication.

To grease the spring shackles nipples are fitted in the heads of all shackle pins and their positions are clearly indicated on Figs. 25 and 26.

A liberal quantity of lubricant from the gun should be inserted at the intervals shown on the lubrication diagram. Every month wipe the springs with engine oil.

Every 3,000 miles jack up the vehicle under the chassis frame thus relieving the springs of their load and after undoing the rebound clip bolts, oil can be forced between the spring leaves.

PART 2. SHOCK ABSORBERS

The shock absorbers fitted to this vehicle are of the hydraulic type and are very simple in operation, namely, when the vehicle takes " a full bump," the pressure generated is assimilated by the fluid, so relieving the hull (and the crew) of any sudden jarring. There are four of these shock absorbers and both front and rear are identical except for length overall and also length of operation.

If the front shock absorbers are shot away or otherwise put out of action, excessive downward movement of the axle when driving over rough terrain would take place and this would result in serious damage to the front propellor shaft joints owing to the excessive angularity developed. This condition would also apply if the hull and turret were removed and the chassis only taken out for test purposes.

Should either of the above circumstances arise, the front propellor shaft must be removed from the vehicle or a snubbing device of the steel rope kind should be fitted to the frame.

Only in exceptional circumstances may the vehicle be driven at high speeds over bumpy ground with the shock absorbers out of action and only then, after a snubbing device has been fitted or the front propeller shaft removed.

The only attention needed to maintain the shock absorbers in service is that they should be topped up with the correct fluid as instructed below.

Maintenance.

It will be readily appreciated that the successful working of any hydraulic unit depends on the absolute cleanliness of the fluid and all working parts. The presence of dirt, dust or abrasive matter will impair the efficiency of the unit.

The nozzle of the filling gun and the nipple on the shock absorber should be wiped clean before the operation of filling is commenced and special care to ensure the cleanliness of the fluid when pouring it into the gun must be taken.

To top up the shock absorbers use the special oil gun supplied and only insert the fluid shown on the lubrication chart.

Remove the dust cover from the filling nipple (this may be of the rubber type shown on Fig. 30

or it may be in the form of a metal cap) pass the point of the small tool attached to the filling gun down the hole in the filling nipple and press down the internal valve (this being of rubber may have adhered to its seat). Then attach gun by screwing the nozzle firmly in position on the nipple and pump by means of the gun lever until the surplus fluid is blown off from the relief valve.

At this point it is necessary to explain that as fluid is injected the air is trapped and a pressure is built up until it becomes sufficient to overcome a spring loaded relief valve in the head of the shock absorber. The excess fluid then escapes through this valve.

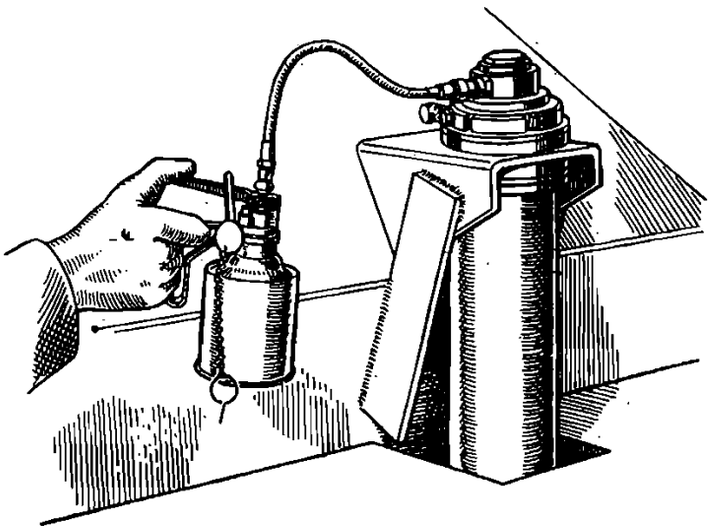


Figure 30. Filling Shock Absorber

A further point is that the filling operation will be performed while the absorber is not in a fully compressed state and so after the topping up has been carried out and a short journey has been made, fluid will be found to be sprayed over the body. This is due to the displacement of the fluid by the movement of the absorber extension rod. Although the amount of fluid rejected may appear to be great, it is actually very little and should not be mistaken for leakage of the absorber cylinder.

Always replace the dust cap after filling.

CHAPTER IV A

Steering and Brakes—Operation and Maintenance

The steering gear fitted controls the front axle through a drop arm and drag link (or side steering tube). Maintenance of the gear is dealt with below, but the attention required by the drag link has already been detailed in chapter IIA part 5.

The footbrake operates on all four wheels and is applied hydraulically. The system consists of an integral tandem type master cylinder and supply tank in which fluid pressure is generated, wheel cylinders which transmit fluid pressure to the brake shoes and a pipe line consisting of tubing, flexible hoses and unions connecting the cylinders.

A safety feature of the cylinder is that should any one part of the system fail, two brakes are still operative.

The handbrake which operates on the rear wheels only is applied mechanically. Operation of the handbrake does not affect the hydraulic operating mechanism and vice versa even though the same shoes in the rear brakes are operated by both systems.

The brakes themselves are of the " Cowdrey " balanced safety type, and they maintain their performance and balance irrespective of variations in adjustment or uneven lining wear.

PART 1. STEERING GEAR

The steering gear, which is of the cam and roller type, requires only lubrication to maintain it in service.

Lubrication.

The filler plug is provided in a tube fitted on top of the rocker shaft housing and the oil should be kept up to this level (see Fig. 31).

A few drops of oil placed occasionally on the top of the steering column immediately below the steering wheel will seep into the felt bush and prove advantageous.

PART 2. BRAKE LINKAGE

The hydraulic system is operated through a pipe line consisting of special tubing and flexible hoses, connected by suitable adaptors. All tubes and hoses are tested to withstand pressure far in excess of that developed in braking, and therefore, providing the tubing is maintained efficiently clipped to the chassis to prevent vibration and the hoses are kept free from contact with oil, no trouble should arise.

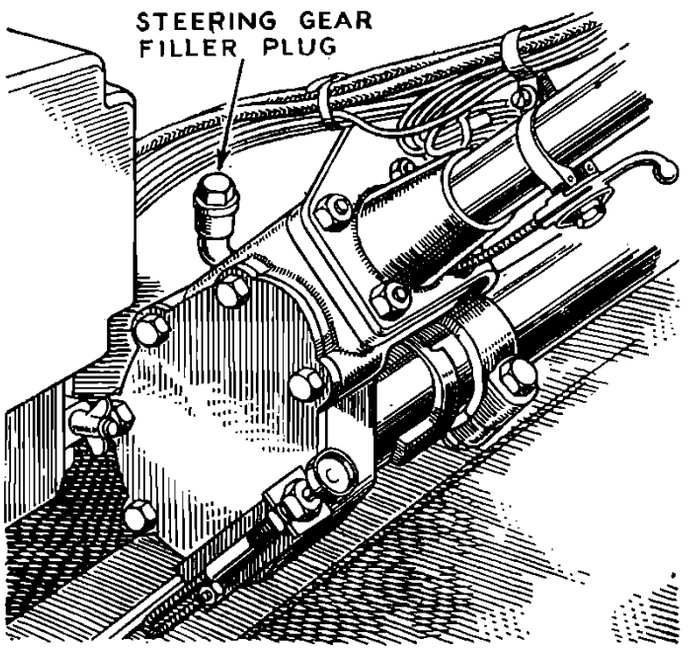


Figure 31. Steering Gear Oil Level

To maintain the system efficiently it is only necessary to check level of fluid in the master cylinder from time to time, and replenish if necessary. Providing this check is regularly made no trouble will be experienced; but if the fluid level is allowed to fall too low then air will enter the system and the operation of bleeding will have to be carried out.

Bleeding is the action of expelling air from the system, and should only be necessary when completely recharging the system with fluid following the removal of a component or the disconnecting of a pipe joint. In normal circumstances air does not enter the system as a result of brake operation, and if bleeding has to be carried out in service it can only be for one of two reasons. Either the level of the fluid in the master cylinder has been permitted to become low, or there is a leakage in the pipe line. In the latter case the matter should be reported immediately.

Maintenance.

As indicated in Chapter IIIA, Part 2, the successful working of any hydraulic unit depends altogether on the absolute cleanliness of the fluid used therein, so care should be taken to ensure that no foreign matter enters the tank during replenishment.

To check level of fluid in master cylinder remove the filler plug and the fluid should be approximately one inch below the orifice. Normally very little will be required for topping up purposes and therefore, should a considerable fall in the level occur, a leak in the system is indicated and this should be checked.

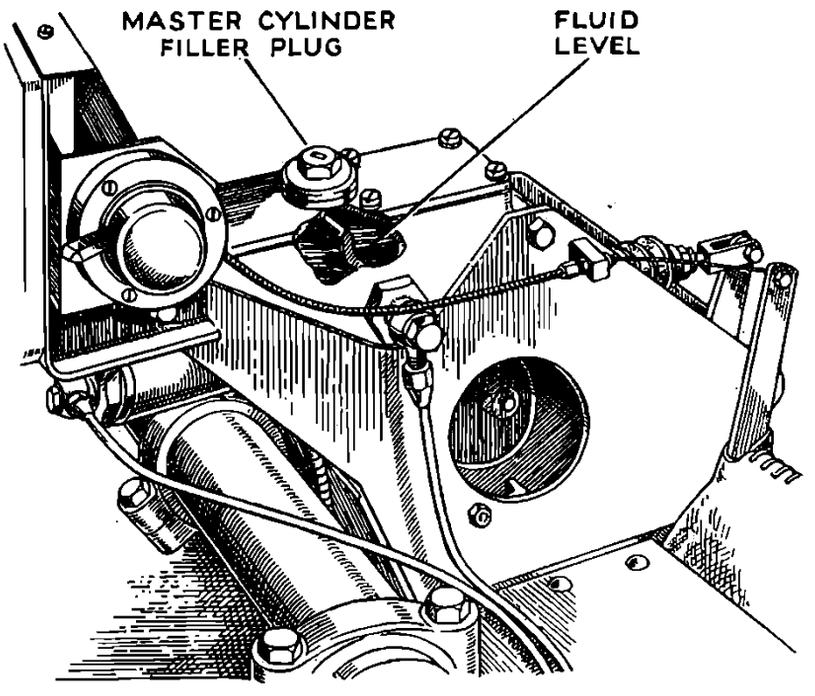


Figure 32. Checking Level of Brake Fluid

To bleed the system two clean receptacles are required, together with two pieces of tube.

Fix the tubes to the bleeder screws, one on a front wheel and the other on a rear wheel cylinder, allowing the loose ends to fall into the receptacles. These receptacles must contain enough of the brake fluid to submerge the end of the tubes.

Slacken the bleeder screw (valve) one turn—position of this is shown on Fig. 33. Depress the brake pedal quickly, allowing it to return without assistance and continue to pump in this manner, making a slight pause between each stroke, until air bubbles cease to appear

in the jars, when the bleeder screw should be securely tightened. Repeat this operation on the remaining two wheels of the vehicle.

It will be appreciated that if proper care has been taken in carrying out this operation the fluid in the jars will be clean and fit for further use, and can be returned to store. If any foreign matter has been allowed to enter the fluid, then it must be used for cleaning purposes only.

PART 3. BRAKES

As wear of the linings takes place it will be necessary to adjust the brakes as instructed below. If this is neglected a point will be reached where so much movement of the operating plunger is required that the foot brake pedal has to be " pumped," and it will also be found that the handbrake lever will move over its full ratchet travel. These conditions must never be allowed to occur.

Maintenance.

Owing to the type of hydraulic system being used, perfect balance between the brakes is maintained at all times, and this has not to be catered for by adjustment of individual wheels.

It will be appreciated that the method of adjustment is extremely simple, and it is quite unnecessary to jack up the wheels of the vehicle to carry it out.

A point to remember in regard to the brakes is that a tendency to pull to one side does not mean incorrect adjustment owing to the full compensation provided. It probably indicates the presence of oil or water on the brake lining. This, of course, should be reported immediately. While water will dry off, it is not possible successfully to eradicate grease from linings, and in such cases the brake shoes should be changed.

The handbrake cable can be greased by means of the gun, for a grease nipple is provided approximately half way along its length (as shown on Fig. 26). A fair amount of lubricant from the grease gun should be inserted.

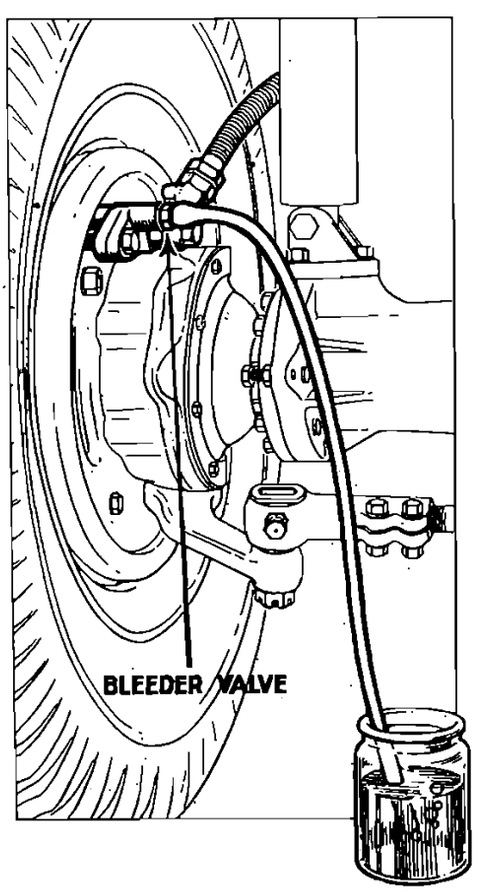


Figure 33. Bleeding System

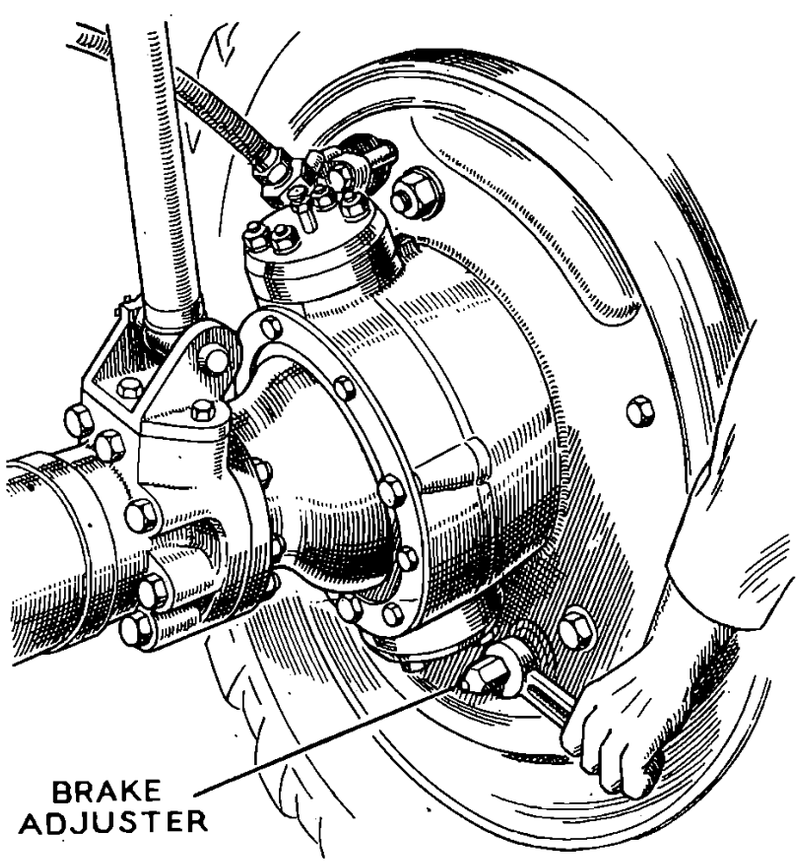


Figure 34. Brake Adjustment

To adjust the brakes screw up the adjusters until tight by rotating in a clockwise direction (see Fig. 34) and then slacken back three-quarters of a turn—approximately five notches or " clicks."

If adjustment has been carried out, and if there appears an indication that the brakes are binding then slack off the shoe adjusters one notch on each brake until satisfactory conditions are attained.

CHAPTER V A

Electrical Equipment—Operation and Maintenance

A 12 volt electrical system is employed with insulated return for all units except the ignition equipment. This latter has already been dealt with in chapter IA, part 6.

The dynamo which is mounted on the engine crankcase is driven by twin belts, and the output is automatically controlled by a regulator unit. This regulator unit combines constant voltage and constant current control, and is provided to ensure that the batteries are always kept in properly charged condition by automatically adjusting the dynamo output to suit the varying conditions of load.

A cut-out to prevent the battery discharging through the dynamo when the vehicle is stationary is fitted and this also is housed inside the control board cover.

All units are protected by fuses and spare fuses are carried.

Considering the amount of use to which the electrical equipment is put, the attention required to maintain it in service is exceptionally small, but this fact does not detract from the vital importance of carrying out this maintenance. It is necessary also for the driver to be in a position to renew a fuse or bulb should one be burned out, and instructions in relation to these operations are given below :—

For the sake of clarity each unit of the electrical equipment is dealt with separately, for it will be appreciated that to deal with the equipment as a whole would probably lead to confusion.

PART 1. LIGHTING

The headlamp and sidelamp can be adjusted for focus, but this does not apply to the remaining lamps fitted, *i.e.* side lamps, tail lamps, convoy lamps and interior illumination lamps. Bulbs in all are renewable and the specification is as follows :—

Fitted in		*Specification of Bulb*	*Lucas No.*
Headlamp	..	12v-36w-D.C.-S.B.C.	33
Sidelamp, Convoy Lamp, Tail Lamp, Oil Warning Light, Roof Lamp	12v-6w-S.B.C. ..	14v-7w-D.C.-S.B.C.	218
Spot Lamp	..	12v-60w-D.C.-S.B.C.	24
Ignition Warning Lamp		16/18v-3w-M.E.S. ..	162M
Panel Illumination Lamp		16/18v-6w-D.C.-S.B.C.	—

The Headlamp

The headlamp front may easily be removed (see Fig. 35) by slackening the single front fixing screw (a coin slot is provided in the head) allowing it to hinge out of the slot in the rim. Grip the rim firmly with both hands opposite the screw and remove the rim with even pressure by lifting out of the slot located in the top of the lamp body. Do not lever or jerk violently.

To remove headlamp bulb push in, twist and withdraw in the normal way. When replacing the rim, first locate in the slot at the top of the body and then apply pressure around the lower half of the rim.

The reflector is secured to the lamp body by means of a rubber bead and can be withdrawn when the bead is removed. When replacing, the projection on the reflector rim must be fitted into the location at the top of the lamp body and the reflector must be secured by refitting the rubber bead, the thicker lip of which must be located between the reflector rim and the lamp body.

Setting and focussing. The lamp must be set to ensure that the beam is projected below the horizontal. The lamp can be moved on its adjustable mounting when the fixing nut at the bottom of the lamp mounting is slackened. Tighten the nut after making the adjustment.

To obtain the best driving light, the bulb should be correctly focussed in the reflector. To adjust the position of the bulb, remove the front and reflector and slacken the screw on the clamping clip at the back of the reflector. Slide the bulb holder backwards or forwards until the smallest circular patch of light is obtained and finally tighten the screw.

Cleaning. Care must be taken when handling the reflector, to prevent it from becoming finger-marked. It can, however, be cleaned by polishing with a fine chamois leather. Metal polishes must not be used.

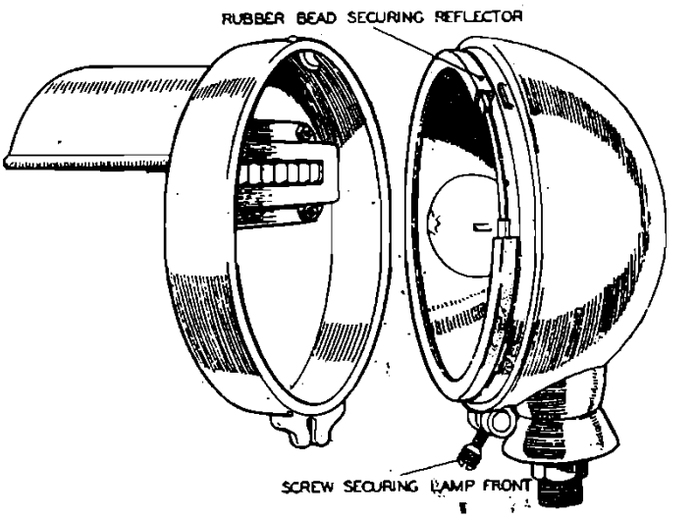


Figure 35. Removing Headlamp Bulb

The Spotlamp.

The focus of the spotlamp fitted to this vehicle can be adjusted by means of the knurled nut at the rear of the lamp.

To remove the bulb release the screw at the base of the lamp, and the front can be swung on its hinge so that the bulb is easily accessible.

The Sidelamps.

The sidelamp front can be taken off by removing the single fixing screw and springing the bottom of the rim off the lamp body (see Fig. 36).

Hold the front and twist the bulb holder in a clockwise direction (*shewn by an arrow on the holder*) until the spring fixings are released. The bulb holder can now be withdrawn and the bulb is accessible.

When replacing bulb holder push on to lamp front and twist until spring fixings drop into their locations.

The front should be located on the lip at the top of the body when being re-assembled. Apply pressure round the lower half of the rim and locate by replacing the fixing screw.

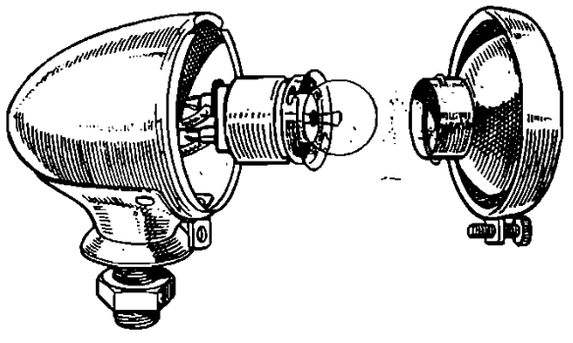


Figure 36. Sidelamp

The Tail Lamps.

To remove the tail lamp bulb turn back the rubber holding the red glass and take away the red glass. The bulb is then easily accessible.

Convoy Lamp.

This is mounted in the centre of the rear chassis crossmember immediately behind the hull rear lower plate and is arranged so as to illuminate a part of the radiator protection shield which is painted white for this purpose.

To remove the body and light tube twist and pull out of its mounting.

When replacing, push the body into the lamp base between the rubber bush and the metal liner, and turn it until the mark on the lamp body is in line with the ridge on the rubber bush and the spring fixings are heard to clip into their locations.

The Instrument Panel.

The instrument panel is fitted on the steering column and carries the speedometer, ammeter and also a combined oil gauge, and water thermometer. Also incorporated in the panel is the lighting switch, the ignition switch and the starter motor switch, together with inspection lamp sockets.

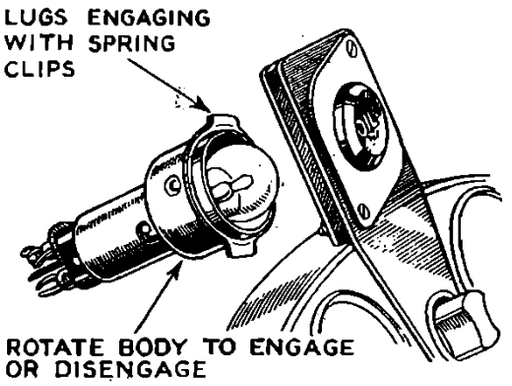


Figure 37. Renewing Oil Warning Light Bulb

The use of these various instruments has been dealt with in the section headed "Starting and Driving Instructions" and no attention in service is required except perhaps the renewal of the ignition and oil warning light bulbs.

To replace the ignition warning light bulb it is only necessary to unscrew the bezel of the lamp and the bulb is taken away with same.

To replace oil warning light bulb. Grip the bulb holder and twist in a clockwise direction to release the lugs from the engaging spring clips. The bulb holder with its bulb, can now be lifted away (see Fig. 37).

When replacing rotate body in anti-clockwise direction and ensure that the lugs are properly engaged with their locating spring clips.

PART 2. STARTER

The starter motor develops sufficient power to start the engine in the severest weather, and it requires no attention in service. The load which it places upon the batteries is fairly considerable and in exceptionally cold weather the engine should be turned over by the starting handle before the starter motor is brought into operation.

If the starter pinion jams in mesh when operating the starter switch it can usually be released by turning the squared end of the starter shaft by means of a spanner. To obtain access to the squared end withdraw the metal cap which is secured by two screws.

PART 3. CHARGING

The dynamo, control board and batteries are dealt with in this section and apart from the attention needed to keep them in service, instructions are given below on how to replace a fuse should one blow.

The dynamo.

The dynamo is of the fixed brush type and will require no attention in service. When the vehicle is undergoing a general overhaul however, it will be necessary to completely dismantle, clean, lubricate and adjust. This, of course, is a job for the workshops and must not be attempted by the driver.

So far as lubrication is concerned, the dynamo is sent out with all bearings packed with high melting point grease and this will not require any replenishment. It will only be necessary to repack the bearings during general overhaul.

The control board.

This is situated on a bracket in front of the driver and to the left of the steering column. It houses the voltage regulator, the dynamo fuse and cut-out.

The dynamo fuse may require renewal, but this is the only operation permitted. Settings of the voltage regulator and cut-out must not be interfered with.

Actually, the voltage regulator and the cut-out are housed under the largest cover which is fastened by setscrews and this cover is sealed. It must not be removed unless definite instructions are received from the competent authority.

The small cover is held in position by two wing nuts and no restriction applies to its removal. Under it is situated the dynamo fuse, together with spare replacements.

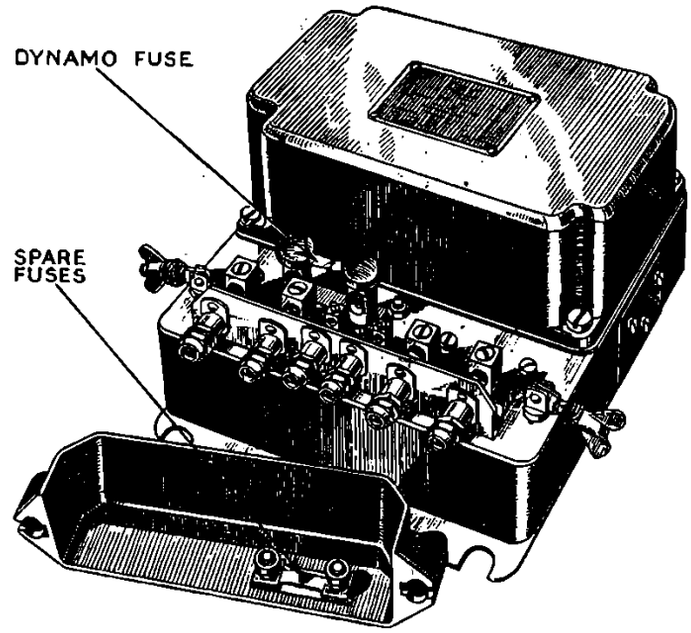


Figure 38. The Control Board

To renew a dynamo fuse lift away the small cover after undoing the wing nuts and it will be found that the fuse is of the strip type fitted between two terminals on the earthing plate of the control board (see Fig. 38). Terminal contacts to be clean and terminal screws tight.

Spare fuses are carried in the cover and a new one can be inserted by lifting the two knobs and giving then a half turn left. The blown fuses can now be lifted out and a new one inserted, after which, the knobs are returned to their original position and are held by their springs.

The capacity of the fuse is 50 amps. and if new replacements have to be drawn from store they should be of a like shape and value. The fusing capacity is stamped clearly on the end of the fuse strip.

Fuse boxes.

As already indicated fuses are provided for the protection of all units and these are housed in two boxes (see Fig. 39). One of these is situated on the right hand side of the steering column and contains five fuses ; the other is fixed on the right hand side of the turret and contains three fuses.

A blown fuse will be indicated by the failure of all units protected by it and to assist in identification of the fuse which has blown, certain markings have been introduced into the fuse boxes. In the five-way fuse box the markings are A, B, C, D and E, whilst in the three-way fuse box the markings are 1, 2 and 3.

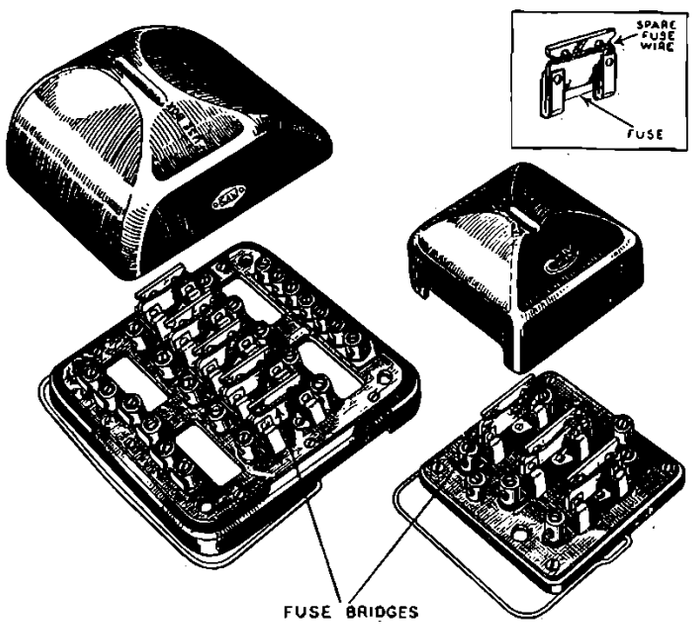


Figure 39. Fuse Boxes and Fuse Holder

The units protected by the 5-way fuse box are A, headlamp, B, sidelamps, C, tail lamps, D, all equipment in turret and E, convoy lamp and windscreen wiper, horn, panel lights, inspection lamp sockets and the interior illumination lamp fixed to the instrument panel.

The fuse marked No. 1 in the 3-way fuse box protects the ventilating fan, No. 2 fuse protects the spot lamp and the turret interior lamps, while No. 3 is the wireless telegraphy feed.

To renew a fuse it is only necessary to withdraw the fuse holder, remove the blown fuse and replace with a single strand of the spare fuse wire which is carried round the top, as shown in Fig. 39.

Fuse holders should be pressed firmly into position and the terminal grub screws kept

securely tightened. The metal contacts should be free from dirt and damp and they can be cleaned, if necessary, with spirit or fine carborundum paper.

If more replacement fuse wire is required, demand 27 S.W.G. for fuses 3 and D and 34 S.W.G. for all other positions. Remember that no increase in capacity of the wire must be made.

Before replacing a blown fuse, inspect the wiring of the units that have failed for evidence of short circuits or other faults that have caused the fuse to blow, and remedy. On no account must a fuse be renewed until the cause of its failure has been ascertained and removed.

The batteries.

Two 6 volt batteries (nominal capacity at 10 hour rate 110 ampere hours) wired " in series " are fitted and are situated on the left hand side of the driver's compartment. They are of the lead acid type and the attention required is detailed below.

To top up battery remove the battery lid and unscrew vent plugs adding distilled water so as to maintain the electrolyte level with the top of the separators—*never add acid.*

Ensure that the vent plugs are always tight and keep the tops of the cells clean and dry. The terminals and connections must be free from corrosion, and coated with vaseline—*do not use grease.*

Take frequent hydrometer readings in order to ascertain the exact state of charge or discharge of the batteries. The readings are effected by the temperature of the electrolyte and three tables covering the limiting temperature conditions are given below.

Table applicable when batteries have been filled to operate in climates with a maximum temperature of 80° Fahrenheit

Condition of Cell	Actual Hydrometer readings at temperature of :					
	20°F	40°F	60°F	80°F	100°F	120°F
Fully charged	1.311	1.303	1.295	1.287	1.279	1.271
Half discharged ..	1.221	1.213	1.205	1.197	1.189	1.181
Fully discharged ..	1.126	1.118	1.110	1.102	1.094	1.086

It will be noted from the following table that the capacity of a battery is somewhat reduced when lower specific gravity acid is used.

Table applicable when batteries have been filled to operate in sub-tropical climates with temperatures ranging between 80° Fahrenheit and 100° Fahrenheit

Condition of Cell	Actual Hydrometer readings at temperature of :					
	20°F	40°F	60°F	80°F	100°F	120°F
Fully charged	1.281	1.273	1.265	1.257	1.249	1.241
Half discharged ..	1.191	1.183	1.175	1.167	1.159	1.151
Fully discharged ..	1.096	1.088	1.080	1.072	1.064	1.056

The temperatures quoted in the tables are, of course, the temperatures of the electrolyte and will not necessarily agree with the temperature of the atmosphere.

Table applicable when batteries have been filled to operate in tropical climates with temperatures above 100° Fahrenheit

Condition of Cell	Actual Hydrometer readings at temperature of :					
	20°F	40°F	60°F	80°F	100°F	120°F
Fully charged	1.251	1.243	1.235	1.227	1.219	1.211
Half discharged ..	1.161	1.153	1.145	1.137	1.129	1.121
Fully discharged ..	1.066	1.058	1.050	1.042	1.034	1.026

The readings for each of the cells should be approximately the same. If one cell gives a very different reading from the rest it may be that the container is leaking or there may be a short circuit in the cell itself. In any case the battery should be examined, for neglect may mean that it will be irretrievably damaged.

Hydrometer readings are unreliable until the acid and water have been mixed by gassing of the cells during charge and for this reason it is advised that water should be added just before the vehicle is taken on the road and the readings immediately after it has returned from a journey.

It may be that excessive use of the starter or lights—say if the vehicle is left standing for long periods at night with the lights on—will bring the battery into a low state of charge and if this is so the remedy is to run for longer periods during the daytime or re-charge from an independent electrical supply at 12 amperes until the specific gravity in each of the cells has reached a maximum, *i.e.* has shown no further rise during 5 hours and all cells are gassing freely and evenly.

The temperature of the electrolyte during charge should not exceed 100° Fahrenheit when the batteries have been filled for operation in climates with a maximum temperature of 80° Fahrenheit. It should not exceed 110° Fahrenheit when they are filled for operation in sub-tropical climates between 80° and 100° Fahrenheit, and 120° Fahrenheit when the filling has been for climates above 100° Fahrenheit.

CHAPTER VI A

Hull—Operation and Maintenance

The actual hull itself, being of welded construction, requires no attention in service, but various associated units will need a certain amount of maintenance.

The driver, whose seat is situated well forward, is provided with adequate vision and the operation of the flap and bullet-proof blocks, through which this vision is obtained, has already been dealt with, so in this section it is only necessary to record the small amount of attention required to keep the unit operating.

Similarly rear vision is obtained by lifting the engine access door and the method of operation has been dealt with so that only the attention required has to be covered here.

PART 1. DOORS

Although two doors are provided, only one is operative, for the spare wheel which is fitted prevents the use of the offside door. This is permanently locked by means of a plate.

An internal catch is provided on the nearside and an outside detachable key is supplied so that the vehicle can be locked up when left unattended.

Lubrication.

The hinges and lock will require a spot of oil from the oil can and a smear should also be given to the lock bolt and the wearing plate on the hull with which it engages.

PART 2. THE DRIVER'S WINDOW

This comprises the bullet-proof flap, the visor shield and the locking mechanism for the bullet-proof block containers and its ease of operation is a vital factor for the driver. It is quite possible that his safety may depend upon the speed at which these protective devices can be brought into play.

Lubrication.

The various parts of the window operating gear, safety visor operating gear and the top and bottom slides for the bullet-proof glass block container should be oiled by means of the oil can.

PART 3. THE ENGINE ACCESS DOOR JACK

A separate feed tank for this is situated on the right hand side of the driver and from this tank a pipe line runs to the jack which is also fitted within easy reach of the driver's right hand. The only attention required in service will be the periodical topping-up of the fluid in the supply tank.

Maintenance.

The feed tank as previously indicated is located at the right hand side of the driver and is denoted as " J " on Fig. 1.

It is only necessary to maintain the level of the fluid within $\frac{1}{4}$" of the top of the tank, but care must be taken when refilling that all foreign matter is carefully cleaned away before the filler cap is removed.

It has already been explained in the sections dealing with the shock absorbers and the brakes that dust or any foreign matter is definitely detrimental to any hydraulic system and particular care must be taken to ensure perfect cleanliness. This will involve the cleaning of the feed tank cap and surround before the former is removed and any vessel in which fluid is held should be kept scrupulously clean.

CHAPTER VII A

The Turret—Operation and Maintenance

The turret is provided with observation flaps so that both Commander/Loader and Gunner can obtain perfect vision for normal observation when not actually in action. The hinges and the catches of these flaps will require lubricating, but this is the only attention required in service.

In order to provide vision when in action, adjustable type periscopes are provided and these will require lubrication. The most important maintenance required however, is the cleaning of the lens and the prisms.

PART 1. HEADFLAPS

Greasers are provided for each of the four main hinges (two hinges to each headflap) and attention should be given by means of the grease gun. The centre hinges are not provided with greasers, but they should be oiled with the oil can.

All the joints of the side and locking catches, together with the forks and rod and the catches themselves, should be oiled by means of the oil can so that the whole of the flap mechanism is silent and easy in operation.

In lubricating the whole of the headflap mechanism it should be borne in mind that too much lubricant should not be applied. If over-lubrication takes place the oil will creep on to the various pads, and mixing with the dust of the atmosphere, will create dirty conditions objectionable to all concerned.

PART 2. PERISCOPE

The periscopes fitted in the turret top plate allow observation to front or rear without the necessity of the observer turning round and the method of operation is explained below.

Details of maintenance, which include cleaning and lubrication, are also given.

Operation.

For observation towards the front. Unscrew both locking screws and adjust the periscope by means of the handles about its vertical axis so that the objective piece meets the field to be observed through the opening of the eye-piece on the mounting.

Observation of the field nearest to the observer or furthest from him is made by inclining the periscope about its horizontal axis.

For observation towards the rear. Turn the periscope through 180° about its vertical axis. Lower the supplementary sliding prism on the eye-piece opening, which is provided with an eye-piece, through which the field of view lying to the rear can be observed.

For zenithal observation. The objective piece must be removed, the locking piece closed and the supplementary prism lowered to its lowest position for observation to be made through the eye-piece (as for observation to the rear).

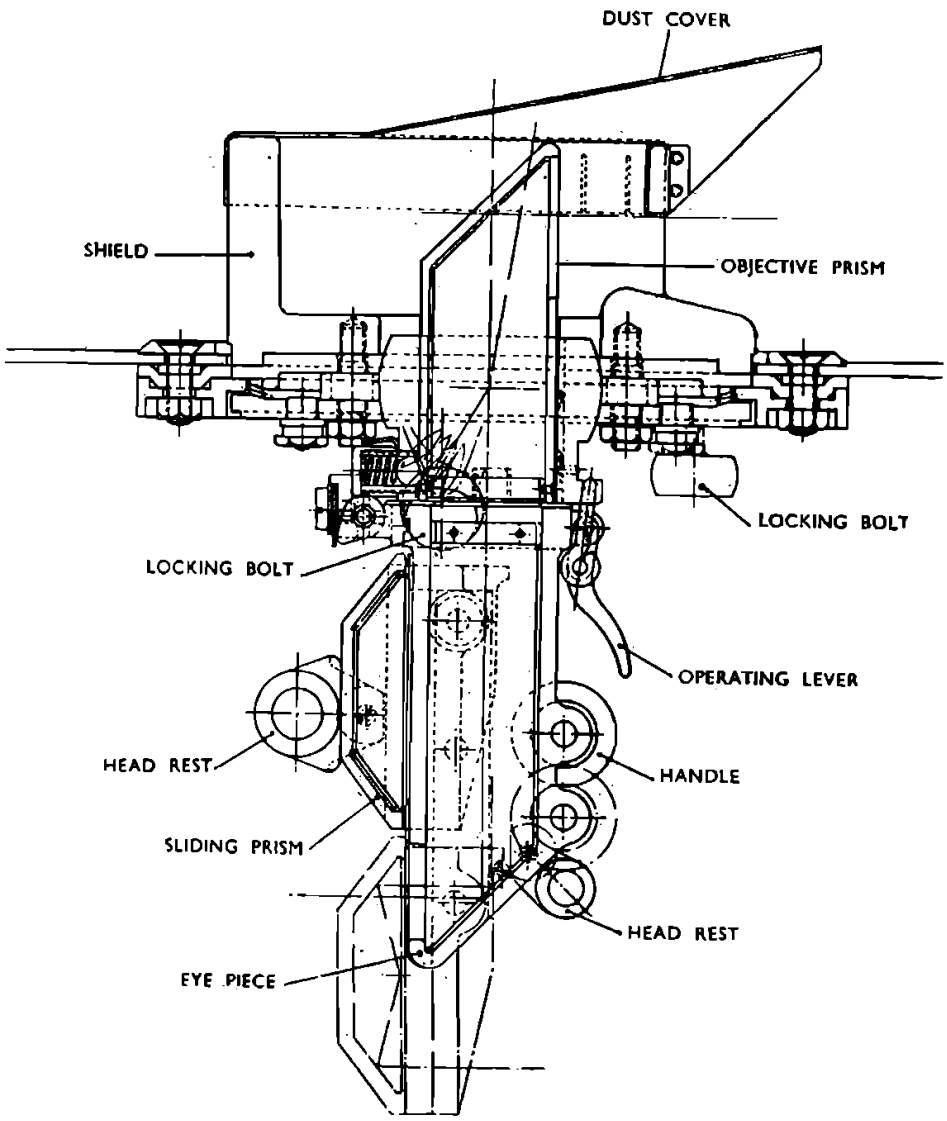


Figure 40. Periscope

Maintenance.

To fit new objective prism open the locking piece by lifting the operating lever and move the eye-piece mounting by pivoting it on its hinges until it is automatically held by a stop. The broken prism is then withdrawn from its housing and one of the spares is inserted in its place, pushing it in until it is automatically held by a stop. The eye-piece mounting is then closed by lowering the operating lever.

To clean lens use a chamois leather. If wet, clean with cotton cloth and polish with a chamois leather. *Do not finger the glass.* To avoid clouding over, smear some anti-dimming compound over the surface of the glass.

To clean supplementary prism it must first be removed after unscrewing the stop screws. Poor vision towards the rear will be caused by a dirty or stained supplementary prism.

To lubricate the periscope all moving surfaces should be kept very lightly oiled, as surplus lubricant will get on to the lens and spoil the vision. The lubricator provided in the lower bearing should be maintained with grease.

CHAPTER VIII A

Turret Traverse.—Operation and Maintenance

The turret which is situated amidships is designed to revolve through 360° and it is operated by the gunner, the hand traversing gear being conveniently placed at his left hand side.

Both the commander/loader and gunner's seats are suspended from the turret and revolve with it.

The turret ball race will require lubrication and so also will the hand traverse gear.

PART 1. TURRET BALL RACE

The turret ball race consists of 176 hardened steel balls, correctly spaced by means of 8 brass segments and will need to be lubricated to prevent stiffness of operation.

Lubrication.

Two grease nipples are situated inside the turret below the traverse gear rack and oil should be inserted by means of the grease gun.

In original assembly the reservoir formed by the lower turret ring is filled with petroleum jelly in order to prevent the oil running away without lubricating the ball race and for this reason it is thought necessary to record that this turret race should not be cleaned with paraffin or other cleaning agent as is the case with many other turret traverse gear races.

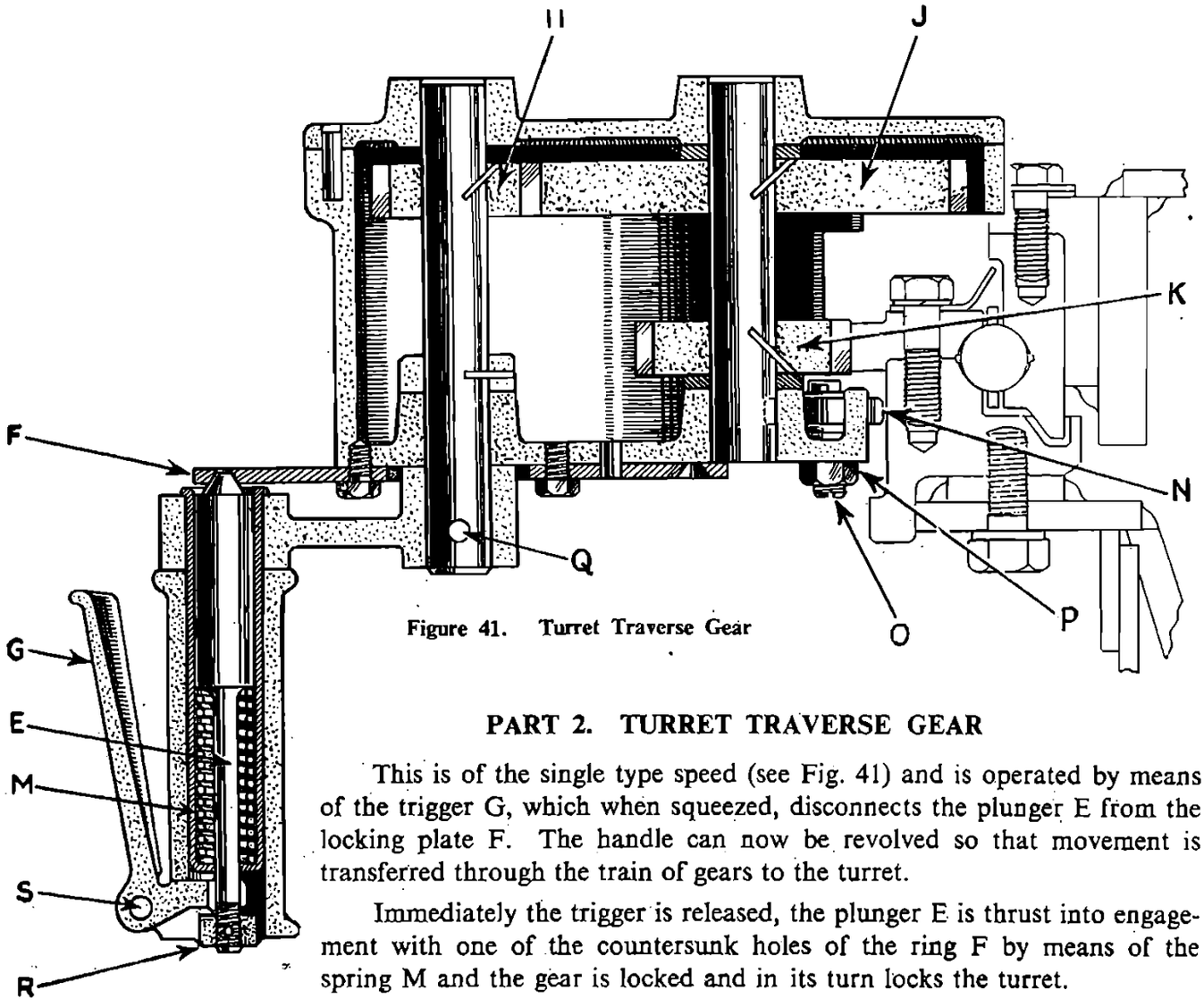


Figure 41. Turret Traverse Gear

PART 2. TURRET TRAVERSE GEAR

This is of the single type speed (see Fig. 41) and is operated by means of the trigger G, which when squeezed, disconnects the plunger E from the locking plate F. The handle can now be revolved so that movement is transferred through the train of gears to the turret.

Immediately the trigger is released, the plunger E is thrust into engagement with one of the countersunk holes of the ring F by means of the spring M and the gear is locked and in its turn locks the turret.

Lubrication.

To lubricate the traverse gear unscrew the setbolts holding the top cover and remove same. Lightly spray the gear with oil and do not over-lubricate. The gears are not fully enclosed and too much oil will only drain through into the fighting compartment.

The replacing of the top cover is extremely simple, for it is only necessary to ensure that the two dowels fit correctly into their holes and then to replace and tighten the holding setbolts.

CHAPTER IX A

The armament fitted in the turret of the Armoured Car, Mark IV is the 37 m/m gun, M6, and the 7.92 m/m Med. Besa M.G., which are co-axially mounted. The 37 m/m gun is on the right hand side, the Besa M.G. in the centre and a No. 30 or No. 33 Sighting Telescope is at the left hand side. The guns are fired from remote control pistol grips. Two Dischargers, Smoke Generator 4 in., No. 2 Mark II are fixed to the exterior of the turret and fired by Lee Enfield rifle actions operated from the interior.

37 M/M. GUN (M.6)

The 37 m/m gun, M6, is a flat trajectory Q.F. gun which fires either a high explosive or armour piercing projectile. The gun has an automatic rise and fall breech block and is provided with breech actuating mechanism operated upon recoil.

Weight of barrel assembly and breech operating mechanism	196 lbs.	Length of barrel	78 inches
		Muzzle velocity	2,900 ft. per sec.

To load the gun (see Fig. 42).

1. Push down the cross bar handle (A) which will open the breech.
2. Insert a round with a flick of the wrist. The breech will close automatically and the gun is ready to fire.

To unload by hand, the same action as to load is required, the round being automatically ejected. Care must be taken to avoid the round hitting anything liable to explode or damage it.

Normally the gun unloads automatically on recoil.

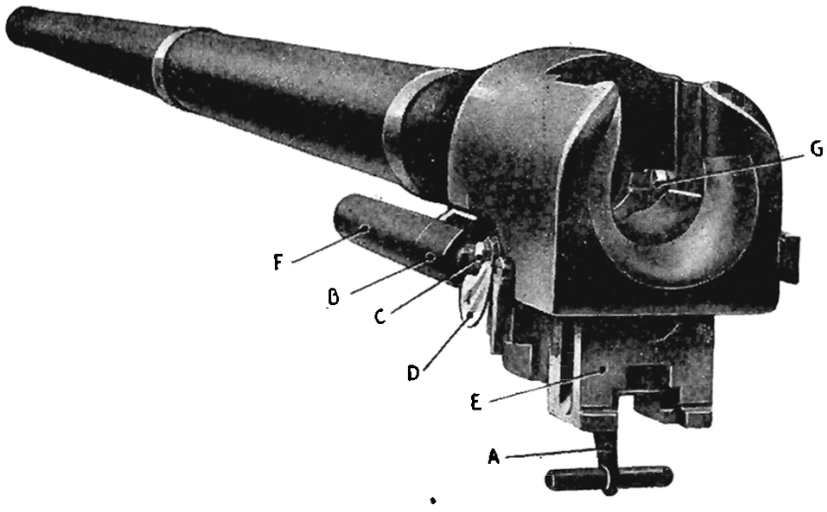


Figure 42. 37 m/m. Gun—Breech Open

To strip the firing pin and guide assembly (see Fig. 43).

1. Close the breech and actuate the trigger.
2. Press the striker retainer (A) one eighth of an inch into the breech block (B), and rotate a quarter of a turn in either direction.
3. Remove retainer and firing spring (C).
4. Cup one hand over the recess in the rear of the breech block, and with the other hand rotate the cocking lever (D) forward smartly so as to eject the firing pin guide assembly. *The firing pin guide assembly must not be dismantled further except when it is required to replace the firing pin.*

5. With the combination tool drive out the guide pin (F) from the forward end of the firing pin guide.
6. With a screwdriver, unscrew the firing pin (G) from the guide, and remove the firing pin, retracting spring (H) and stop (J).

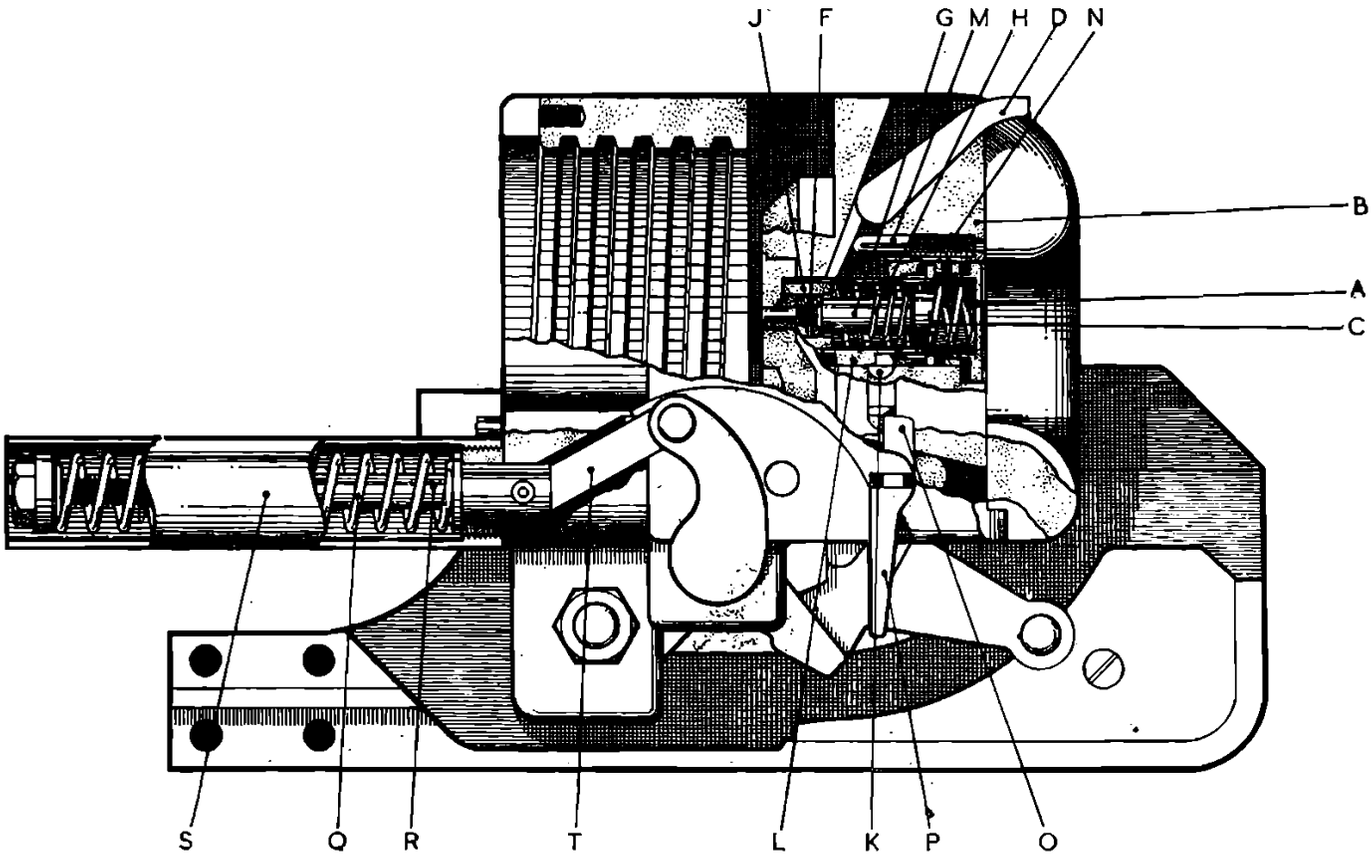


Figure 43. Breech Mechanism

To assemble the firing pin and guide.

1. Replace the stop in the guide, with the prongs protruding through the forward end of the guide.
2. Place the retracting spring on the firing pin (G), insert the firing pin and retracting spring into the guide with the striker end of the firing pin to the front.
3. Screw the firing pin into the guide as far as it will go, and back it off just enough to clear the hole for the guide pin.
4. Drive in the guide pin (F) until it is flush on each side of the guide.
5. Insert the firing pin guide assembly into the guide chamber in the breech block.
6. Hold the trigger to the rear, and push the firing pin guide assembly forward until the prongs of the stop strike the breech block bushing.
7. Release the trigger.
8. Insert the firing spring into the guide.
9. Place the cup end of the striker retainer (A) over the rear end of the firing spring, keeping the slot on the rear face of the striker retainer horizontal.
10. Press the retainer into the face of the breech block one eighth of an inch, and rotate until the slot is in the vertical position (indicated by arrows).

To strip the breech block (See Figures 42 and 44) .

(*a*) Pull the handle (A, Fig. 42) downwards until a pin can be inserted through the hole (B, Fig. 42) in the closing spring housing and rod.

(*b*) Remove the closing spring locking pin (C, Fig. 42) and while supporting the breech block, withdraw the lever arm shaft (D, Fig. 42).

(*c*) Remove the crank assembly (A, Fig. 44) and lower the breech block (E, Fig. 42) placing it face downwards.

(*d*) Depress the cocking lever plunger (B, Fig. 44) and at the same time remove the cocking lever (C, Fig. 44).

(*e*) Release the plunger, remove, with spring (D, Fig. 44).

(*f*) Press the sear arm (E, Fig. 44) into its recess in the breech block as far as it will go, and remove the sear retaining lock and washer. Release the pressure and withdraw the sear and sear spring assembly.

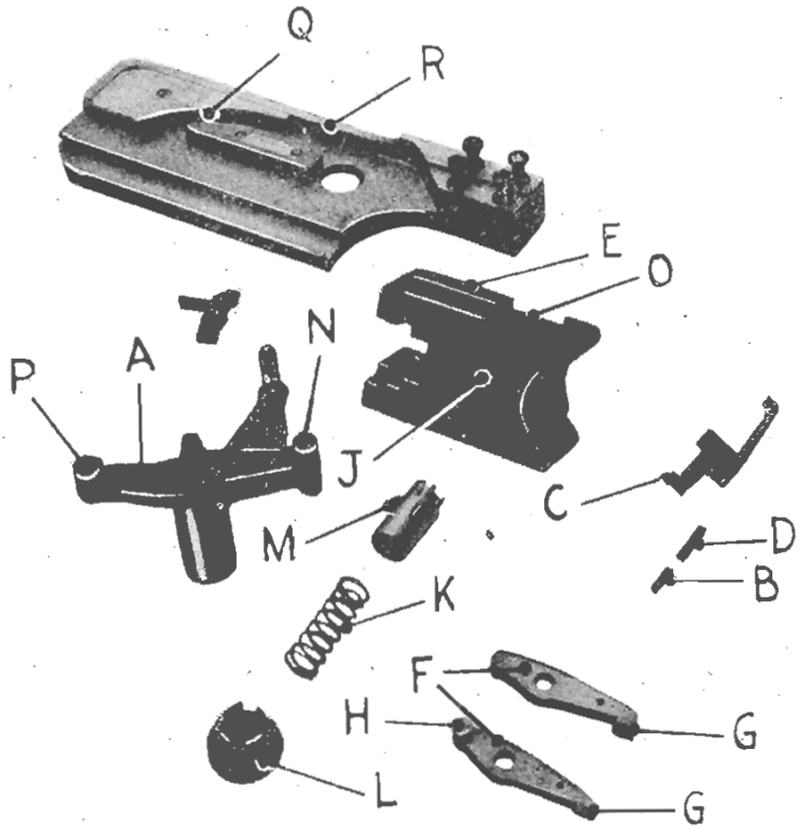


Figure 44. Breech Block Operating Mechanism

To assemble.

(*a*) Place the sear spring over the small end of the sear and insert the sear and spring into its recess in the breech block.

(*b*) Align the arm of the sear with the slot and press the sear into its recess as far as it will go.

(*c*) Replace the sear retaining lock and washer.

(*d*) Release the pressure on the sear spring.

(*e*) Insert the cocking lever plunger spring (D, Fig. 44) into its hole in the top of the recess in the left hand side of the block.

(*f*) Press the cocking lever plunger (B, Fig. 44) into the hole, and insert the cocking lever (C) into its recess with the short arm down.

(*g*) Start the breech block (E, Fig. 42) into its recess, keeping the cocking lever up.

(*h*) Push the breech block up far enough for the upper arms of the extractors to rock forward.

(*j*) Push the block up and replace the crank assembly (A, Fig. 44) and the lever arm shaft (D, Fig. 42).

(*k*) Secure the lever arm shaft to its link by inserting the closing spring locking pin.

(*l*) Remove the pin from the holes in the closing spring housing body and rod.

To strip the firing and extracting mechanism (see Fig. 45).

(*a*) Remove the breech block and withdraw the tripper.

(*b*) Lift the extractors off their pivots (A).

(*c*) Level the gun and remove the coupler pin, which holds the lugs (B) to the recoil mechanism, using a screwdriver and the wrench provided.

(*d*) Slide the barrel back 8 to 10 inches to clear the trigger.

(*e*) Depress the trigger plunger and remove the trigger.

(*f*) Release the pressure on the plunger and remove the plunger and spring.

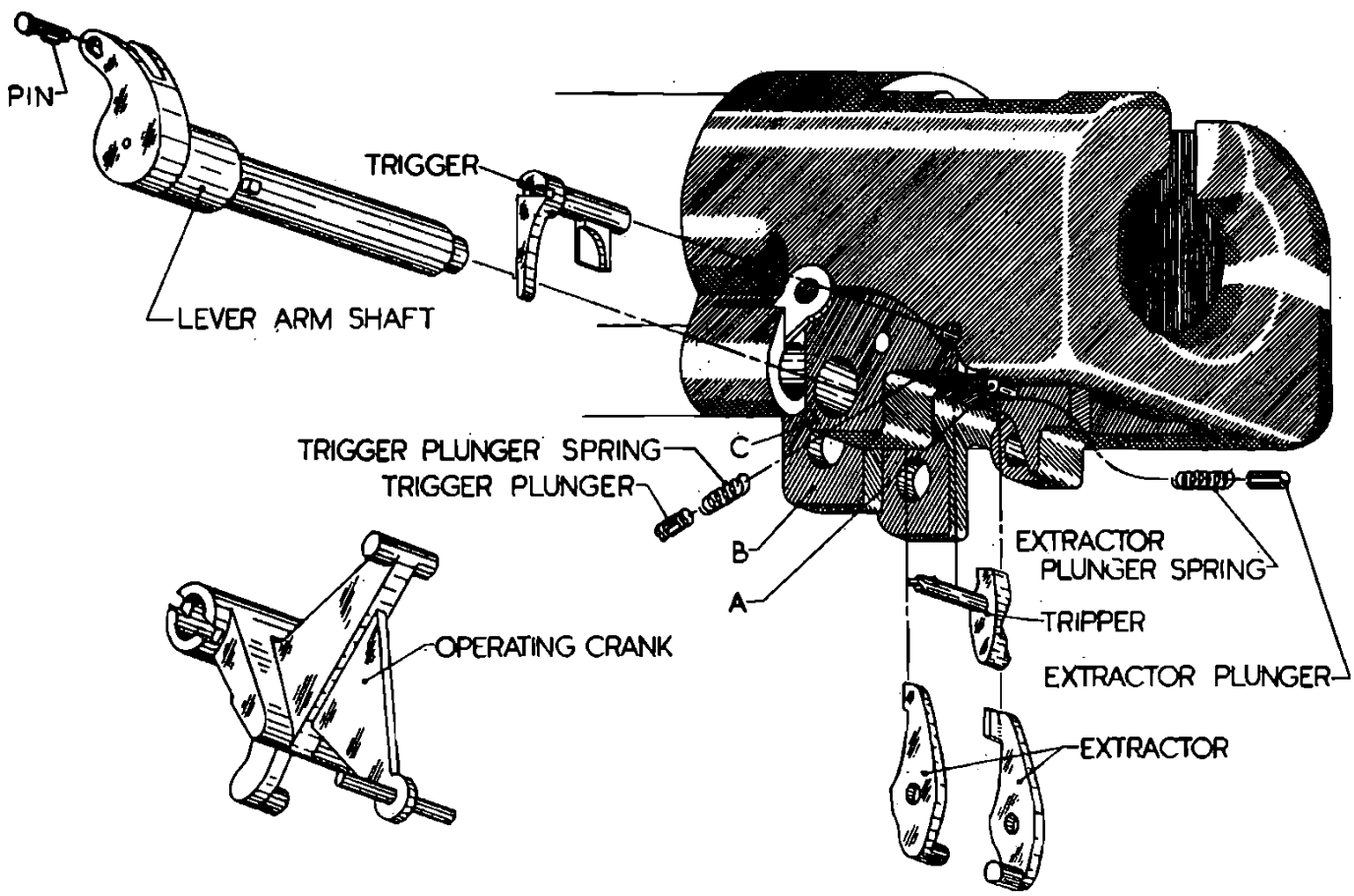


Figure 45. Breech Ring Assembly

To assemble the firing and extracting mechanism.

(*a*) Replace the trigger spring and plunger.

(*b*) Press the trigger plunger to the rear.

(*c*) Replace the trigger and release the plunger.

(*d*) Slide the barrel to the forward position and replace the coupler pin.

(*e*) Insert the shaft of the tripper into the hub of the trigger, with the short arm forward.

(*f*) Slide the shaft of the tripper through until the short arm of the tripper enters its recess inside the breech ring.

(*g*) Slide the extractors on to their pivots (A).

(*h*) Replace the tripper and breech block.

STOPPAGES AND IMMEDIATE ACTION 37 M/M GUN

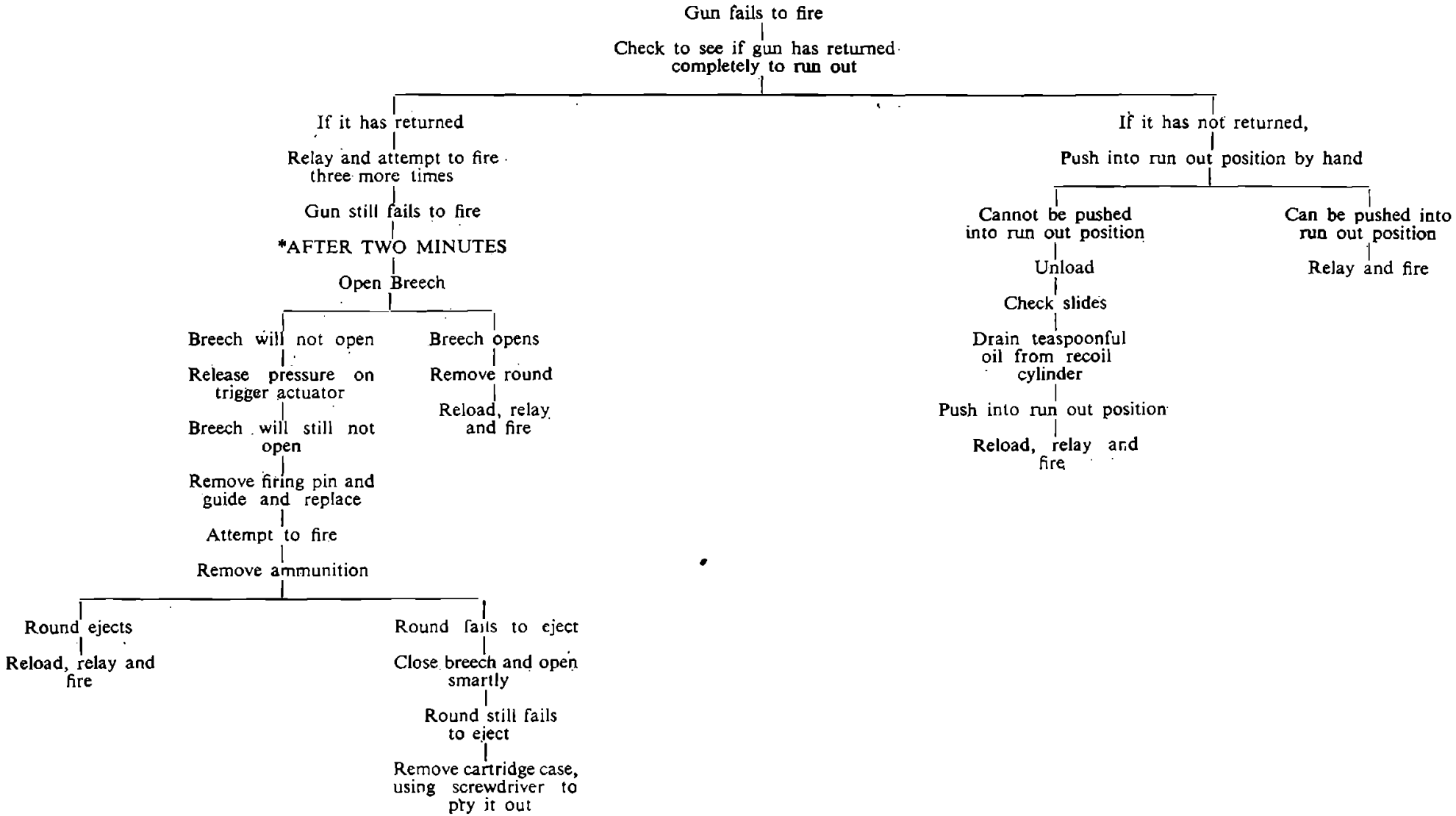
A stoppage is cessation of fire caused by failure of the gun or ammunition.

Immediate action is the procedure used to remove a stoppage.

Most stoppages are prevented by proper care and cleaning of gun and ammunition.

Stoppages	*Causes*	*Immediate Action*
Gun fails to fire	Gun fails to run out completely	Push home the gun, relay and fire. If the gun cannot be pushed into run out position, unload, check recoil cylinders for proper amount of oil. Drain out about a teaspoonful if necessary. If gun still will not run out, check slides and guides for burrs, dirt and lack of lubrication. Clean, remove burrs, lubricate, reload, relay and fire.
Gun fails to fire	Breech block fails to close when gun is in run out position.	1. Close it manually, relay and fire. *2. If it will not close, see if ammunition is seated. If ammunition will not seat, change the round, reload, relay and fire. If ammunition still will not seat, clean chamber, reload, relay and fire. †3. Ammunition is seated. Check for broken or worn extractor, replace as necessary. Check for broken or weak closing spring. Adjust or replace as necessary. Clean and lubricate bearing surfaces of breech block as necessary.
	Breech closed and gun in run out position. Defective trigger actuating mechanism. Broken or bent trigger arm Damaged firing pin Defective firing spring Defective sear Defective sear spring Dirty sear lug or firing pin guide Lack of lubrication Defective ammunition	1. Re-cock the piece. 2. If cocking action shows that the piece is still* cocked (indicated by no resistance other than the cocking lever spring to be overcome) examine for bent or broken trigger arm and for malfunction of trigger actuating mechanism. Replace parts as necessary, relay and fire. If trigger mechanism is not defective remove firing mechanism and check for weak or broken firing spring. 3. If cocking action indicates that the firing pin guide sear lug has been released from the sear (indicated by heavy resistance to cocking action) relay and fire. If gun still fails to fire after twice repeating this action, *after* 2 minutes remove firing pin and guide, clean, lubricate, replace defective parts, re-cock, relay and fire. 4. If gun still fails to fire, wait 2 *minutes*, unload, load with a new round, relay, and fire. 5. If cocking action shows that the firing pin guide sear lug will not remain engaged in the sear, after 2 *minutes* unload, dismantle breech block, clean and replace defective parts.
Failure to feed	Defective or dirty ammunition Dirty chamber Round loaded with insufficient force to trip extractor	See * above.
Failure to extract	Defective ammunition Dirty chamber Worn or broken extractor	Pry out empty case by inserting a sharp tool in front of the flange of the ease or drive it out by inserting a cleaning staff in the muzzle of the gun. Clean the chamber. Examine extractors and replace as necessary.
Failure of breech block to stay open.	Broken or worn extractor Defective extractor plunger springs	See † above.

THE FOLLOWING PROCEDURE IS USED FOR THE REDUCTION OF STOPPAGES :—



* In action, the situation must govern the time.

GUN, MACHINE, BESA 7.92 M/M

The 7.92 m/m Besa Machine Gun used in Armoured Fighting Vehicles is an air cooled gas operated weapon with buffered action, ammunition being supplied from a belt holding 225 rimless cartridges. The mark is stamped on the left hand side of the gun body.

The 7.92 m/m Besa M.G. as intended for mounting in A.F.V's has no ground mounting, and aiming is carried out by means of a sighting telescope housed in the gun mounting.

The barrel cannot be changed unless the gun is removed from the A.F.V. mounting.

The gun can be fired dismounted, provided the ejection opening is clear of the ground.

Approximate weight, complete	48 lbs. (varies according to mark)
Approximate weight of barrel	15 lbs. (varies according to mark)
Overall length	3 ft. 7½ ins.
Length of barrel with flash eliminator..	2 ft. 5 ins.

Rates of fire (Rounds/Min.)	High	Low	
Mark I	750/850	450/550	Without Accelerator
Mark II	750/850	450/550	
Mark II*	750/850	450/550	
Mark III	750/850	—	Fixed Accelerator
Mark III*	—	600	No Accelerator

To load.

(*a*) Grasp the pistol grip with the right hand with fingers clear of the trigger and pull back trigger guard until the cocking catch lever can be pressed down with the thumb. Slide the trigger guard forward as far as it will go and then pull back until retained by the cocking catch. The gun is now cocked.

(*b*) Feed in the belt. Pass the tag of the belt through the feed block from the right and pull to the left as far as it will go. The gun is now ready to fire. Tuck the end of the tag into the metal chute on the left side of the cartridge case reflector.

To fire squeeze the trigger of the remote control firing gear. Firing will continue until the trigger is released or the end of the belt is reached. If the ammunition is expended, the gun must be cocked again before leading in a fresh belt.

To unload. With the gun cocked hold back the trigger guard, pull out the cover locking pin, raise the cover and hold it open by the ring suspended near the gun, remove the belt, see that the chamber is clear, lower the cover and engage the locking pin. Pull back the trigger guard slightly, depress the cocking catch lever and ease the working parts forward by holding the trigger guard. With the trigger squeezed, pull the trigger guard back, release the trigger and draw the trigger guard right back until retained by the cocking catch.

STRIPPING AND ASSEMBLING.

Precautions.

(*a*) Always treat the gun as loaded until proved otherwise. Cock the gun, open the cover, and *see that the chamber is clear.*

(*b*) Do not fire the working parts forward when the gun is unloaded, unless absolutely necessary. Ease them forward (see "To unload").

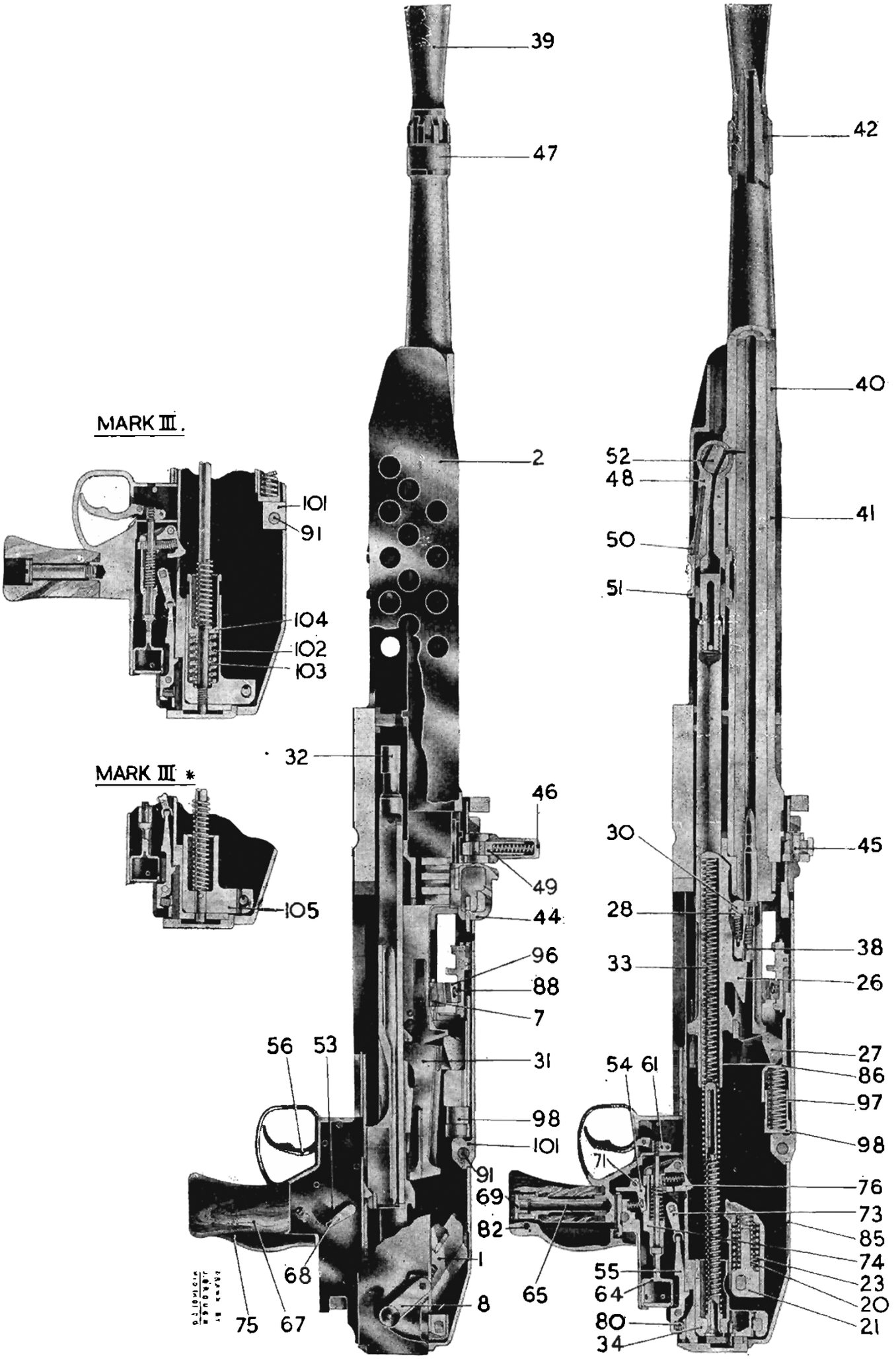


Plate 6. Besa M.G. in Section

(*c*) The gas cylinder is very easily damaged. Avoid the following :—

(i) Attempting to remove or replace the barrel when the gun is not cocked.

(ii) When replacing the barrel, knocking the cylinder against the body of the gun.

(iii) Firing the working parts forward with the barrel retainer disengaged.

(*d*) Although the parts of the guns are designed to be interchangeable experience has shown that the components of each particular gun should be kept together and not assembled to another gun, except in emergency.

Stripping—see Plate 6.

Do not strip the gun further than is necessary. For cleaning, maintenance and examination the following procedure is adopted :—

(*a*) Lift off the rear baffle plate.

(*b*) Raise the carrying handle (46) until just clear of the lug on the right side of the body and push the barrel retainer (44) forward until clear of the slides in the body (2). Raise the carrying handle to the vertical position, lift the rear of the barrel (41) and push it forward until the guides on the barrel sleeve (40) are disengaged from the guides at the front of the body.

(*c*) Pull out the cover locking pin as far as it will go. Remove the cover (85).

(*d*) Press in the belt guide (if fitted) and lift the belt guide from its housing in the body.

(*e*) Lift the feed block from the body and slip out the feed slide.

(*f*) Remove the breech block (31) by lifting the rear and sliding it out backwards.

(*g*) Remove the accelerator (1) (if fitted) by pulling out the accelerator arm plunger from the body, turning it to the vertical position (upward for Mark I guns and downward for Mark II and II* guns) and lifting the accelerator from its seating in the body.

(*h*) Ease the working parts forward (see "To unload," page 63).

(*i*) Press the return spring guide block (34) forward (1 inch approx.) and with a lift remove the return spring guide and return spring (33) from the body.

(*j*) With one hand on the piston extension (26) and the other at the rear end of the barrel extension (27), lift out the piston (32) and the barrel extension. Slide the piston out of the barrel extension.

(*k*) Lift out the feed lever.

(*l*) Raise the trigger guard catch. Grasp the pistol grip, squeeze the trigger (56), draw the trigger guard to the rear as far as it will go, release the trigger and again draw the trigger guard to the rear until it comes away from the gun.

(*m*) Return to the barrel. With a punch or the point of a bullet, depress the gas cylinder sleeve spring (50) and, using the spanner end of the combination tool or an adjustable spanner, rotate the gas cylinder (51) sleeve until it is free of its housing in the barrel. Swing the rear end of the gas cylinder (48) away from the barrel sleeve (40) until the gas cylinder becomes detached from the barrel sleeve. Tap the gas regulator (52) out of the cylinder with a copper hammer or brass drift. Slip off the gas cylinder sleeve (51) and spring.

(*n*) Turn the breech block (31) upside down, lift the front end of the extractor stay (28) until it is disengaged from the extractor (30) and remove it, together with its spring. Lift out the extractor.

(*o*) Finally, turn the breech block upright, press the firing pin retainer downward with a punch or the point of a bullet. The spring will force the firing pin (38) out. Take precautions to prevent their loss.

Assembling.

(*a*) Assemble the spring to the firing pin (38), and with the retainer still down, press the pin and spring into the breech block (31), taking care that the slot in the pin is facing the retainer. Push home the retainer.

(*b*) Turn the breech block upside down, and slide the extractor (30) into its guides. Assemble the spring to the extractor stay (28) and place them in the breech block, rear end first, with the projection uppermost. Press in the front end of the stay until it is retained.

(*c*) Replace the gas cylinder sleeve spring in the gas cylinder (48). Slip on the gas cylinder sleeve (51), with the interruptions on the opposite side to the spring. Depress the spring and push down the sleeve so that it holds the spring depressed. Insert the gas regulator (52) into the cylinder. Engage the flange on the gas cylinder in its housing in the barrel sleeve (40) and swing the cylinder to the rear until it lies along the barrel. With the combination tool or a spanner, rotate the gas cylinder sleeve until it engages in its housing in the barrel sleeve.

(*d*) Raise the trigger guard catch and engage the flanges of the trigger guard with the guides in the body; with the cocking catch thumb-piece depressed, slide forward the trigger guard, keeping the fingers clear of the trigger (56). Release the cocking catch thumb-piece and drop the trigger guard catch. Pull the trigger guard back until the cocking catch (55) engages with the body.

(*e*) Replace the feed lever and swing its upper arm out to the right.

(*f*) Slide the upper flanges of the piston extension (26) into the lower groove of the barrel extension (27). With the piston in the forward position, lower the piston and barrel extension into the body.

(*g*) Assemble the return spring (33) over the return spring guide (34). Grasp the top of the return spring guide block with the right hand and insert the free end of the spring into the piston extension. With the left hand supporting the spring, force the return spring guide forward until the guide rod enters the body and then press the guide downward and release. See that it is correctly positioned.

(*h*) Cock the gun, keeping one hand pressed down on the barrel extension.

(*i*) Replace the accelerator (1) (if fitted) and engage the plunger.

(*j*) Replace the breech block (31), making sure that it is properly settled down on to the piston extension.

(*k*) Slip the feed slide into the feed block and position the left edge of the slide itself in line with the left edge of the feed block. Lower the feed block into the body and ensure that the stud on the slide is engaged in the slot in the feed arm.

(*l*) Replace the belt guide in the body and press it downwards until the catch (if fitted) engages.

(*m*) Engage the cover (85) with the trunnions on the body, close it and push in the cover locking pin.

(*n*) Take hold of the barrel carrying handle (41) and raise the rear end of the barrel. Keeping the gas cylinder clear (48) of the body (2), engage the guides on the barrel sleeve (40) with the guides at the front of the body, pull the barrel to the rear and lower the breech end into the barrel extension (27). Push the carrying handle over to the right so that it rests on the ramp; knock back the handle with the hand and push it down into the locked position.

(*o*) Replace the rear baffle plate.

(*p*) Ease the working parts forward (see "To unload").

(*q*) Test the gun for correct assembly by cocking and easing the working parts forward again.

Stripping in Action.

When the gun is mounted, the barrel piston, barrel extension, feed lever, and gas cylinder cannot be removed. *The following parts can be removed if replacement or repair is required in action.*

In each case the cover must be opened first.

(1) Breech block and components. With the gun cocked, see "Stripping" (*f*) and (*o*) (page 65).

(2) Return spring and guide. With the working parts eased forward, after removal of the accelerator (if fitted), see " Stripping " (*g*) and (*i*).

(3) Belt guide. By pressing in the catch (if fitted) and lifting out.

(4) Feed block and feed slide. By lifting out, after removal of the belt guide.

(5) Accelerator (if fitted). See " Stripping " (*g*) (page 65).

(6) Trigger guard. See " Stripping " (*l*).

(7) Feed and retaining pawl springs. These can be replaced in emergency by manipulation, using a small screwdriver.

STOPPAGES 7.92 M/M GUN

Breakages are rare with the 7.92 Besa Machine Gun. Correct handling, attention to maintenance and periodical examination are essential to ensure freedom from stoppages, most of which are due to faulty handling, careless preparation or lack of inspection.

It is essential to protect the gun and ammunition from rain, dust and extreme cold, and efforts should be made to avoid overheating.

It is advisable to " run-in " new guns during training, to bring to light any defects which can be remedied before battle.

Parts of a gun found reliable, should not be exchanged with other guns, except in an emergency.

" Immediate Action " (I.A.) is the action carried out by the gunner to make the gun fire again in the least possible time, and should be instinctive.

Precautions when clearing stoppages. Serious damage to guns and injuries to gunners will result upon careless handling when loading or clearing stoppages, and the following precautions must be observed :—

(*a*) Keep the fingers clear of the trigger when cocking.

(*b*) Always cock the gun or hold back the working parts by the trigger guard, open the cover and do not release the trigger guard until engaged by the cocking catch.

(*c*) When cocking, once the action of drawing back the working parts has been commenced, they must not be allowed to slip forward, even if they cannot be drawn right back. Carelessness in this action will result in a double feed, with a possibility of the round in the belt, when the cover is raised and usually results in a bullet lodged in the bore.

(*d*) If a lodged bullet is suspected, the bore must be cleared before firing to prevent the barrel being bulged and the breech block fractured.

(*e*) Do not use the head to support the cover, but suspend the cover from the roof of the vehicle by the ring provided.

(*f*) Clear the chamber as soon as possible, as an overheated gun will give a " cock-off " with the same results as in (*c*).

(*g*) Never fire the working parts forward even if the gun is clear, unless the cover is closed and locked.

(*h*) When removing the belt, ensure that the exit guide, when not fitted with a retaining catch, is not drawn out of place.

(*i*) When replacing the belt in the gun see that the first round is in line with the chamber.

Any unusual or persistent stoppages should be reported and the gun handed in to an armourer together with defective parts and samples of fired and unfired ammunition and belts. A statement should be made of the circumstances, and particulars on the ammunition boxes should be quoted.

IMMEDIATE ACTION 7.92 M/M BESA MACHINE GUN

Indication	*Probable Cause*	*Immediate Action*
1. Gun stops	Misfire. Snubbed round. Space in bolt	Cock the gun, relay and fire. (If the gun after being warmed up fires single shots or only very short bursts oil the working parts. In guns earlier than the Mk. III it may be necessary to adjust the gas regulator)
	Separated case withdrawn by cocking	
	Trapped case. Friction	
2. After the first I.A. the gun will not fire		Cock the gun, examine the bolt, feed and chamber
(*a*) **First round not in line with chamber**	Bolt prevented from feeding	Free the bolt. Reload, relay and fire
(*b*) **Round in chamber**	Double feed (caused by friction, tight links or weak return spring; followed by gunner's applying the first I.A.)	If the round is fully in the chamber or can be pushed home, ease the belt back one space, close the cover, relay and fire
	Separated case	If the round cannot be pushed fully into the chamber, remove belt guide and round (see note)
		If the separation has been withdrawn on the round, replace the belt guide. Close the cover, reload, relay and fire. If it has not been withdrawn, remove it with the clearing plug. Replace the belt guide close the cover, reload, relay and fire

If on applying the second I.A. the belt is feeding correctly, but the chamber is empty, examine the firing pin. If the round (or the empty case) is still in the chamber after 2 (*b*), change the extractor and spring. Fire the parts forward, recock and examine the chamber.

Note.—To position the round so that the extractor will grip it, rest the handle on the Mk. II clearing plug (or mounting spanner) on the base of the round and force downwards. Ease the working parts forward for the extractor to grip the round. Withdraw the working parts and examine the rounds.

DISCHARGER, SMOKE GENERATOR, 4 IN. NO. 2, MARK II

The four inch Smoke Generator Dischargers are fitted to the A.F.V. for generating smoke screen. They are fitted in a fixed position to the outside of the turret and aimed by rotating the turret, using the turret sighting vane as a sight.

The distance the generator is projected when fired is approximately 125 yards. The dischargers are fired from inside the vehicle by Lee Enfield rifle actions.

Remember.

(1) *To aim up wind and let the smoke drift to the target.*

(2) *That a high wind will move and disperse smoke quickly.*

(3) *To reload.*

Breech and muzzle covers are provided for the discharger, and both must be kept in place when the discharger is not in use. The muzzle covers are expendable so that the discharger may, if necessary, be fired without removal of the cover. It is important that the discharger muzzle cover be used to prevent water entering the barrel ; the presence of water in the barrel must be avoided at all costs as it considerably reduces the range of the discharger. The muzzle cover is made of an approved cloth, hemmed to enclose an elastic band and fixed tightly over the muzzle. The canvas breech cover encloses the action and is secured by quick release fasteners.

The action should be kept free of dust and oiled. Make certain that the cartridge chamber and the barrel are cleaned and oiled and that the trigger action works efficiently.

GUN TOOLS CARRIED IN A.F.V.

The accessories include tools for normal assembling and reassembling, making adjustments and cleaning gun. The principal accessories comprise the following :—

37 m/m gun.

Bore brush and rammer. The bore brush is made of fibre bristles. The lower end of the brush is provided with an external threaded stud which can be screwed into the thread end of the forward section of the rammer.

The brush is carried in the tool kit.

The rammer consists of two sections. The forward section is threaded at both ends. One end is threaded to receive the cleaning brush and the other end the rear section of the rammer.

Protective muzzle cover. The muzzle cover is provided to protect the gun from dirt, moisture, or obstructions. It fits over the muzzle of the gun. It is made of heavy leather and protects the bore from dirt and water.

Oil can, 1 quart. This can is for recoil cylinder oil. It is carried in its compartment of the tool case.

Oiler, oval, 3-ounce. This is the spout type oiler. It should be filled with light lubricating oil and carried in the tool case.

Grease gun (Lincoln No. 5951). This grease gun fits the lubricating fixtures of the gun and mount and is carried in the tool case.

Oil gun, with cap. This oil gun is used in refilling the recoil cylinder. It is made of brass and has a fixed threaded spout which fits the filler hole of the recoil cylinder.

Tool roll M.6. This roll is made of canvas and is designed to carry the tools.

Assorted tools. The tools furnished with the guns are :—

Hammer, machine, ball-peen, 8-ounces.
Pliers, combination, slip-joint.
Punch, driven pin, standard $\frac{3}{32}$ inch point, 4 inches long.
Screwdriver, regulator, 3 inch.
Wrench, adjustable, 8 inch.
Wrench, engineer's, double head, $\frac{3}{8}$ inch and $\frac{1}{2}$ inch.
Wrench, socket, head, setscrew, $\frac{3}{32}$ inch hexagonal.
Wrench, socket, head, setscrew, $\frac{1}{8}$ inch hexagonal.

The spare parts for the gun are :—

Guides firing pin.
Extractor left.
Extractor right.
Plunger, cocking lever.
Pin, firing.
Spring, operating handle latch.
Spring, cocking lever plunger.
Spring, retracting firing pin.
Spring, sear and plunger trigger.
Spring, firing (main spring).

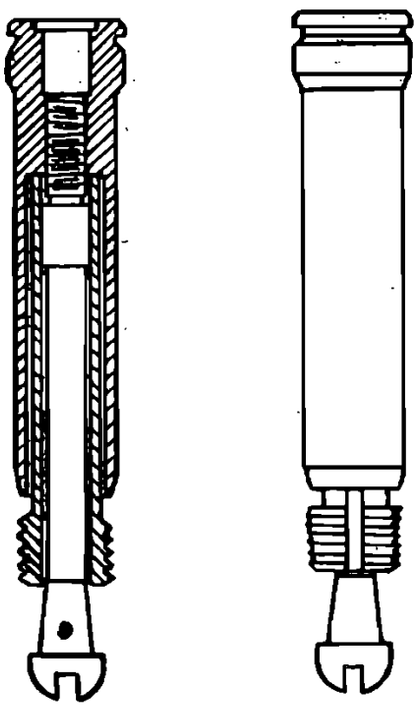


Fig. 46. Plug, Clearing, Besa 7.92 m/m., Mark I

7.92 m/m BESA M.G.

Plug, clearing, Besa 7.92 m/m M.G. Mark I (see Fig. 46). For removing separated cases from the chamber.

Plug, clearing, Besa 7.92 m/m M.G. Mark II (see Fig. 47). For removing separated cases from the chamber.

Tool, combination, Besa 7.92 m/m M.G. Mark I (see Fig. 48). For removing gas cylinder sleeve and flash eliminator and as a grip on the carrying handle, when removing a hot barrel. The spanner end provides a copper hammer and the handle accommodates two plain and two forked screwdrivers.

Tool, combination, Besa 7.92 m/m M.G. Mark II (see Fig. 49). Simplified version of the Mark I with the screwdrivers and hammer omitted.

Rod, cleaning, .303 inch M.G. Mark IIB or V (see Fig. 50). For cleaning and oiling the bore and for removing "hard extractions."

Brush, rod, cleaning, Besa 7.92 m/m M.G. Mark I (see Fig. 50). For cleaning the gas cylinder.

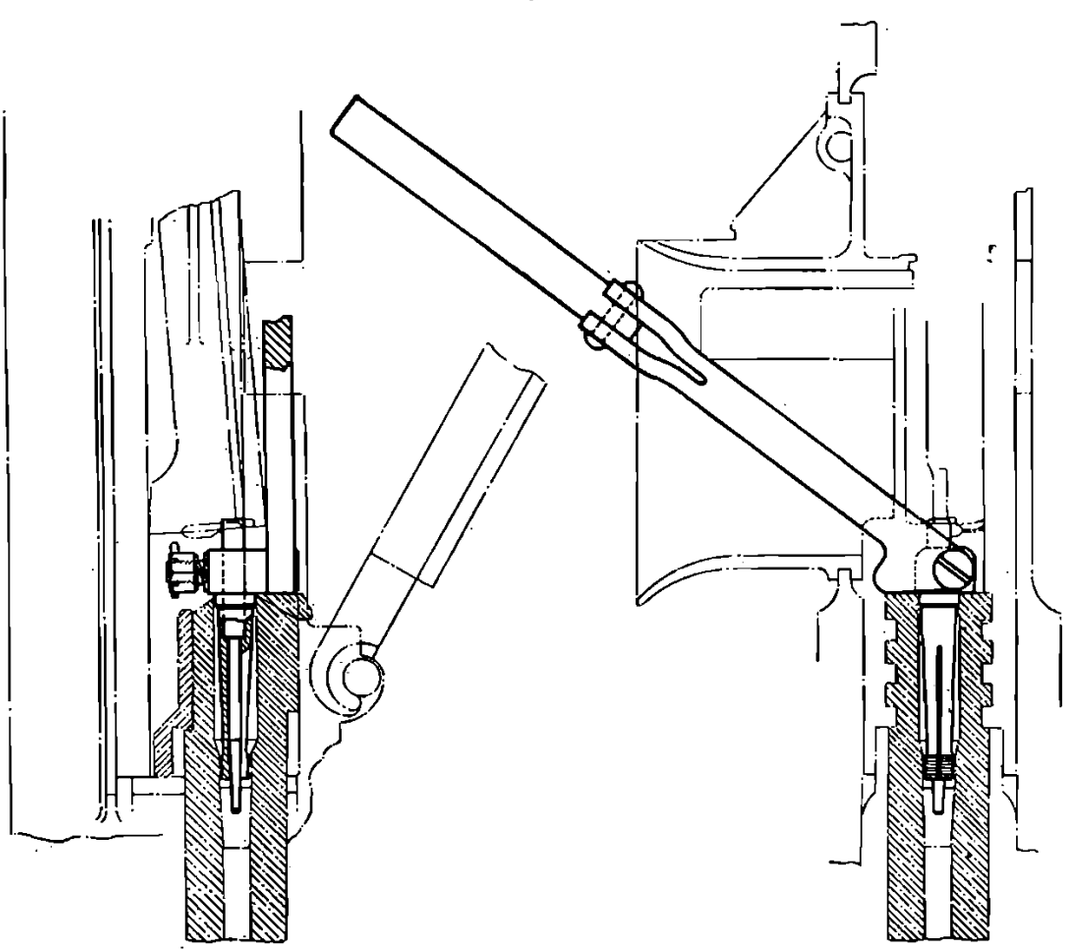


Fig. 47. Plug, Clearing, Besa 7.92 m/m., Mark II

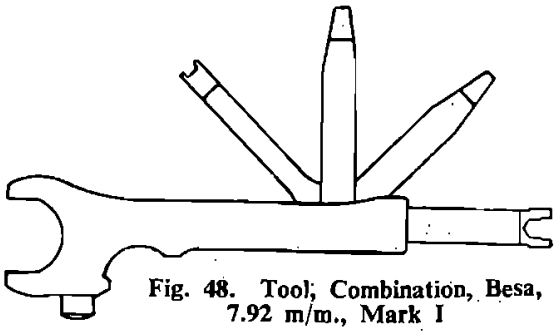


Fig. 48. Tool, Combination, Besa, 7.92 m/m., Mark I

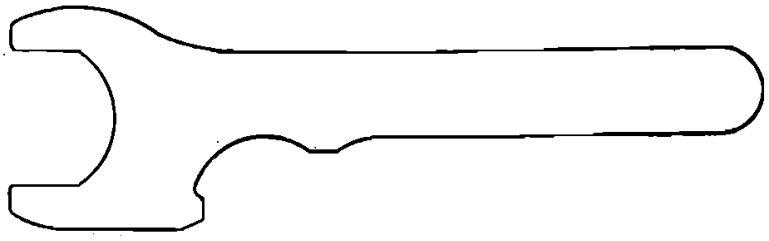


Fig. 49. Tool, Combination, Besa, 7.92 m/m., Mark II

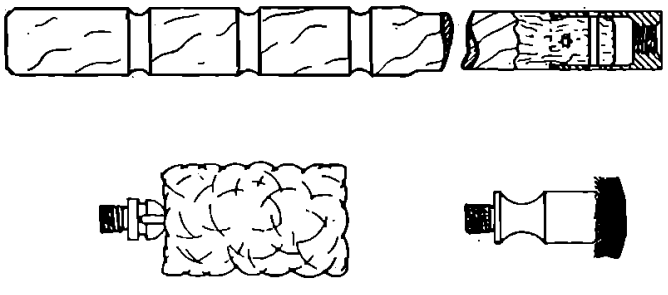


Fig. 50. Rod, Cleaning, Brush and Mop

Mop, rod, cleaning, cylinder, Bren .303 inch M.G. Mark I (see Fig. 50).
For wiping out and oiling the gas cylinder. It should be covered with flannelette when used.

Bottle, oil Mark IV or V.
For carrying graphited grease RD.1179.

Box, small parts, M.G. No. 4, Mark I.
For carriage of small spares for the gun.

CARE AND MAINTENANCE

The guns are normally kept lightly coated with oil, inside and out, but before firing, certain parts are wiped dry and others smeared with graphite grease. After firing, the guns must be stripped, thoroughly cleaned and dried. The parts must be examined visually for defects. After inspection the parts must be oiled all over and reassembled.

When guns are unlikely to be used for long periods, they must be preserved in a mixture of mineral jelly and oil to obviate frequent cleaning and inspection.

Particular care must be taken that all spare parts fit and operate properly and steps must be taken to ensure interchangeability immediately after receipt.

37 m/m Gun.

Breech fittings must be frequently taken apart and inspected, to ascertain that they are in proper working order. They must be treated with care, violence avoided and no unnecessary force employed. The threads on both the breech end of the barrel and the inside of the breech ring will be coated with graphite grease and after reassembly, a coating of graphite grease applied to the front end of the breech ring to exclude moisture.

The bore and chamber should be inspected before and after firing. Prior to firing, the bore will be wiped out to ensure it being clean and dry.

As soon after firing as practicable, strip, clean, examine and oil the working parts of the gun and mounting. The barrel should be scoured out with boiling water, to retain the highly polished surface of the bore and minimise the effects of fouling. Place a spent cartridge case in the chamber and close the breech. Elevate the gun and partially fill the barrel with boiling water. Plug the muzzle and swill the bore by repeatedly elevating and depressing the gun. Drain off the water, clear of the I.F.V. and repeat until the water, after swilling, remains clear. Soda in any form must on no account be used. Inspect the barrel for defects. Clean the bore with the bristle cleaner, dry clean and lightly oil. If the bore sweats, the procedure should be repeated daily, until sweating ceases.

Any deposit on the breech block and other parts should be removed and the parts thoroughly cleaned and oiled.

Where guns have to be kept ready for immediate action, the firing mechanism must be stripped and cleaned daily.

Guns when not actually in use, must have their covers in position.

7.92 m/m Besa B.G.

Before firing. Strip the gun (see " Stripping and Assembling," page 63). Wipe dry the outside of the barrel, cover, trigger guard ; the body and all parts forward of the baffle plates ; piston head, gas cylinder, gas regulator, breech block. Dry the bore with flannelette (4 inches by 2 inches) inserted in the loop of the cleaning rod.

Smear the following frictional surfaces *lightly* with graphite grease RD.1179 :—

Locking shoulders and frictional surfaces of the breech block.

Frictional surfaces of the piston extension.

Slides of the barrel and guides on the gun body.

Ensure the flash eliminator is properly secured and the rear baffle plate present.

Lubrication during firing. If the gun becomes sluggish, remove the breech block, feed block and belt exit guide. Wipe them as clean as possible with a dry rag, being careful to remove any accumulation of splinters from the ammunition or belts. Also wipe over any of the moving parts in the body that are accessible. Re-lubricate frictional surfaces with a thin smear of graphite grease and re-assemble the gun.

Cleaning after firing. Clean the gun as soon as possible. If it cannot be cleaned immediately, remove superficial fouling from the bore by means of a piece of dry flannelette (4 inches by 2 inches) in the loop of the cleaning rod and pushed through the muzzle end. Then oil the bore by means of another piece of flannelette (4 inches by 1½ inches) soaked in oil " A " or M.80. This should be pushed up and down the bore several times. Take out the breech block and oil its face and the point of the firing pin. At the first opportunity, dismount the gun and strip it, and continue as follows :—

Holding the barrel, muzzle downwards, by means of a piece of rag looped tightly round the breech end, pour about a gallon of boiling water through it. This will remove internal fouling. If hot water is not available, cold may be used in an emergency. Thoroughly dry the bore. Wipe out the inside of the flash eliminator and the chamber. Inspect the bore from each end in turn, holding the barrel up to the light. Look for superficial and metallic fouling, wear scoring or bulges. Note the degree of polish on the surface. Serious wear, scoring or bulges should be reported to an armourer.

Remove fouling from inside the flash eliminator with a small screwdriver, and, if necessary, clear the gas hole in the barrel with the No. 5 reamer. If it will not enter the hole, see that the barrel has not slipped back or twisted in its sleeve.

Wash the gas regulator, gas cylinder and sleeve, and the piston head in boiling water, remove fouling with an oily rag, and, if necessary clear the gas holes by means of the correct reamers.

Clean the gas regulator sleeve, its seating, the cylinder, the breech block, extractor and firing pin point with an oily rag. Scrape off fouling from the piston face with a screwdriver. Take care not to damage the front edge of the piston.

Remove fouling from the gas hole in the barrel seating (No. 7 reamer) from the axial hole leading to the gas chamber (No. 6 reamer) and, in the case of Mark II and III cylinders, the coned end of the gas chamber (No. 9 reamer). Clean the gas chamber with the cylinder cleaning brush and rod, wiping out with the mop, covered with flannelette.

Clean and wipe dry other working parts and exterior surfaces.

The following maintenance should be carried out to be constantly ready for action. Variations to suit climatic or special conditions will be made at the discretion of the Inspecting Officer.

Daily.

37 m/m Gun :—

Clean and lubricate the bore.

Clean, lubricate and operate the breech mechanism.

Check oil level of buffer, elevate gun and ascertain that it remains fully run out position.

Clean and lubricate the mounting, and operate it through the full range of elevation.

Test, clean and oil lightly, the firing gear.

Clean and lubricate the cradle and recoil system.

Traverse the turret completely, by hand.

7.92 m/m Besa M.G. :—

Strip, clean, examine and lightly oil the M.G. and M.G. cradle.

General.

Clean and examine all ammunition.

Clean and examine telescope and apply anti-dim compound if necessary.

Weekly.

Clean and lubricate 37 m/m gun semi-automatic gear, and armament mounting generally.

Test the traversing gear, the depression and elevation stops and clamping gear.

Test buffer for leakages and replenish if necessary.

Clean and check spare parts, tools and stores.

Cleaning and Lubrication under Special Conditions

Sandy or dusty conditions. As little oil as possible must be used. Clean guns frequently. Parts to be wiped with a slightly oiled rag. Under conditions where dust and sand are plentiful graphited grease should be very lightly applied at those parts where its use is specified. No oil will be used even in the absence of graphited grease. Care should be taken that all covers are properly secured and only removed when necessary.

Extreme cold or frosty conditions. Oiling should be reduced to a minimum and low, cold test oil used. Buffers must be protected as much as possible from the cold to prevent the buffer oil freezing. Should this become frozen, the gun must not be fired.

For temperatures between + 40 degrees and — 40 degrees F, thoroughly dry clean the guns and re-lubricate with low cold test oil. If the temperature drops below —40 degrees F, dilute four parts of this oil with one of paraffin. For further falls of temperature, increase the amount of paraffin. Before oil, low cold test is applied, all G.S. oil or graphited grease must be removed by means of paraffin or petrol. If low cold test is not available, leave the guns dry. If possible, keep some of the M.G. parts (breech block, return spring, return spring guide, etc.) in a warm place, *e.g.* near the engine of the A.F.V. until required. If the situation permits, fire occasional bursts to keep the M.G. warm. Avoid breathing on the guns, as breath contains moisture which will freeze on the working parts. In extremes of cold the moving parts should be operated by hand at frequent intervals. It is preferable to use no lubricant if oil, low cold test, is not available.

Damp. Routine cleaning should be carried out daily.

Heavy rain. The guns and mounting should be more heavily coated with oil than for normal conditions and covers must be properly secured. Guns should be left in depression.

Exposure to sea water. Paint external non-working parts. Put on all canvas covers securely. A small amount of Cooper's grease may be used but, it should be noted, it is not a good lubricant.

Preservation. If the guns are not to be used for several months or are to be sent away for storage or sea transport, they should be stripped, thoroughly dry cleaned and coated all over with a mixture of mineral jelly and oil " A " (or M.80) 50 ; 50 by weight.

To coat the bore of the M.G., first heat the mixture until it becomes thin, take a strip of flannelette 8 inches by 1½ inches, saturate it in the mixture and draw it through from each end in turn.

The remainder of the mixture should then be allowed to cool till fairly stiff before applying it to the rest of the gun or guns. It must be applied with pieces of flannel, *not* rags or cotton waste.

AMMUNITION

37 m/m Gun. Q.F. fixed ammunition authorized for use in the 37 m/m gun comprises both high explosive and armour piercing, practice, blank and drill ammunition are also issued (see Fig. 79, page 133).

Rounds are packed in sealed metal lined boxes containing twenty and weigh 100 lbs. when packed.

Projectiles are painted to prevent rust, and the colour identifies the type.

Armour piercing	Black
High explosive	Yellow
Practice	Blue

LUBRICANTS—37 M/M. GUN

Purpose	*Normal Conditions Temperatures above 32° F.*	*Cold Conditions Temperatures below 32° F.*	*Sub Cold Conditions Temperatures below 0° F. to —40° F.*
Buffer	M.120 (U.S. Army equivalent " Oil recoil heavy 2.96 ")	M.120	
External screw threads, etc.	Grease graphited	Grease graphited diluted with paraffin	
As a preservative generally	Mineral Jelly		
Cradle guides and gun slides	Oil M.120	Oil M.80	Oil, low cold test No. 1
Force feed lubrication	Oil C.600	Oil C.600 diluted with paraffin	Oil, low cold test No. 1
Cleaning bright parts and general purpose lubrication	Oil M.120	Oil M.120	Oil, low cold test No. 1
Breech Mechanism	Oil M.120	Oil M.120	Oil, low cold test No. 1

LUBRICANTS—7.92 M/M. BESA M.G.

Purpose	*Normal Temperature + 40° F.*	*Conditions of extreme heat*	*Conditions of extreme cold to —40° F.*
Parts and frictional surfaces	Graphited grease (RD.1179)	Graphited grease (RD.1179)	Oil, low cold test No. 1
Inaccessible parts such as pins, etc.	M.80 or Oil " A "	M.80 or Oil " A "	Oil, low cold test No. 1
In transit or out of use	M.80 or Oil " A "	M.80 or Oil " A "	
In store	Mineral jelly (mixed with Oil " A " or M.80)		

7.92 m/m Besa M.G. The 7.92 M.G. takes a rimless cartridge, comprising case, cap, charge and bullet (see Fig. 88, page 141).

The case of the cartridge is stamped with the Mark, contractor's initials, or recognised trade mark, and the last two figures of the year of manufacture. The annulus is coloured to indicate the character of the cartridge.

The following marks of cartridges are issued :—

(1) **Cartridge S.A. Ball 7.92 m/m** :—Mark IZ and Mark IIZ, annulus coloured purple.

(2) **Cartridge S.A. armour piercing 7.92 m/m** :—Mark IZ and Mark IIZ, annulus coloured green.

(3) **Cartridge S.A. Tracer 7.92 m/m** :—Mark IZ and IIZ, annulus coloured red.

(4) **Cartridge S.A. Incendiary 7.92 m/m** :—Mark I, annulus coloured blue.

(5) Blank, drill and dummy cartridges are available.

The cartridges are carried in belts holding 225 rounds, the filled belts stored in wooden boxes holding two tinned plate boxes or liners from which the gun is fed direct. Each liner holds two belts which may be loaded with ball or ball and tracer, A.P. or incendiary in a combination in definite proportions.

The boxes and liners are labelled to state the contents.

Discharger, smoke generator. The cartridge used for firing the discharger is Cartridge S.A., Rifle Grenade or Smoke Discharger, .303 inch, Ballistite, " H," Mark IZ. The smoke generator is the Generator, Smoke, No. 8, Mark IV (see Fig. 93, page 145).

Care and Preservation of Ammunition

Ammunition is not fool-proof—be careful of it. Keep it away from water, rain, damp, direct sunshine and gas, whether it is stored in the tank, or in packages. Try to avoid extreme heat or cold. Ordinary temperatures will not affect ammunition.

Load or unload ammunition in dry weather, or under cover. Loads in open vehicles and stacked ammunition, should be covered by tarpaulin. If your ammunition package has been exposed to wet in transit, make sure there is no water inside. If so, dry the contents of the package and carefully repack.

Don't throw packages about.

Always stack ammunition under cover, and provide for a free circulation of air. If possible stack ammunition packages on battens. Keep them 12 inches clear of walls, and leave passages of at least 18 inches between stacks. Maximum height of stacks allowed is 12 feet. Try and keep one end of each package visible.

Always see that the round is clean, dry and free from oil, before firing.

On receipt of ammunition, examine all labels carefully to see that the ammunition is suitable and sort it into kinds if there are several in the consignment. Look for broken seals, open any boxes which appear to have been tampered with, and ensure that the contents correspond with the labels and are still serviceable.

Ready-use Ammunition. The amount of ammunition opened for ready use should be kept to a minimum. The opening of sealed liners should be deferred till the last possible moment, as they cannot be re-sealed. Ready-use ammunition must be inspected daily by an officer. If possible, it should be periodically " turned-over " ; by expenditure for training. Do not oil ready-use ammunition as this leads to the accumulation of dust.

Damaged Ammunition. Damaged or faulty ammunition should be returned immediately in its original boxes, care being taken to see that the labels are not missing, as these are the means of tracing faulty batches to their source. If ammunition has to be returned in boxes other than the originals, the labels must be altered to correspond with the contents. Reports of faulty ammunition must always be accompanied by an extract from the box labels giving the batch dates of the cartridges.

Ammunition Salvage. Fired cases, spent belts, felt strips and packing pieces, empty liners and boxes are all required as salvage and must be returned whenever circumstances permit. Live rounds must be separated from empty cases. If conditions do not permit sorting, the boxes of empties should be conspicuously labelled to indicate that rounds are present.

Don't—

Hammer or tap packing cases containing ammunition.

Tamper with a round.

Use live rounds for drill purposes.

Have rusty rounds.

TESTING, ADJUSTING AND CARE OF SIGHTING TELESCOPES

Upon the correct adjustment of sights depends the effectiveness of fire and frequent testing of sights is of great importance.

Sights should be tested after removal and re-insertion in the mounting before firing and especially after firing or travelling, when shocks and vibration may have disturbed the telescope.

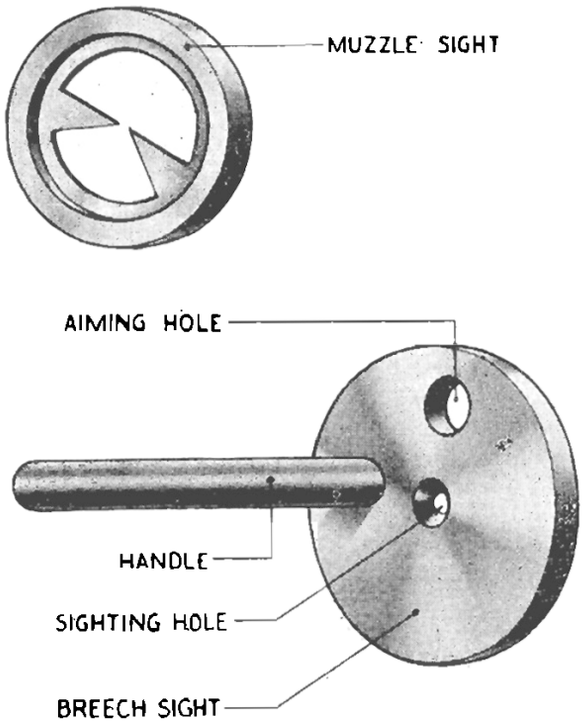


Fig. 51. Bore Sight 37 m/m. Gun

Testing and adjusting.

The distant object method of testing should be used if possible. Select a well defined object, approximately 1,000 yards distant, on which to lay the gun. Place the bore sights (see Fig. 51), *i.e.*, the muzzle sight and breech sight issued with the 37 m/m gun, in the bore of the gun after opening breech. In the absence of bore sights fix fine wires horizontally and vertically across the front face of the muzzle of the gun in the four axis lines marked and remove the firing pin and guide assembly.

Remove the breech block and accelerator (if fitted) from the Besa M.G. in order to give a clear view through the bore of the barrel from the sight hole at the rear of the body.

Align the bore of the 37 m/m gun on the distant object, using the bore sights or the inter-section of the cross-wires as a foresight, and the central aperture in the breech sight or the firing hole bush as a backsight, and lock the mounting in position. Movement of the eye whilst sighting must be avoided. The eye should be drawn back as far as possible from the sight holes without losing sight of the aiming mark.

If the mounting is correct the M.G. should lay on the object when using the sighting hole and the bore of the barrel. If deviation is present the co-axial mounting should be referred to an armourer for adjustment.

It is essential that the sights should be taken exactly in the centre of the bore. Considerable errors will arise if the eye is not in the line of the axis.

Movement of the gun after alignment of the axis and prior to completion of the test will negative the result. Such movement may be produced by movement of the tank as a whole, jolting of the gun or rocking, or rotation of the turret in any way.

The tests made should be repeated, by the same man, to ensure correct alignment.

Adjustment of No. 30 Mark I and Mark I A. The line of sight through the intersection of the vertical and horizontal cross-lines in the telescope should be on the same spot of the distant object

as the gun. If not, the telescope must be collimated by slightly withdrawing the telescope from the mounting, removing the erecting lens cover and operating the eccentrics by means of a pair of erector lens adjusting tools (see Plate 20, page 147).

It is essential that the erecting lens cover be replaced after collimation adjustment is completed because the collimation setting is locked by means of springs carried on the cover.

From time to time a film of G.S. grease should be applied to the cover to ensure that it is waterproof.

Adjustment of No. 33 Mark II. The line of sight through the intersection of the vertical cross-line seen in the telescope and the zero line (*i.e.* the short line immediately above the horizontal cross line) should be on the same spot of the distant object as the 37 m/m gun. If this is not so the telescope must be collimated by first slackening the four antagonistic adjusting screws and then positioning the requisite adjusting screw or screws until correct alignment is obtained. Tighten all adjusting screws after the correct setting has been obtained.

Care and Preservation of Telescopes

A telescope, when issued, is in correct optical adjustment, watertight and with cells secured by fixing screws. It must not be taken apart unless necessary, and then only by a qualified artificer, after which it must be carefully re-assembled and adjusted.

All metal parts are to be kept clean with a soft cloth. If very dirty, turpentine or paraffin may be used on the cloth, but abrasives such as emery or bath-brick are not be to used.

The telescope holder must be carefully protected. Any burrs or damage to the bearing surfaces will throw the telescope out of alignment.

The object glass and eye lens should be cleaned periodically with a piece of dry clean linen, used only for the purpose.

Telescopes should be kept in a dry place.

The rubber eye guards should not be exposed to extreme temperatures, contact with oil or grease or prolonged contact with petrol. Should oil or grease come in contact, it should be removed with the eye guard washed in clean warm water with a little soap. Rinse in clean water. Spare eye guards should be stored in french chalk in such a way that they are not distorted.

If vision through a telescope is impaired by mist, rain or dust, the eye lens should be cleaned and anti-dim applied as lightly as possible. If this is not satisfactory, remove the telescope from the mounting bracket, clean the object glass protector and apply anti-dim.

If after fire, the vision is impaired, it is probable that the object glass protector has been damaged by splash. Change the protector ; spares are carried in the A.F.V.

In dusty or sandy conditions, a greasy wad plugged into the aperture in the mantlet will give protection to the telescope when not in actual use.

REMOVING AND REPLACING GUNS

To replace 7.92 Besa Gun. Slacken the clamping strip retaining bolt with the spanner attached to the mounting and turn the recoil bolt until the flat on its diameter is uppermost. *Push forward the trigger guard body*, slide the gun into the cradle and secure it by turning the recoil bolt. Bring the trigger guard body to the rear and lock the gun by tightening down the clamping strip. Keep the spanner in the clip provided, when not in use.

To connect the remote control firing gear, pull out the plunger and push the slide into the guide on the right side of the gun. Release the plunger, which will locate the slide, and tighten the securing screw.

To remove the gun, reverse the procedure.

To remove and replace the 37 m/m gun. The work entailed in removing and replacing the 37 m/m gun from and in the turret must be supervised by a gun fitter.

The sequence of operations to be followed :—

1. See that the guns are unloaded.
2. Remove telescope and Besa Guns.
3. Rotate turret to bring gun into a rearwardly direct position.
4. Remove ammunition rack from centre platform (5 bolts).
5. Remove cartridge case bins which are bolted as a single component to the platform (3 bolts).
6. Remove ammunition rack support (2 bolts). (The lower bolts are inaccessible until the bins (operation " 5 ") have been removed).
7. Remove the rear support which connects platform to turret by taking out the hinge bolts at the top and bottom of the support.
8. Remove deflector (4 bolts).
9. Remove firing gear bracket.
10. Remove M.G. belt guide (4 C'sk screws).
11. Remove M.G. belt box carrier. (Two of the four fixing bolts have distance pieces).
12. Remove cam plate and slide out to rear, freeing the roller by opening the breech.
13. Strip breech mechanism.
14. Remove barrel nut, after slackening the two grub screws.
15. Remove recoil bolt.
16. Introduce a wedge between sleigh and barrel protector to maintain sleigh in its forward position and pull back gun sufficiently to enable breech ring to be rotated.
17. Remove retaining screw and breech ring locking piece, then unscrew breech ring from barrel. The threads at the breech end of the barrel should be wrapped in a piece of sacking or other suitable material for protection.
18. Lock the mounting at full elevation by means of the elevation lock, taking care that the barrel does not slide back out of control.
19. One man should take up a position in the driver's seat and the gun slid back from the mounting to the right, the man taking the weight of the breech end.
20. Lower muzzle of gun clear of mounting and pass, muzzle first, through the escape door in the side of vehicle.
21. To replace reverse the sequence of operations.

PREPARATION FOR BATTLE

When ordered to prepare for battle remember that the following essential steps must be taken. Preparedness may have been impaired by a long approach march or in some other way.

Remove any obstruction likely to affect the traverse of the turret.

Test the traversing gear by hand.

Ensure that the ammunition and equipment stowed in the hull and fighting chamber have remained in the proper places. Such obstruction may effect the rotation of the turret.

Remove the breech and muzzle covers and see that the flash eliminators are secure.

Lower and lock the deflector and see that the chute is correctly fitted.

Test breech and firing mechanism of the 37 m/m gun.

Ensure that the M.G. is locked in its cradle and that the deflector chute is fitted.

Test the firing mechanism of M.G.

Adjust the seats and test intercommunication apparatus.

Load the guns.

During battle. Should the gun feel uncontrollable during firing, it may be due to the weight of the spent cartridge cases in the chute. Shake the chute and scatter the cases.

During a lull in action. If the traverse has failed, look for obstructions.

Remedy, if within the scope of the crew, any faults observed during firing.

Open the breech of the 37 m/m and clean the chamber. This can be done with a cloth wrapped round a stick.

Lubricate the working parts of the guns and mounting.

Rearrange disposition of the ammunition within easy reach of the loader.

Empty the chutes and clear the floor of spent cartridge cases.

Ensure that the M.G. is secure in its cradle.

If the action of the M.G. during firing has been violent or intermittent, adjust the gas regulator.

After battle. Unload the guns.

Dry clean and oil the chamber and bore of the 37 m/m gun. Oil the face of the breech block.

Oil the bore, face of the breech block and firing pin of the M.G.

DISABLEMENT OF GUNS

To prevent the enemy using the guns, armament should be disabled by removing certain parts or damaging the guns permanently.

The first method enables the guns to be brought into action again if the opportunity is offered, but where more than one gun is being disabled, the same parts must be removed from each to prevent the assembling of a complete gun from parts of another.

Essential parts to be removed.

The telescopes, and spares of the 37 m/m gun.

The breech block and spares box of the M.G.

Permanent damage to the guns. Load the gun and place a heavy metal object, *e.g.* hammerhead or crowbar down the bore, with stones and earth. Drain the buffer and fire the gun from a distance.

The M.G. must, whenever possible, be removed from its mounting together with spares and ammunition, so that the crew can fight a dismounted action. If this is impossible, all working parts and spares will be removed and the gun damaged with a hammer or crowbar.

Optical instruments must always be taken when A.F.V. is abandoned as they are difficult to replace.

CHAPTER X A

Gun Mounting, Operation and Maintenance

The main armament is fitted in the mounting, 37 m/m and Med. Besa M.G. No. 1 Mk. I the nomenclature, showing the mark and the serial number of the mounting is given on an inscription plate secured to the side of the 37 m/m gun cradle. This information must always be quoted in any written reference to the mounting for instance, when ordering spares.

The mounting is of the free elevation type being elevated or depressed by pressure on a shoulder piece, traverse of the armament is effected by rotating the turret. The firing gear for both guns is remote controlled from pistol grips and the telescope used is the No. 30 sighting telescope. The recoil system is of the fluid buffer type including a recuperator spring and has a movement of approximately eight inches. The semi-automatic gear is attached to the right hand side of the 37 m/m gun cradle.

Adjustment.

Firing gears. Test the firing gears of each gun before firing, the cables may have stretched or their means of attachment worked loose causing lost motion.

37 m/m Gun. The firing control rod should just bear against the firing trigger of the gun. If the pressure is too heavy the gun may be fired as the breech block closes. Before testing the firing gear *first see that the gun is unloaded* then cock the firing mechanism and squeeze the trigger at the pistol grip. If the firing pin is not released adjustment is necessary.

To adjust. Cock the firing mechanism, loosen the lock nut abutting the fork end connecting the control rod to the bell crank, lengthen or shorten the effective length of the control rod by screwing it out of or into the fork end until the requisite adjustment has been made, tighten lock nut.

Adjustment can also be effected by altering the length of the cable at the pistol grip end, make sure to tighten lock nuts after adjustment.

7.92 m/m M.G. The operating arm of the remote firing gear should just bear against the trigger shaft when the trigger guard body is to the rear. Should the pressure be too great the cocking catch may not function or a " run away " gun result. *When testing see that the gun is unloaded,* correctly mounted and that the safety catch, if fitted, is set at " off." Cock the gun and squeeze the trigger, if the gun cannot be cocked or fired adjustment is necessary.

To adjust. Slacken the lock nut of the cable connector at the upper part of the firing control assembly and adjust until the operating arm is just bearing on the trigger shaft. Tighten lock nut and test.

The pistol grip can be rotated to suit the gunner after releasing clamping bolt.

The shoulder-piece can be adjusted by loosening the clamping nuts and manipulating to fit the individual gunner. Ensure that the clamping nuts are tightened after adjustment as the shoulder piece takes some pressure during operation of the mounting.

The browpad must be adjusted to give the gunner an unrestricted view through the telescope. Distance between browpad and eyepiece is altered by adjustment of the browpad arm in its clamp and the browpad can be fitted to the forehead by adjusting the position of the wiring nut by which it is secured. If the shape of the browpad is unsuitable this can be altered by the use of packing introduced under the pad or coat.

Recoil System

Filling recoil cylinder. The recoil cylinder must be kept filled in accordance with the following instructions or damage to the gun will probably result. The proper grade of oil for the recoil cylinder-oil, recoil, heavy, equivalent (M120) must be used. The substitution of any oil other than that issued is prohibited.

In no circumstances use fuel oils such as petrol, or illuminating oil such as paraffin or kerosine.

Alternative liquid may cause damage to the buffer. Every effort should, therefore, be made to obtain the correct oil as soon as possible to replace it.

Only clean liquid may be used. Before any is put into the buffer it should be strained, as it is of utmost importance that the oil should be clean and free of foreign matter.

Oil emptied from buffers must not be re-used except in an emergency.

The amount of oil in the recoil cylinder should be such that the movement of the gun in recoil is smooth and of uniformly decreasing velocity, and the maximum point of recoil is reached without shock ; the recuperator strings will then return the gun without shock. Too rapid recoil, and shock at the end of the recoil is usually caused by too little oil in the recoil cylinder or may be due to lack of lubrication or the presence of foreign matter on the guides or rails.

To fill the recoil cylinder proceed as follows :—

1. Elevate the barrel slightly.
2. Fill the oil gun with oil. When filling, keep the nozzle well under the surface of the oil supply to avoid drawing in air. After filling, point the nozzle upwards, push the piston until the oil starts to flow in order to force out any air in the oil gun.
3. Remove the front (filler) plug and screw the nozzle of the oil gun into position in its stead, keeping a slight pressure on the oil gun piston as the oil gun is being seated.
4. Remove the rear plug in the right side of the recoil cylinder.
5. Introduce the oil into the recoil cylinder by slowly pushing on the piston of the oil gun until the oil flows out of the rear hole.
6. Fully depress the barrel and continue to slowly force oil through the cylinder and out of the rear hole until no more bubbles emerge with the oil.
7. Screw in the rear plug tightly.
8. Fully elevate the barrel, unscrew the oil gun, and replace the front plug.

The filling of the recoil mechanism should be carefully done to ensure that all air has been " bled off " and that the mechanism is completely full. The presence of air can be detected by " air bubbles " appearing in the oil. After completing the above filling process, it is sometimes found necessary to drain off a small amount of oil from the recoil cylinder. This establishes a " void " which compensates for an expansion of the oil during firing. If draining is found necessary, elevate the muzzle slightly and unscrew the rear filler plug sufficiently to permit about one tablespoonful of oil to flow out. The amount of oil in the mechanism should be such that the gun returns completely and does not end the action of recoil with any appreciable jar.

Excess oil used during filling should be caught in a clean receptable and must be strained through a clean cloth before being used again.

SECTION "B"

DETAILED DESCRIPTION OF UNITS AND EQUIPMENT

CHAPTER I B

Engine—Detailed Description

Before describing the actual unit employed, it would be desirable to understand what are the demands made on the engine while the car is running.

As the car travels at varying speeds up or down hill or on the level, the load on the engine is constantly fluctuating between the maximum required for starting or climbing a hill and a much reduced loading when running on a level road. The car speed depends on the power of the engine and the magnitude of the driving force exerted by the tyres on the road. This force is proportional to the turning effort—or torque as it is usually termed—exerted by the crankshaft of the engine as a result of the explosion of a mixture of petrol and air in the engine cylinders, and the turning effort (torque) is dependent on the horse power and speed of the engine. These quantities—power, speed and torque —are all related, and in any engine there is one speed at which the torque or turning effort reaches a maximum and another and higher speed at which the maximum horse-power is developed. Over the speed range between these two points the torque is falling while the horse-power is rising. If the torque is fairly constant throughout the ordinary speed range the engine is said to be " flexible," that is to say the car will adapt itself readily to the different conditions encountered on the road and will respond readily to the controls. When the torque reaches its maximum the car can exert its greatest driving force, as in hill climbing, and when the horse-power is at its maximum the car will attain its highest speed under any particular conditions of road and wind resistance.

The maximum engine torque must be augmented to provide sufficient driving force to enable steep gradients to be climbed, or for operation under exceptionally severe conditions. Just as a force can be increased by applying a lever, so can the driving force at the road wheels, which is derived from the engine torque, be increased by speed reduction gearing, and this is the function of the gear box and driving axles. It should be clearly understood that this increase of driving force is not an increase of power, which is actually reduced due to frictional losses in gears and bearings, but it is an increase of driving force at the expense of speed.

The engine used in this vehicle is a six cylinder side valve unit fitted at the rear of the chassis and it has a bore of 85 m/m (nominal) and a stroke of 120 m/m.

The crankcase and cylinders are a one-piece casting, the lower half being heavily ribbed to provide housings for the crank-shaft main bearings and prevent distortion.

The cylinder bores, instead of being equidistant from each other, are located in pairs, the two bores of the pair have a common cylinder wall, *i.e.* there is no water space between them. This method of location reduces the overall length of the cylinder block while still permitting unrestricted cooling water flow from the block to the cylinder head.

The crankshaft is counterweighted and balanced under stationary and running conditions. Three balance weights are bolted to the crankshaft webs between Nos. 1 and 2, Nos. 3 and 4 and Nos. 5 and 6 crankpins. The effect is to eliminate crankshaft whip, so that the loads on the main bearings are evenly distributed over their entire surface areas and the tendency for such bearings to wear bell mouthed is counteracted.

The main bearings, of which there are four, are detachable steel backed white metal shell type, constructed in two halves and held in position on the journals by the main bearing housings and caps. Small tags on the edge of the bearings fit into recesses machined in the joint between the bearing cap and housing, to prevent rotation. End thrust is taken on steel backed white metal washers fitted on each side of the rear main bearing, the lower half being dowelled to the bearing cap.

The clutch end of the crankshaft incorporates an oil return scroll, and a flange machined to receive the flywheel and the gearbox primary shaft spigot ball race. The other end of the shaft is tapped for the starting handle dog nut ; a long keyway accommodates the key driving the timing sprocket and fan pulley.

The connecting rods are of " H " section and the big ends are split to facilitate assembly to the crankshaft. The bearing caps are secured to the connecting rods by special bolts and nuts, although an alternative design, incorporating studs instead of separate bolts, is also used.

The big end bearings are of white metal, run directly into the rod and cap, the whole being accurately reamered to form a bearing surface.

An oil way is drilled up the centre of each rod, from the big end to the small end bush, to lubricate the gudgeon pin. A small hole is also drilled in a boss on each big end to provide an oil spray for the cylinder walls. Each small end bush is of bronze, pressed into the rod and suitably grooved for gudgeon pin lubrication.

Due to the method of arranging bores, mentioned above, the connecting rods are offset in relation to the big end, one type fitting Nos. 1, 3 and 5, and the other Nos. 2, 4 and 6 cylinders.

The pistons are of aluminium alloy with a " T " shaped slot cut in the non-thrust (*i.e.* camshaft) side of the skirt to compensate for irregularities in expansion.

The gudgeon pins are fully floating and, to prevent contact with the cylinder walls, are positioned by circlips at each end.

The cylinder head is detachable and is secured to the cylinder block by 22 studs and nuts, a copper and asbestos gasket being used to seal the joint. The lower face of the head is shaped to provide the combustion spaces for the cylinders. The cylinder head also embodies passages for the flow of coolant (a word used to describe the cooling medium, which in this case is water or an anti-freeze solution), to the outlet pipe leading to the radiator.

Internally the cylinder head is provided with stiffening webs to prevent distortion, while externally it is fitted with a steam release pipe, a pressure release valve and thermostat.

The camshaft runs parallel to the crankshaft on the manifold side of the crankcase and is driven by a roller chain fitting over the crankshaft and camshaft sprockets. The latter is secured by a key, a setscrew and a locking washer and nut.

Four white metal bearings are located in the cylinder block by dimples and carry the camshaft. Lubrication is direct from the main bearing oil ways. End thrust is provided for by a plate fitted between the camshaft sprocket and the camshaft itself.

In the centre of the shaft is a spiral gear, driving the oil pump and distributor through a similar spiral gear fitted to a diagonally placed shaft. An eccentric is provided to operate the petrol pump.

The timing chain tensioner consists of a wide steel blade spring carried by a shoe which is hinged at its foot, this is caused to swing towards the chain by means of a toggle link, the ball end of which rests in a short spring loaded piston.

The pressure of the blade spring is sufficient to follow up and tension the chain and the toggle device ensures that the necessary pressure is available automatically to eliminate chain thrash.

A cover, enclosing the timing chain is secured to the cylinder block by bolts, an oil seal of the spring loaded leather type being fitted to prevent leakage along the hub of the fan pulley.

The tappets, which are hollow cylinders, are supported in guides cast in with the inner wall of the valve chest, and follow the cam contours as the camshaft rotates, thus providing the " lift " to open the valves.

The tappets are slotted to permit adequate lubrication from the oil gallery forming the base of the valve chest. Each tappet is fitted with a screw and locknut to permit adjustment of valve and tappet clearance.

The valves which are arranged in a line immediately above the camshaft and tappets, operate in guides pressed into the cylinder casting.

Each valve is positioned by two " nested " springs, compressed between the top of the valve chest and a collar fitted round the valve stem. This collar is located on the valve stem by conical cotters, fitting in suitable recesses in the collars and valve stem.

Induction and exhaust manifolds. Both are secured on the valve chest side of the cylinder block.

The induction manifold has three branches, each mating with ports in the cylinder block and supplying two cylinders.

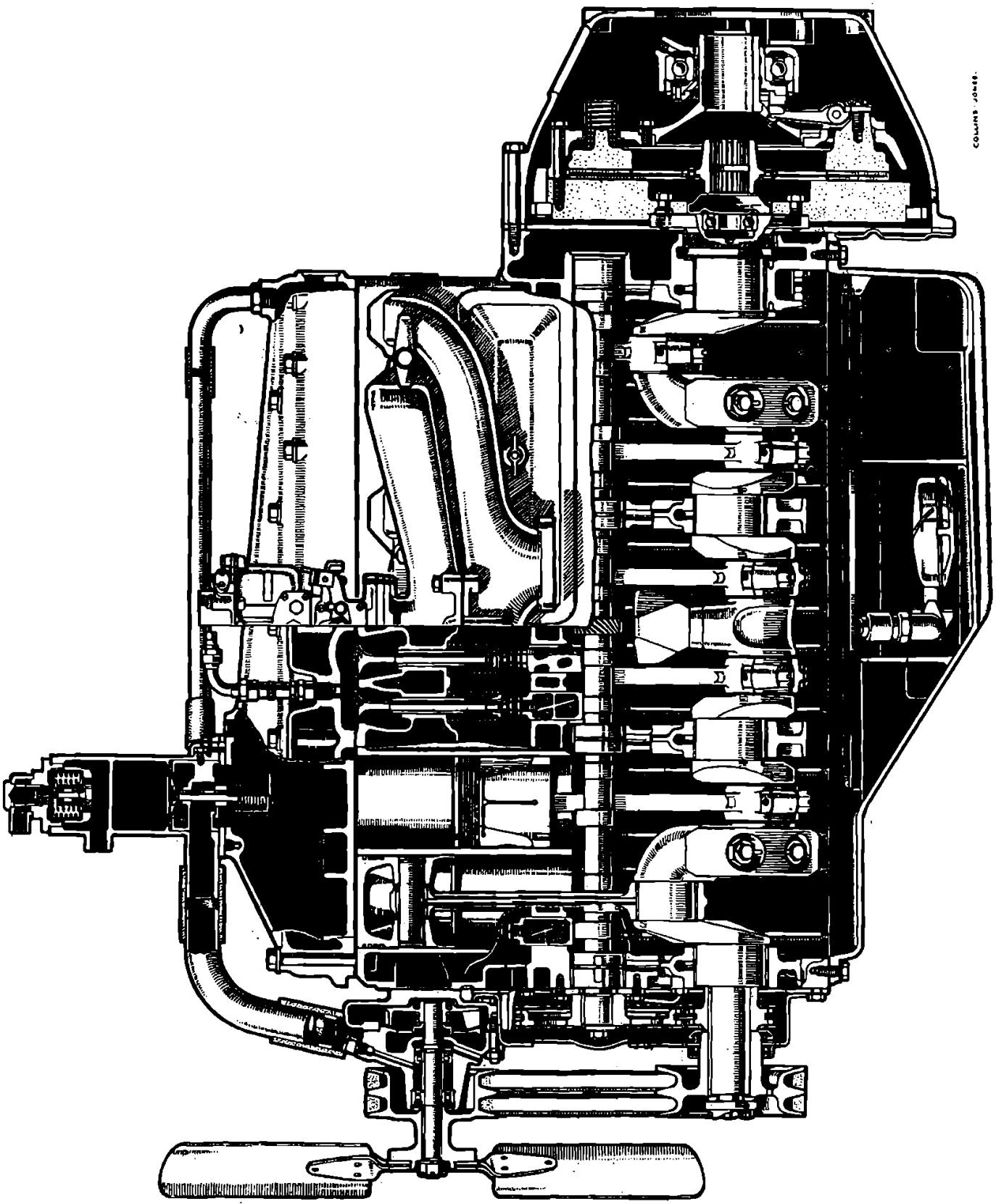


Plate 7. Engine—Longitudinal Section

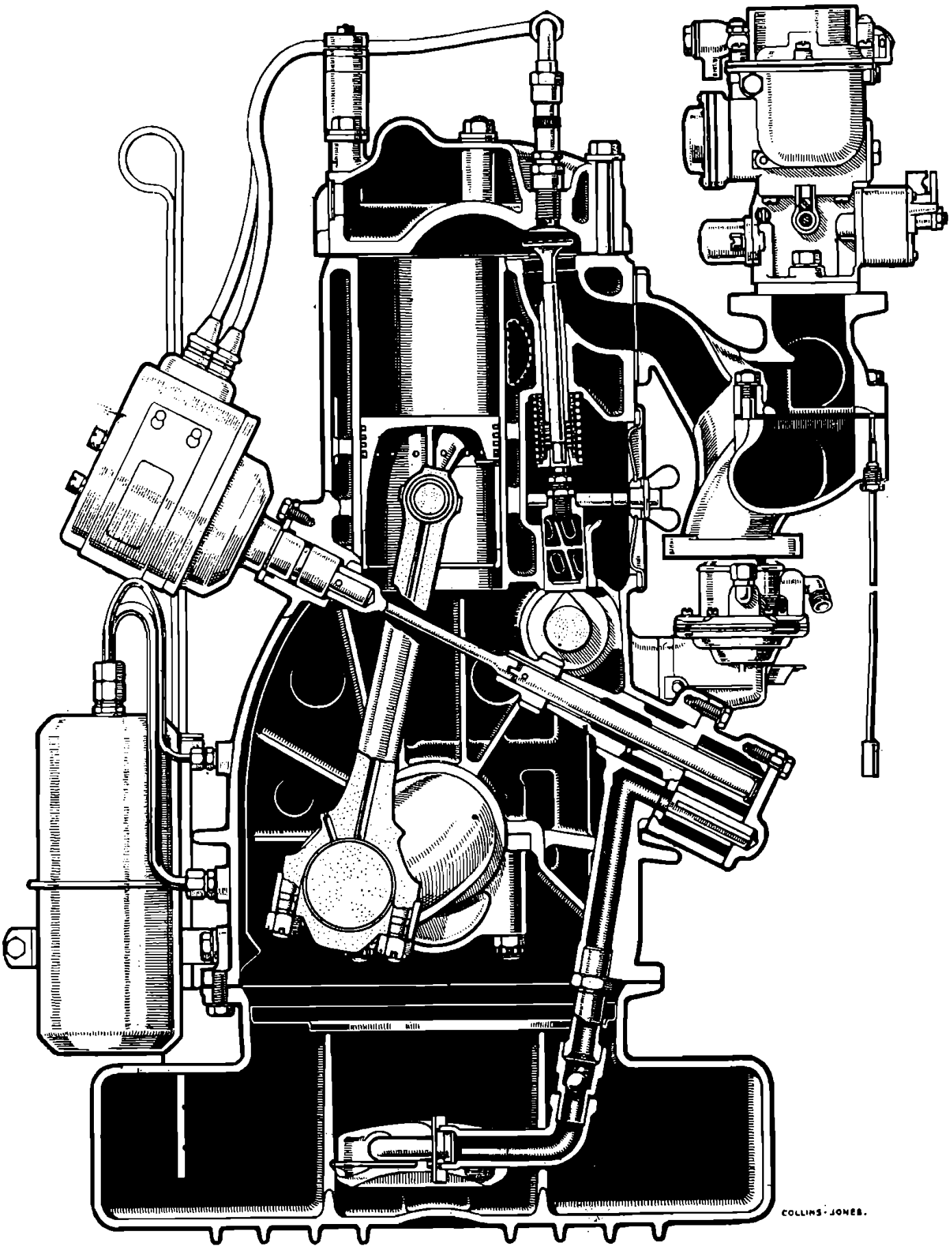


Plate 8. Engine—Cross Section

The carburettor is mounted on a flange immediately above the point where the three branches meet and this point is separated from direct communication with the exhaust manifold only by a copper plate, so that a hot spot is provided upon which the incoming petrol/air mixture impinges before passing to the branch pipes. Contact with this hot spot ensures complete vaporisation of the particles of petrol before the mixture enters the cylinders, a factor which improves both petrol consumption and performance.

PART 1. CARBURETTOR

The down-draught dustproof carburettor fitted to the engine incorporates a governor and an economy device, together with a special starting device for extremely low temperatures. There are two float chambers with an inter-communicating channel between them and the main jet connects with the centre of this channel.

In Fig. 52 the communicating channel (J) is shown together with the two float chambers (F) and in Fig. 53 it will be seen that there is one needle valve (P) only, which is of standard design with swivelling union (U) and filter gauze (Z).

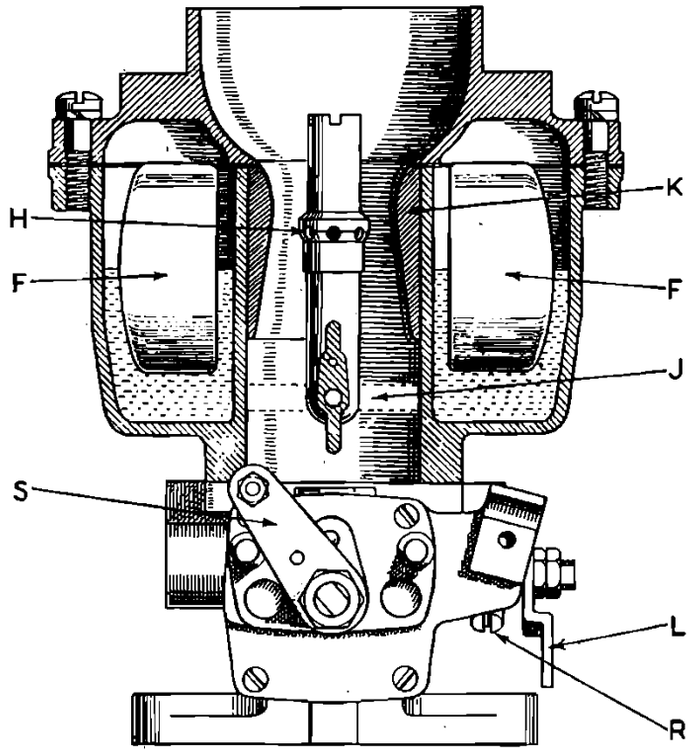


Figure 52. Carburettor Float Chambers

This does not bear directly upon the float itself, but on the lever (F1) attached to a spindle to which a similar lever over the other float is also anchored, so that both operate in unison. This ensures constant fuel supply regardless of gradient.

The main jet (G Fig. 54) is fed from the float chamber, and from this main jet petrol passes to the drilled emulsion tube (s), where it meets the air entering from the correction jet (a) and the mixture then passes outwards via the six holes in the emulsion tube into the annulus represented by the space between the emulsion tube and the wall of the petrol well. From here it travels vertically upwards, finally passing out through the row of six radial holes (H) into the choke tube waist, where it meets the main high velocity air current, and is atomised thereby.

The pilot jet (g) is supplied from the emulsion tube well via a small channel. The jet meters the mixture and passes it vertically downwards to the outlet on the left-hand side of the throttle where it is controlled by the volume screw (W).

To comprehend the functioning of the economy device refer to Fig. 54 where there will be seen an assembly consisting of a chamber (e) occupied by a spring (J) compressed between the wall and a set of diaphragms (M) through the centres of which, and fixed thereto, passes a shaft terminating in a valve (PV).

At the bottom of the chamber (e) a channel leads to an orifice on the engine side of the throttle which will obviously be under depression when the throttle is closed, and the engine is turned over.

In these circumstances, suction is transmitted to (e) with the result that the diaphragms are drawn to the left against the pressure of the spring, the valve (PV) seating itself.

As the throttle is opened the depression on the sub-throttle opening is relieved, and consequently, the suction in the chamber (e), and the diaphragms are moved to the right by the pressure of the spring.

In the meantime, petrol has passed via the channel (V) filling the chamber (f), so that the thrust of the diaphragms to the right, and the simultaneous lifting of the valve (PV) from its seating ejects the petrol from (f) displacing a similar quantity from the area (PW). Incidentally, it will be noted that a ball in the channel (V) is, under pressure, forced into the hole at the right of it, thus preventing the return of the petrol to the float chamber (not shown in the sketch).

The petrol dislodged from the area (PW) travels along a channel and an injection tube until it is ejected from (f) and so the petrol output for acceleration independent of the main spraying assembly is provided.

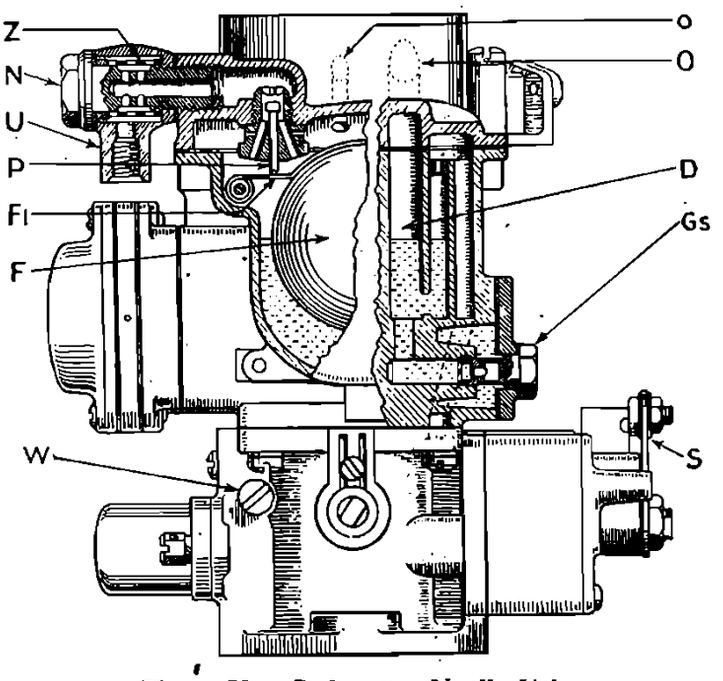


Figure 53. Carburettor Needle Valve

There is, however, another function to this device for the injection tube is situated in the choke tube and points downwards alongside the main spraying assembly.

At major throttle openings, it is subject to depression under the influence of the air passing at high velocity down the choke tube.

Thus, the petrol rising to the level in the capacity tube when the valve (PV) is no longer on its seating, is then lifted, and emerges from the end of the injection tube and thus gives a supplementary supply of fuel for high speeds. The capacity tube to which reference is made, is calibrated at the bottom and so controls the output of petrol for high speed performance.

From the foregoing it will be evident that at ordinary speeds the valve (PV) is seated and no petrol will issue from the chamber (f) and that suction on the end of the injection tube will be insufficient to lift the petrol out of the capacity tube. Therefore, the petrol output is supplemented when required for both acceleration and high speed, but the spraying mixture is reduced in strength when extra performance is not required.

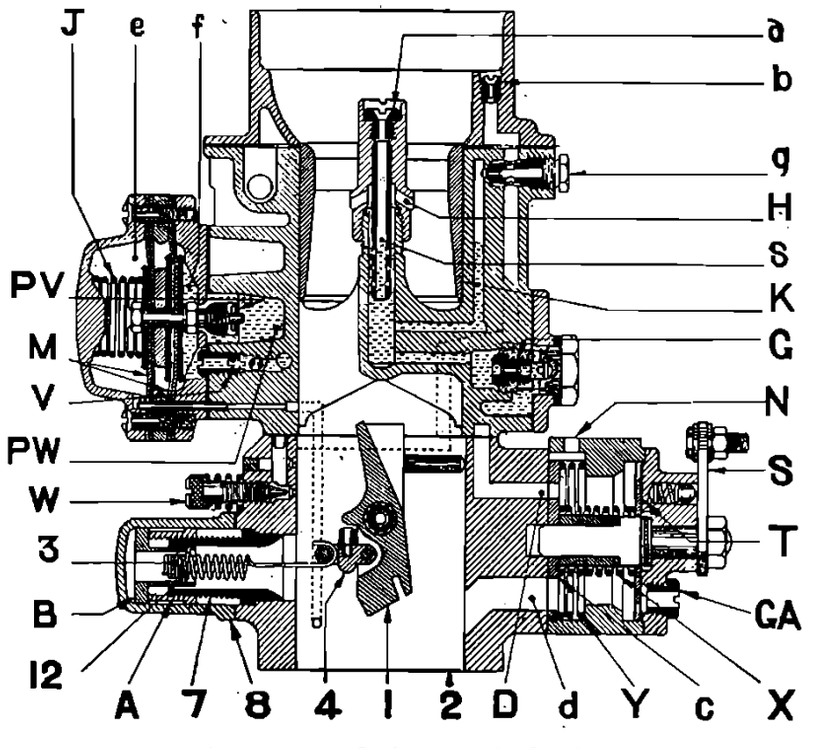


Figure 54. Carburettor in Section

The "Self-Starter" device is shown at the bottom right hand of Figure 54 and reference to this will show that two discs (c) and (T) are mounted on an operating spindle, the rotation of which is controlled by the lever (S). The inner and larger spring (Y) holds the inner disc in hermetic contact with the carburettor face, drilled with a hole (D) through which the fuel enters the mixing chamber of the starting device, and two holes (d) (only one of which is shown) to admit the starting mixture to the induction pipe.

The disc (c) is suitably drilled with holes, so that when the lever is operated to put the starter into action they register with the channels (D) and (d).

A petrol jet (Gs, Fig. 53) controls the supply of petrol to the mixing chamber.

On the right, outer disc (T, Fig. 54) is also in spring-loaded hermetic contact with the opposite wall of the mixing chamber, the air supply to which is controlled by two air jets (GA), one of which is shown. In this particular case actual air jets are not fitted. The carburettor has been specially built and the air volume is calibrated by fixed holes in the casting.

The disc (T) is capable of appreciable lateral movement along the spindle and is controlled by the strength of the spring (X).

It is also drilled with suitably positioned holes to correspond with the (GA) air jet openings when the lever is rotated.

On starting from cold in *normal* weather the dashboard knob is pulled out to its first stop. This in turn pulls the lever (S) half-way over its arc of travel to a point located by the spring-loaded steel ball which registers with a small hole in the starting lever, so positioning it for normal weather conditions, including ordinary light morning frost.

Thus positioned, a hole of suitable size in disc (c) registers with the channel (D) and the holes in the disc (T) register with the (GA) air jets.

Thus a mixture of approximately 10 : 1 air-petrol ratio is obtained for easy starting.

After the initial start is effected, the richness of the mixture automatically decreases, as with rising engine speed a progressively increased quantity of air is inspired, whereas the flow of petrol by virtue of gravity through the petrol jet (Gs, Fig. 53) remains constant as governed by the size of the jet.

For *severe frost* conditions, the dashboard control knob is pulled out to the first stop, turned half left and pulled again. This operation takes the lever (S, Fig. 54) to the full limit of its travel.

In this case, the disc (c) rotates to bring in line with the channel (D) a hole which is of a larger size, enabling petrol to the full capacity of the (Gs, Fig. 53) petrol jet calibration to enter the mixing chamber. At the same time, disc (T, Fig. 54) presents a blank face to the (GA) air jet orifices, thus closing off all air from this source.

Immediately the engine fires, however, the suction in the inter-disc space (*i.e.* mixing chamber) pulls the outer disc (T) off its seating to an extent controlled by the strength of the spring (X), air at once enters via the (GA) air jet openings and the mixture is progressively weakened as engine speed rises.

The initial mixture strength is approximately in the ratio of 1 : 1 air-petrol, so it will be obvious that in this case particularly, the dashboard control *must be pushed back to normal position, and to the original position, as soon as possible.*

The governor is shown on the cross section Fig. 54 and the exploded view Fig. 55. It operates on the velocity principle, the closing of the throttle sufficiently to remain constant being accomplished by velocity of the ingoing air stream taking effect on the inclined face of the butterfly type of throttle.

It will be seen that the throttle is mounted eccentrically on the spindle, *i.e.* the " tail," or lower half, is shorter than the " head." Thus air pressure on the head has the closing effect mentioned.

Resisting the closing effort is a coil spring (3) anchored to the throttle. Since the pressure of the air charge on the throttle increases as the engine speed rises, it will be clear that by adjusting the pull of the spring to any required tension, the throttle will start to close when the pressure of the air charge and, therefore, the engine revolutions reaches an equivalent value.

In order that the throttle shall be properly sensitive to opposing forces of air pressure and spring tension, it floats on a hardened and ground spindle on needle-roller bearings. The spindle, in turn, operates in substantial bronze bearings with full provision for taking end thrust. It is coupled to the accelerator in the usual way, but the throttle is free to rotate on it independently. This free movement is limited by a simple drive, of dog formation, which ensures that the throttle is always positively closed by the dog when the accelerator pedal is released, but opens again automatically when the pedal is again moved.

Sufficient lost motion is allowed for throttle movement on the spindle during governing, so that the governor will operate freely, controlled only by the speed of the engine even should the pedal be kept right down.

The outer anchorage of spring (3) consists of a steel peg (12) housed in a sleeve (B) and passing through the spring coils. The sleeve itself has no lateral fixing device, but the inner face of its hexagon abuts against the outer end of the tension nut (A), as shown on the cross-sectional view. This member is threaded and screws on to the housing (7). By screwing (A) out or in, therefore, sleeve (B) will also move with it, and increase or decrease, as the case may be, the tension of the spring.

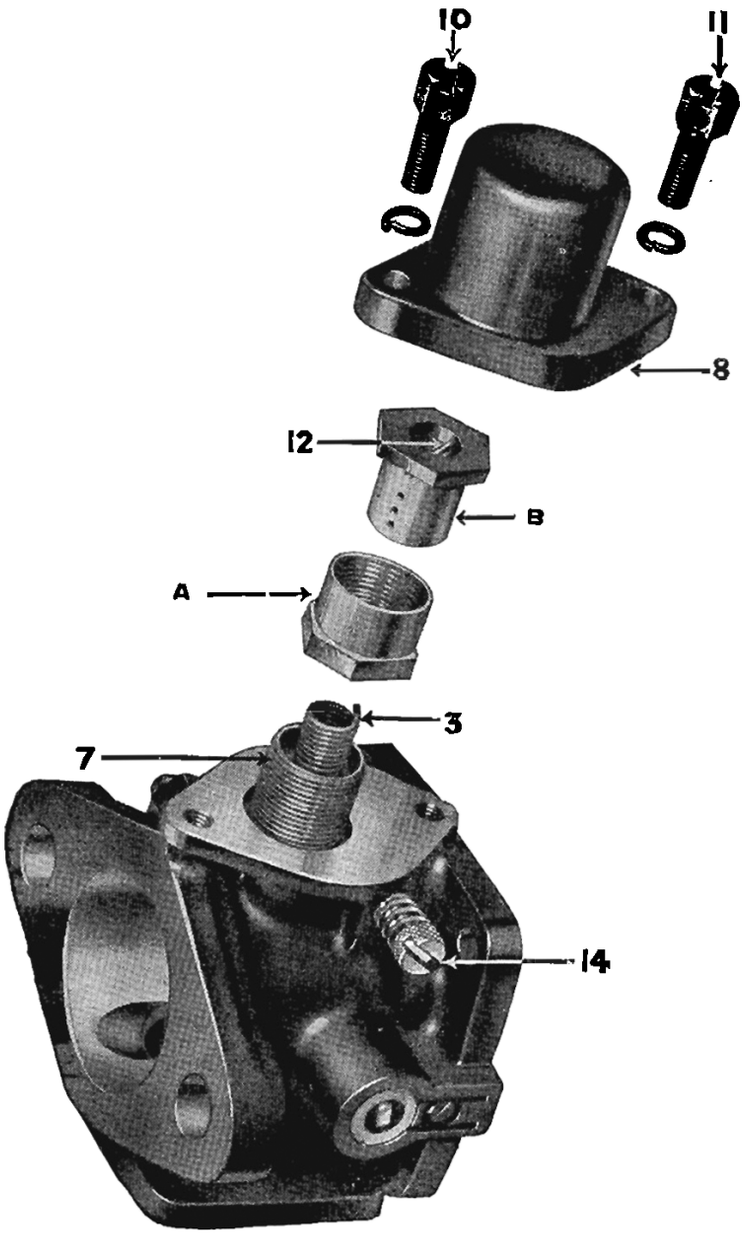


Figure 55. Exploded View of Governor

To prevent uneven governing of the engine the vibrational " rate " of the spring is controlled.

This " rate " is varied by increasing or decreasing the number of spring coils in action and this adjustment is used to match up the spring " rate " with the varying force of the air charge on the throttle at the particular engine speed selected.

The sleeve (B) if revolved, will cause the peg (12) to be screwed along the spring, thus altering the number of coils between peg and spring hook. These, which are the ones in action, are the only ones that matter, those on the outer side, farthest from the throttle, being " dead."

The successful tuning of a Solex governor carburettor, therefore, centres in the adjustment of spring regulating sleeve (B) *and tension nut* (A).

An important adjunct to steady and sensitive governing lies in the method of attaching the spring hook to the throttle. Referring again to Fig. 54, a link (4) is seen, pivoted to the throttle at its one end. The other extremity houses a bronze roller, over which the spring is hooked, this roller, of course,

affording a wear-free anchorage for it. A small boss, or distance-piece, fixed in the upper face of the link, is shown as preventing it from meeting the platform-shaped lip on the throttle, which lies immediately above the link. The action of this simple mechanism is rather subtle. With the throttle fully open the link and spring are in a straight line. As, however, the throttle closes, a point is reached where the boss of the link touches the platform-shaped lip, and from that point onwards the increasing downward tilt given to the outer end of the link results in progressively increased loading of the spring.

Having in mind the construction of the various parts, especially link (4), sleeve (B) and nut (A), we can picture briefly the sequence of events.

On depressing the accelerator pedal, the dog drive on the spindle allows the throttle to open fully under the influence of the spring.

The pressure of the air charge on the tail of the throttle, is at first very light and does not move it. As the selected governed speed is approached, however, the throttle commences to close and the pressure builds up very rapidly indeed as this closing movement progresses.

A correspondingly sharp increase in the build-up of spring resistance is called for, without having to alter the already determined tension at the full open throttle position, and this is provided by the link (4) and its boss, as already described.

In this way the throttle remains wide open until immediately before the governing speed is reached, so that pick-up is not restricted. Then the whole of the closure takes place over the smallest possible number of engine revolutions.

PART 2. AIR CLEANER

The abrasive action of dust when mixed with the oil film inside an engine, is well known, and for this reason a great deal of care is taken to filter all air entering the engine.

On earlier vehicles air is drawn from the fighting compartment through a filter gauze covering a hole in the bulkhead and thence through a connecting hose to the outer case of the air cleaner (see Fig. 56).

On later vehicles the air enters through two " Pre-cleaners " of the centrifugal type which are mounted inside the engine compartment. It then passes into a hose connecting with the outer case of the air cleaner.

The air cleaner itself, which is of the self oiling type, is completely enclosed in an outer case connected with the pipe leading either to the filter gauze or to the " Pre-cleaners." This ensures that all air is filtered before it actually passes into the cleaner.

A point of interest is that a pipe runs from the outer case of the air cleaner to the front valve cover so that the engine " breathes " into the filtered air stream.

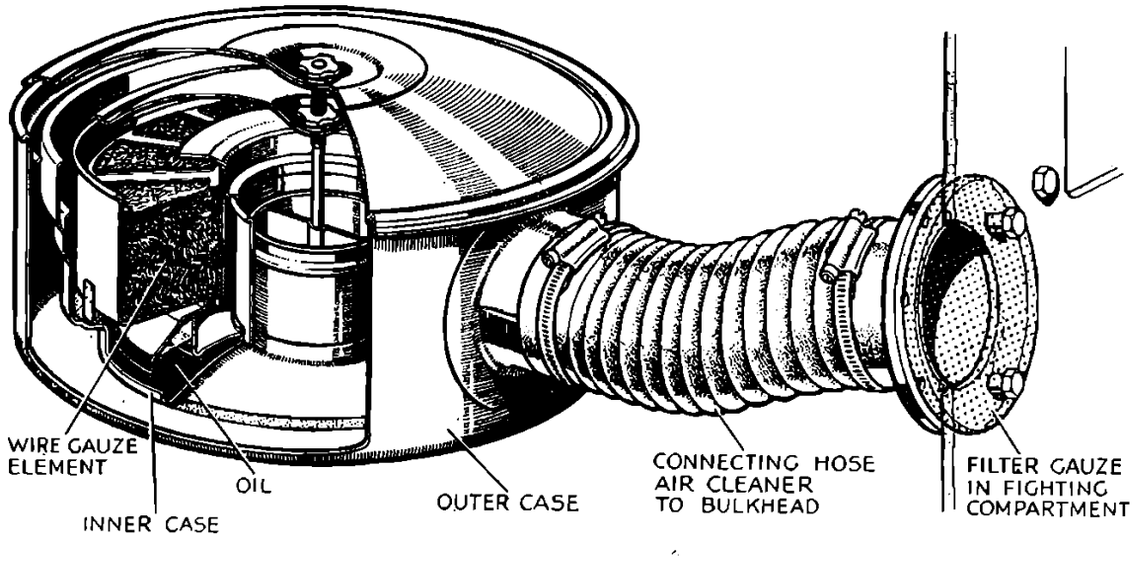


Figure 56. Air Cleaner in Section

The incoming air enters the cleaner by passing over the top of the inner case. It then passes downwards through the passage between the inner case and the wire gauze element.

At the bottom of this passage it strikes a shelf, formed in the inner case, and reverses upwards into the wire gauze element. The oil level extends about ⅛" above this shelf and it follows that a certain amount of oil is picked up by the air stream and carried into the element. The purpose of the shelf is to meter the oil going into the filter element so as to keep only a predetermined amount in circulation. This prevents the oil pulling over into the carburettor.

The element is therefore automatically oiled and washed, and all dirt in the air is trapped by the wetted metal mesh and carried back into the sump formed by the bottom of the inner case.

After passing through the wire gauze element the air turns downwards into the carburettor intake.

PART 3. FUEL SYSTEM

A suction fuel system consisting of three main units is employed. Firstly there are the tanks for storing the liquid, secondly the pump for feeding the fuel from the tanks to the carburettor and thirdly the carburettor for mixing the petrol with air into an explosive mixture.

There are two petrol tanks situated to the left hand of the engine compartment and the larger of the two contains the main supply, the smaller provides a reserve. The tanks are of welded metal construction and are secured to the hull by metal straps. Steel sheets, faced with asbestos, are fitted between the tanks and the engine to act as heat shields.

Petrol is introduced into the tanks through detachable gauze filters after the filler caps have been removed (see Fig. 57) and calibrated dipsticks are provided to enable accurate checks to be made.

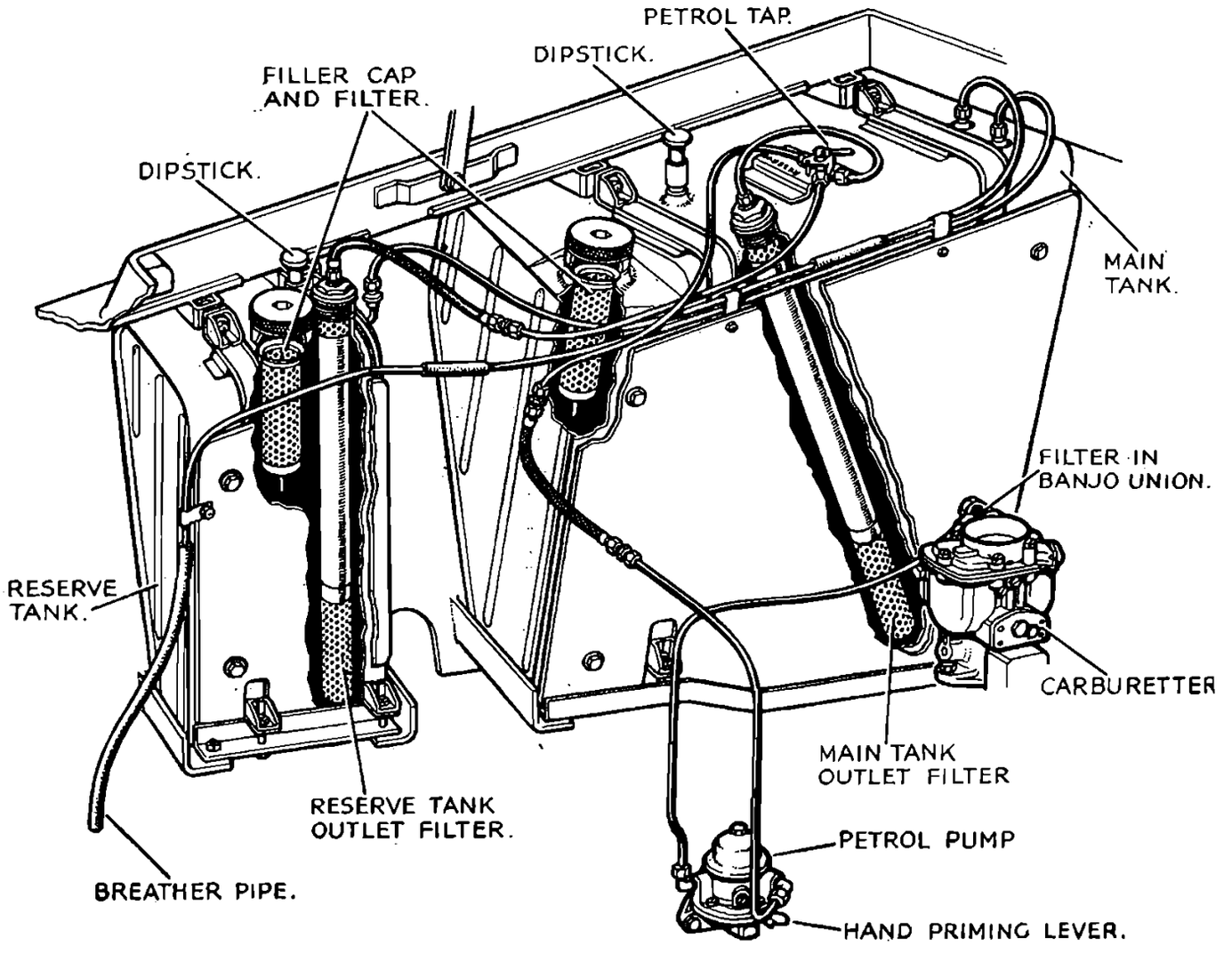


Figure 57. Layout of Fuel System

In order to prevent an accumulation of inflammable gas, the reserve tank is vented into the main one. A pipe then carries the accumulation from the main tank to the radiator grille where the air stream from the fan disperses it in the atmosphere outside the vehicle.

A three-way petrol tap mounted on top of the main tank allows petrol to be drawn at will from either main or reserve and there are large capacity outlet filters in both tanks through which the petrol must pass to reach the pipe line leading to the petrol pump.

PART 3B. PETROL PUMP

The petrol pump is fitted on the manifold side of the engine and is driven by the camshaft. The operation is shown on Fig. 58 and it will be seen that if the eccentric (H) is revolved then the rocker arm (D) will be lifted and as this is pivotted at (E) the pull rod (F) will be pulled downwards together with diaphragm (A) against spring pressure (C), thus creating a vacuum in pump chamber (M).

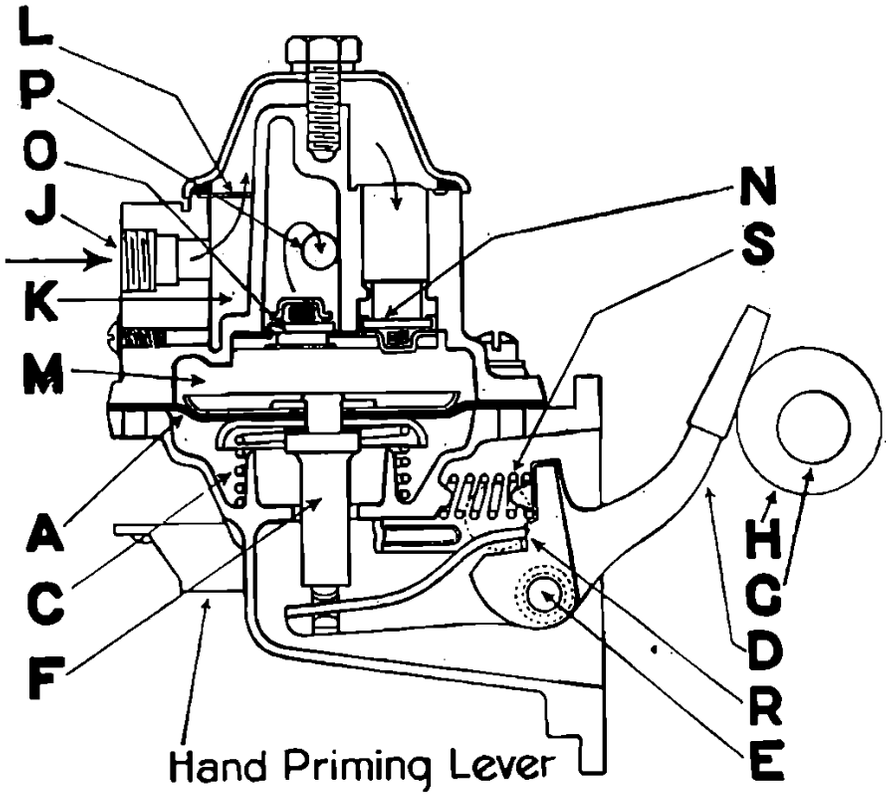


Figure 58. Section of Petrol Pump

Fuel from the tanks will enter at (J) into sediment chamber (K) and through filter gauze (L) and suction valve (N) into pump chamber (M). On the return stroke, spring pressure (C) pushes diaphragm (A) upward forcing fuel from chamber (M) through pressure valve (O) and opening (P) into the carburettor.

When the carburettor bowl is filled, the float in the float chamber will shut off the inlet needle valve, thus creating a pressure in pump chamber (M). This pressure will hold diaphragm (A) downwards against the spring pressure (C) and it will remain in this position until the carburettor requires further fuel and the needle valve opens. The rocker arm (D) is in two pieces, the outer operating the inner one by making contact at (R) and the movement of the eccentric (H) is absorbed by this "break" when fuel is not required.

Spring (S) is merely for the purpose of keeping rocker arm (D) in constant contact with eccentric (H) to eliminate noise.

The hand priming lever (emergency handle) shown in the drawing is for use when for any reason the carburettor float chamber or pump have become empty. A few strokes of the lever will fill the carburettor with petrol, and ensure an easy start.

PART 4. LUBRICATION SYSTEM

The lubrication of the engine is based on the wet sump principle, that is to say, the oil reservoir is formed by the metal cover at the base of the cylinders (the sump) and no separate oil tank is used.

Lubricant is pressure fed throughout the engine by means of a gear type oil pump which is driven in tandem with the distributor by means of a gear secured to its shaft. This mates with the gear on the camshaft.

The circulation system is shown on Plates 9 and 10 and the following description will be more easily followed by reference to these illustrations.

The intake side of the oil pump is connected to the oil sump by a pipe line, on the end of which is pivoted a floating oil intake unit which lies on the surface of the oil. An advantage of this arrangement is that any foreign matter in the oil settles at the bottom of the sump and cannot be drawn up and circulated through the engine. Clean oil only is drawn from the surface, but this also, before it reaches the pump, passes through a gauze filter embodied in the floating unit.

From the floating filter unit the oil is lifted to the pump past a non-return valve situated in the oil intake tube.

From the pump, the oil, in first production machines, is sent direct to a by-pass valve, but on later models it passes from the pump through an oil filter unit known as the " Purolator " before reaching the by-pass valve. This filter is mounted on the hull to the right hand side of the engine compartment.

This unit consists of a wire wound filter element enclosed in a two piece casing. The inlet and outlet orifices are situated in the head of the casing and are clearly marked by arrows showing the direction of flow. A non-adjustable relief valve is incorporated in the head as a safeguard, in the event of excessive pressure being developed as the result of a dirty filter element.

The oil from the by-pass valve is sent to an oil cooler situated behind the radiator and then it is returned to the main oil gallery which runs the length of the crankcase. The object of the by-pass valve is, that should the cooler become damaged the oil can be by-passed direct to the main oil gallery by moving the handle shown on Plate 10. This handle is also shown on Plate 4.

Incorporated in the same casting as the by-pass valve, is an adjustable relief valve which will automatically allow the oil to return to the main gallery should the cooler become choked or damaged, so that the oil supply to the engine will be maintained.

From the main oil gallery oil is forced along oilways in the cylinder block to the four main bearings, and enters under pressure into oilways drilled in the crankshaft to lubricate the big end bearings. A drilled oil-way in the central web of each connecting rod provides lubricant for the gudgeon pins and a small hole in each big end boss permits a limited amount of oil to be ejected for lubrication of cylinder wall shown on Plate 10.

Oil passages from the main gallery also serve the camshaft bearings.

The timing gears are lubricated from No. 1 main bearing feed, a jet of oil being directed by a short pipe line to a special trough and thence to the timing chain. Surplus oil from the trough is fed through a hole in the cylinder block to a channel along the base of the tappet chamber.

An oil relief valve is incorporated in the main oil gallery and is set to open when oil pressure builds up in excess of 40 to 50 lbs. per sq. inch.

The oil way to No. 2 main bearing extends right through the cylinder block and terminates in a tapped hole in the cylinder block on the opposite side to the oil pump. From this tapped hole a copper pipe leads to a by-pass filter mounted on the side of the engine just behind the dynamo and a further pipe leads from the filter to a tapped hole in the cylinder block through which oil can return direct to the sump. It will be seen that a certain proportion of the oil is always being filtered by this unit.

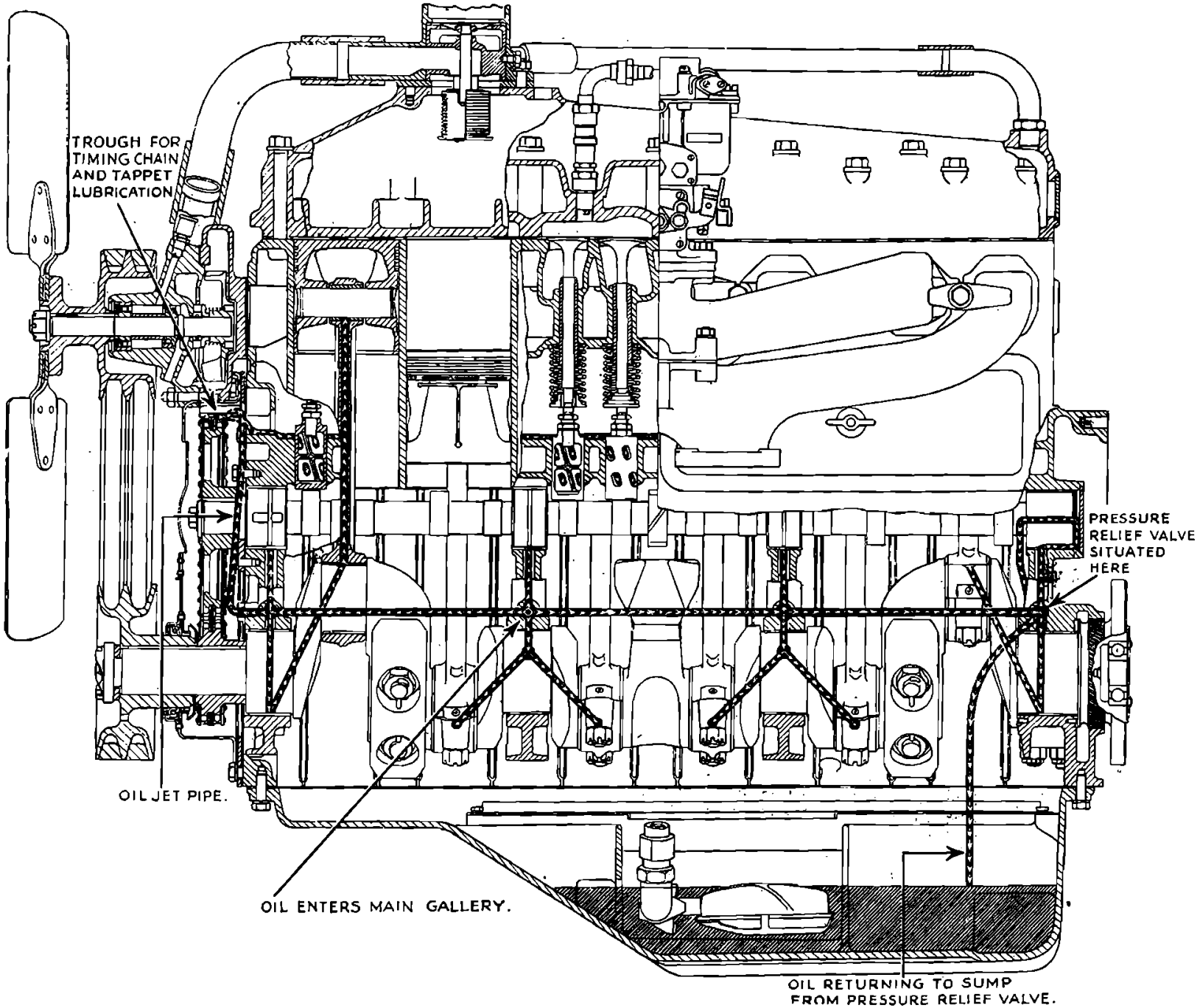


Plate 9. Engine Oil Circulation—Longitudinal View

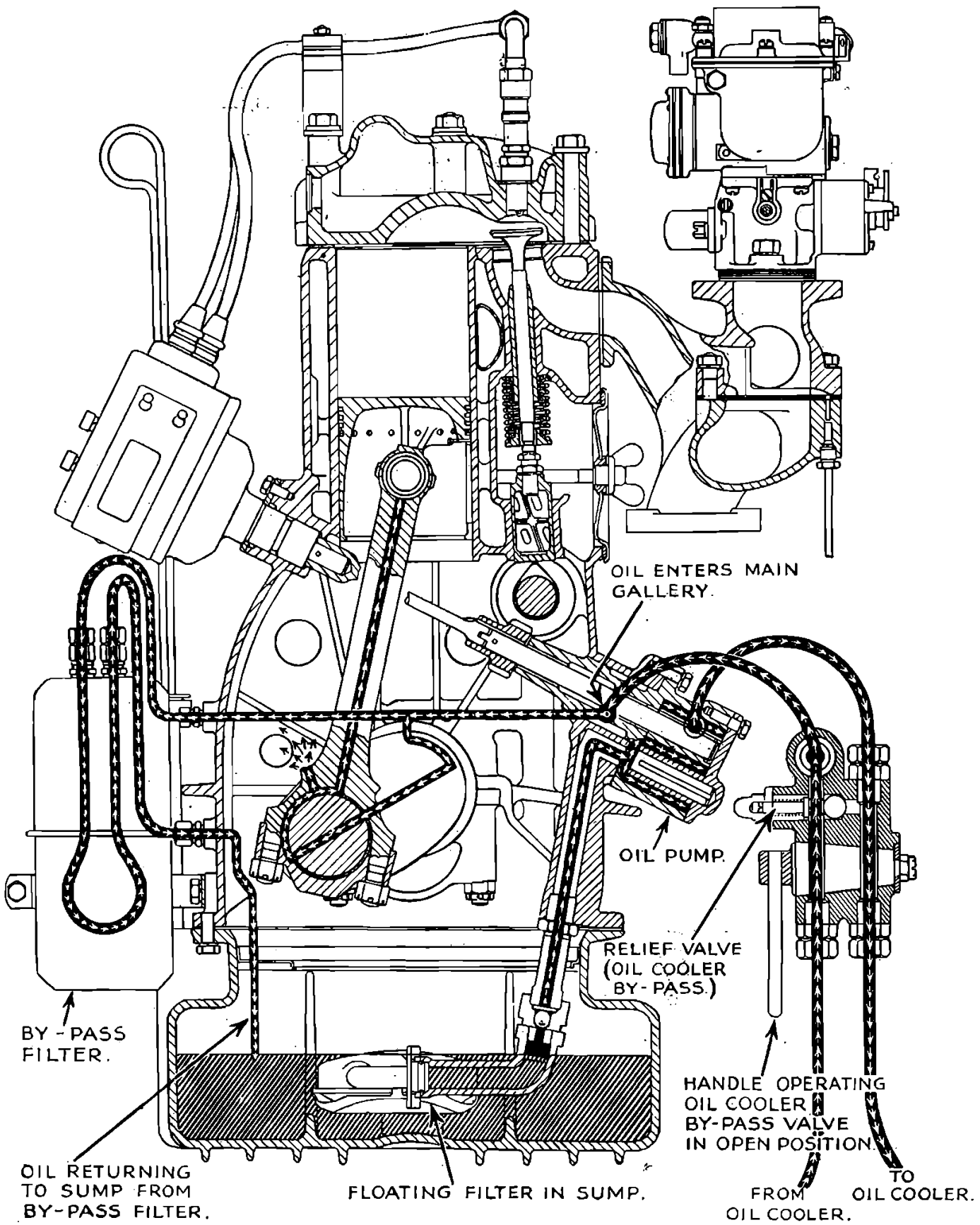


Plate 10. Engine Oil Circulation—Cross Section View

PART 5. COOLING SYSTEM

The object of the cooling system is to prevent the cylinder walls from attaining a temperature, high enough to seriously affect the lubricating properties of the oil film between the piston and the cylinder walls. If this was allowed, the increased friction would reduce the mechanical efficiency of the engine and eventually lead to seizure.

This condition is obtained by providing the cylinder walls, valve pockets, and combustion chambers with jackets through which water is made to circulate. These water jackets are connected to a radiator, whose function is to cool the water by " radiating " its heat to the atmosphere. A fan driven by the engine and fitted behind the radiator, increases the flow of air and so assists the cooling of the water. The system forms a closed circuit in which the water can circulate naturally, but a pump is also fitted to assist circulation.

This natural circulation is due to the fact, that the water heated in the jackets as a result of the burning of the fuel rises and enters the top of the radiator, its place being taken by colder water from below. The heated water on its passage through the tubes of the radiator block is cooled by the current of air which is forced through the block by the fan, and falls continuously to the lowest point of the circuit, whence it returns to the cylinder water jackets.

The layout of the cooling system is illustrated by Plate 11 and Fig. 60, to both of which reference should be made in order to understand the following explanation.

Plate 11 shows the air circulating arrangement and it will be noted that the cooling fan expels air from the engine compartment through the radiator, instead of drawing it through the radiator as on most motor vehicles. The air is drawn into the engine compartment underneath the engine access door and through gaps in the lower engine shields. It is then forced by the fan through the radiator and out through the grille guard at the rear of the vehicle.

The six-bladed fan is driven in tandem with the water pump by twin V-belts from the engine crankshaft and it will be noted that the fan rotates inside a sheet metal cowl attached to the radiator. This cowl causes the air flow to be distributed over the whole of the tube block area and considerably improves the efficiency of the system.

The water circulation arrangement is shown in detail on Fig. 60. As already mentioned, circulation is continuous whilst the engine is running, but it is necessary to increase the rate of flow by a pump. This is located at the timing cover end of the cylinder block and is of the impeller type.

The pump spindle is supported on ball bearings in a cast iron housing and extends into the pump casing to carry the impeller (C) and outwards to receive the fan pulley, from which the drive for both units is derived.

Cool water from the radiator bottom tank (A) is drawn into the pump via pipe (B) and directed through an oval section pipe (D) housed inside the cylinder block. Holes drilled in this pipe opposite the exhaust valve passages, ensure a supply of relatively cool water to the hottest parts of the engine. Passing around the cylinder bores and through appropriate passages in the top face of the cylinder block, the water absorbs further heat from the combustion chambers in the cylinder head and rises upwards past a thermostat (F) and thence through a communicating pipe to the radiator top tank (G).

The cooling process is completed by the passage of the heated water downwards through the radiator tube block, where it is brought into contact with the vigorous current of air which is being forced through the tube block by the fan. The heat is thus extracted and is " radiated " to the atmosphere and the cooled water is returned to the bottom tank where the process is recommenced.

Two features of the cooling system used on these vehicles are best described separately ; they are (*a*) the thermostat and (*b*) the pressure loading valve. They are not essential to the working of this or any cooling system, but are incorporated because they have certain special advantages.

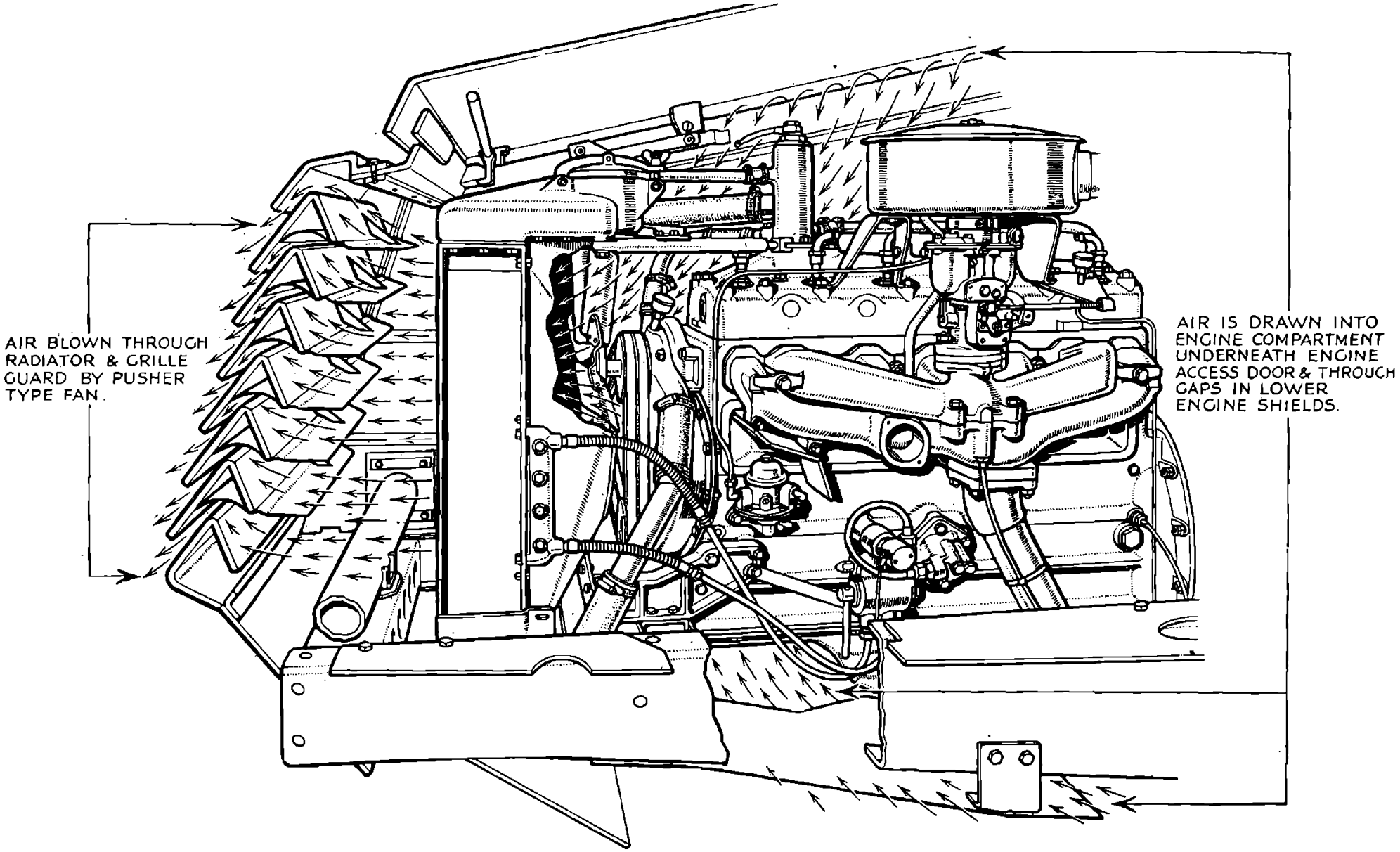


Plate 11. Air Circulating System

The thermostat shown as (F on Fig. 60) is a device which enables the engine to reach its normal working temperature as quickly as possible and it establishes this condition by restricting the quantity of water in circulation. It consists of a mushroom shaped valve which is controlled by a flexible metallic " bellows " to which the valve stem is attached. This " bellows " contains a special fluid with an alcohol base and is therefore sensitive to temperature changes.

With a rise in temperature, the fluid expands and causes the " bellows " to extend and open the valve, while conversely as the temperature falls the " bellows " are made to contract and close the valve. On starting up from cold, the thermostat valve will be closed and so cut off the circulation of the water through the engine to the radiator. When the temperature of the water enclosed within the engine water jackets reaches a pre-determined figure, about 170°F, the valve opens and normal circulation commences.

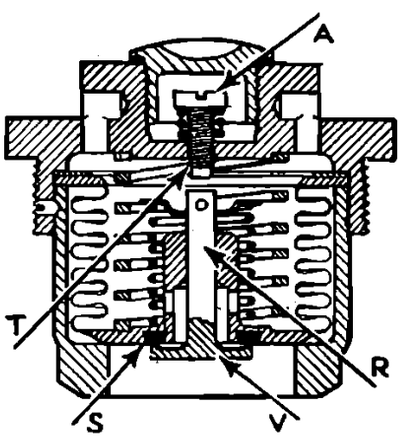


Figure 59
Pressure Loading Valve

During the period of warming up, while the thermostat valve is closed, there is a tendency for the water pump to build up a pressure and this is relieved by the provision of a by-pass pipe (H Fig. 60) leading from the underside of the thermostat valve to the water pump.

Incorporated in the thermostat housing is a pressure loading valve (Fig. 59). Water under normal conditions of air pressure boils at 212° F, but this boiling point can be raised by about 20° F if the pressure under the cooling system is increased by approximately 5 lbs. per square inch.

When the system cools down, a partial vacuum is created within it, so that it is subjected to atmospheric pressure on the outside. To avoid the risk of trouble with the radiator header tank, rubber hose and so forth, under this condition, a simple vacuum relief arrangement is incorporated in the valve.

The construction of the valve and its operation under pressure and vacuum conditions can be understood by reference to the accompanying drawing (Fig. 59). It will be observed that the valve seat is attached to the lower end of a flexible, metallic bellows, which is capable of contraction if pressure be applied from below.

Increase of pressure within the cooling system, acting upon the bottom of the valve (V Fig. 59), moves the valve and the seat (S Fig. 59) upwards until the valve stem (R Fig. 59) abuts on the adjustment stop (T Fig. 59), the projection of which can be varied by means of a screw (A Fig. 59), to pre-set the opening pressure.

Further increase of pressure forces the lower bellows-plate, carrying the seat (S Fig. 59) upwards, and the valve is thus opened to atmosphere, permitting steam to escape at the pre-determined pressure to the condenser can situated on the left rear mudguard through pipe (L Fig. 60).

Under vacuum, the valve (V Fig. 59) is forced downwards by atmospheric pressure away from the seat, again opening the valve to atmosphere and relieving the vacuum.

It will be noted that the pressure loading valve is situated at the highest point of the system and to prevent any possibility of a pocket of steam being formed in the radiator top tank, a pipe (J Fig. 60) runs between the highest point of the tank and the bottom of the valve, thereby allowing any pressure built in the radiator to excape. Similarly to prevent a like possibility in the cylinder head a pipe (E Fig. 60) is run from the back end of the cylinder head to the thermostat housing.

The word " water " used to describe the cooling medium in the preceding text is also extended to cover any liquid which may be used in its place and referred to in Service literature as " coolants."

A pipe line (L, Fig. 60), is connected to the atmospheric outlet of the pressure loading valve, terminating in a condenser can (M), so that steam released by the valve is condensed, and the distilled water so collected can be re-used.

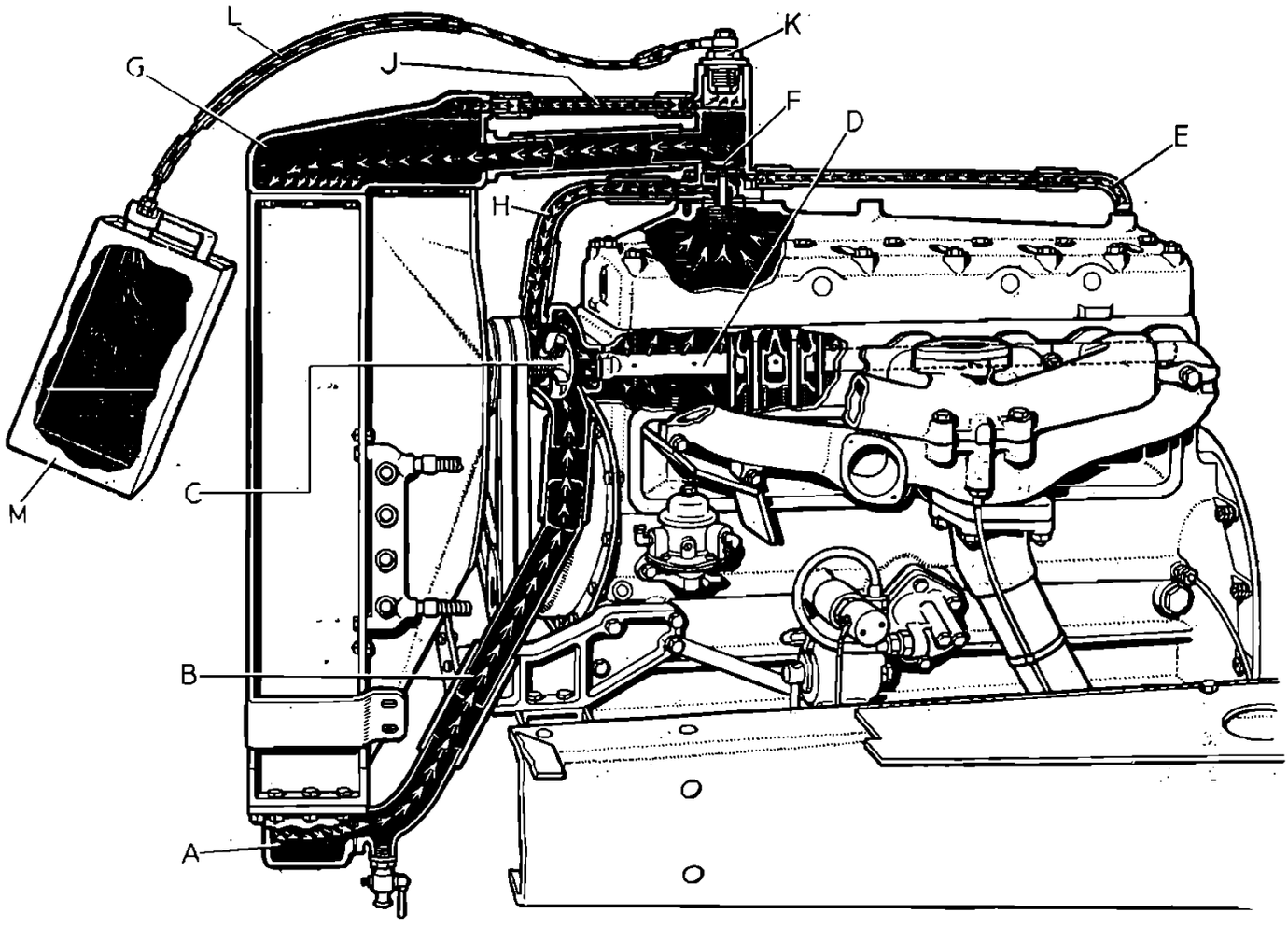


Figure 60. Water Circulating System

PART 6. IGNITION EQUIPMENT

While there is no need for operating personnel to be familiar with all details concerning the production of high-tension (H.T.) electricity from low-tension (L.T.) electricity, some knowledge of the elementary principles will be helpful.

Low-tension or low voltage electricity is produced by the engine driven dynamo and is stored in the vehicle batteries at a " pressure " of about 2 volts per single cell, so that by connecting together six cells a " pressure " of 12 volts is obtained in a " twelve-volt battery." This is quite insufficient to bridge the gaps between the electrodes of the sparking plugs used for igniting the explosive mixture, and it is necessary to convert the low-tension voltage of 12 to something in the order of 6,000 volts for the purpose.

The process of converting low-tension electricity to high-tension is effected by what is known as " induction," and the equipment used for the purpose consists essentially of a coil and a combined distributor and contact breaker, the latter being driven by gearing from the engine camshaft.

The coil consists of an iron core around which is wound the primary or low tension and the secondary or high tension windings. Its duty is to convert the low tension battery voltage of 12 to a high tension current of the order of 6,000 volts so that a spark may be formed across the plug points. When the ignition is switched " On," current flows from the battery through the primary winding and this current is interrupted by means of the contact breaker in the distributor, and thereby a high voltage is induced in the secondary winding.

The distributor, which is mounted at an angle on the side of the engine, is driven in tandem from the oil pump shaft to which it is connected by a tongue coupling. It has two duties, firstly it interrupts the flow of low tension current to the primary windings of the coil and secondly it distributes the high tension voltage produced by the secondary windings to each sparking plug in correct sequence.

The interruption of the current to the primary winding of the coil is accomplished by means of a three lobed cam operating two pairs of contact points, so that each contact operates alternately for half the number of cylinders.

To distribute the high tension voltage, metal inserts are provided on the inside of the distributor moulding and these are in contact with the high tension cables connected to the sparking plugs. The central terminal is connected to the high tension terminal of the coil and on the inside it is connected by means of a carbon brush contact to the rotating distributor arm (or rotor). The distributor arm is provided at its outer tip with a metal electrode which, when the arm rotates, passes very close to the metal inserts.

The operation of the set is, that when the distributor shaft rotates, the contact breaker points " make and break " alternately, so that every time the contacts open, a high secondary voltage in the coil is passed to the distributor rotor. From here it jumps the gap to one of the metal inserts in the distributor moulding which is in turn connected by cable to the appropriate sparking plug.

The distributor shaft is still rotating and immediately after the spark occurs, the contact breaker points close and the cycle of operations is repeated through the other contact breaker so that the spark is repeated in the cylinder next in firing order.

When the distributor is fitted to the engine the contact points are set to open when the piston reaches the top of its travel on the compression (or firing) stroke. This means that the spark occurs at the time when the mixture in the cylinder is at its highest compression.

As the engine speed increases however, its efficiency will be increased if the time at which the spark takes place is advanced to a point before the piston reaches the top of its travel and this point will vary with the speed of the engine. The distributor is therefore provided with an automatic control which varies the firing point accordingly.

The mechanism consists of a centrifugal governor housed in the base of the distributor. The unit incorporates spring controlled weights suitably coupled to a plate to which the cam is mounted. As the engine speed increases these weights are acted upon by centrifugal forces and move outwards to cause an angular motion between the distributor shaft and the cam, thus " advancing " the ignition timing.

The whole of the ignition equipment is suppressed to prevent interference with wireless transmission or reception. The coil and distributor are completely screened, and both high and low tension cables are of the shielded metal braided type. In addition, a filter unit is connected in the ignition primary circuit between the coil and the ignition switch to prevent interference by the low tension "make and break" circuit.

Special spring loaded plunger type connectors are fitted at the ends of all cables connecting to the coil, distributor and sparking plugs.

CHAPTER II B

THE TRANSMISSION

As already indicated in Chapter II A, this is the name given to the series of arrangements by which the power of the engine is conveyed to the driving wheels of the vehicle. The transmission is divided into several components, each making their special contribution to the propulsion of the vehicle. Their respective duties are described in the appropriate sections which follow.

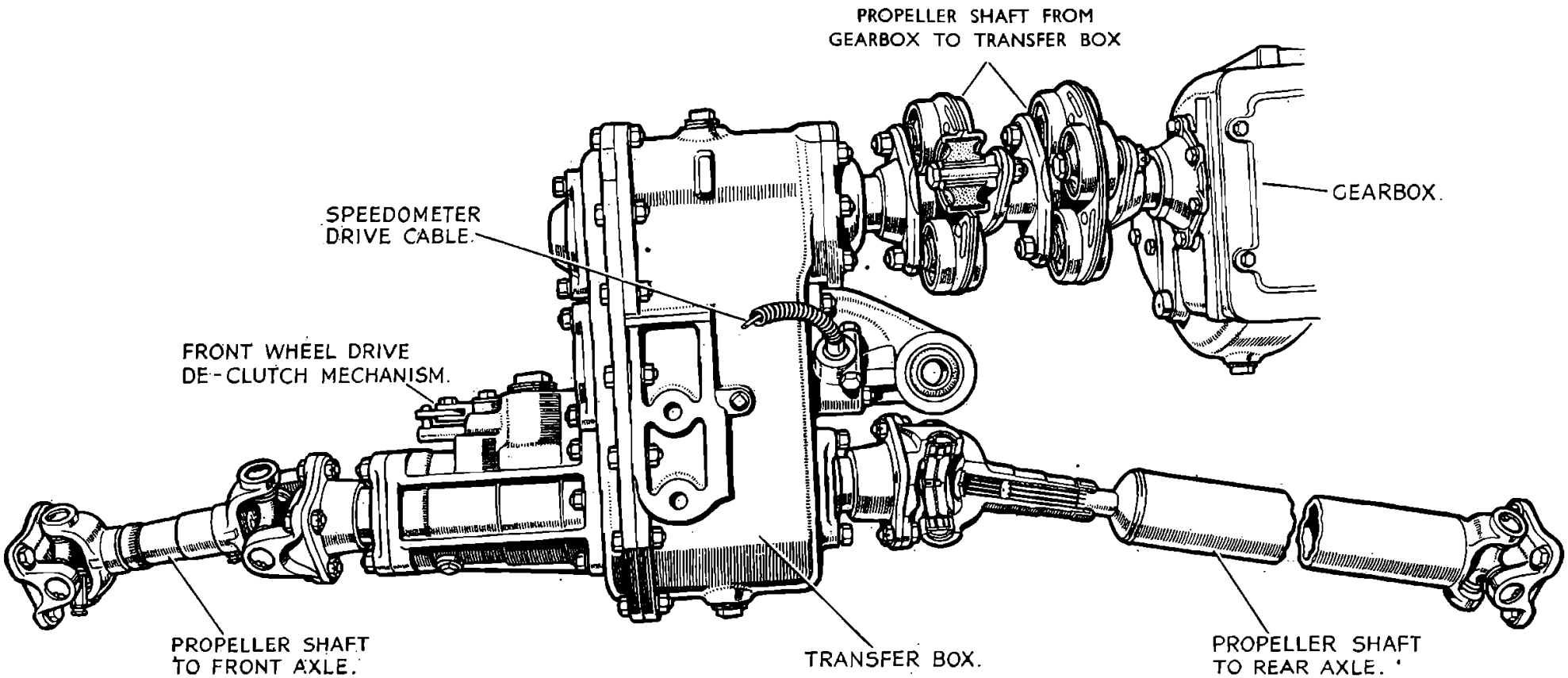


Plate 12. Shewing Transmission Line

PART 1. CLUTCH

The clutch is fitted to enable the driver to interrupt the transmission of power as required, by means of the foot pedal, shown on Fig. 1. At the same time it not only permits progressive engagement when the vehicle is moved from a standstill, but also facilitates gear changing when in motion.

The clutch fitted to this Armoured Car is a single dry plate type, consisting of a friction lined steel plate held in firm contact between the flywheel and pressure plate by means of coil springs.

Fig. 61 indicates the complete arrangement and by reading the following paragraphs in conjunction with this illustration, the operation of the clutch unit will become clear.

The driven plate (3) of thin steel with a friction lining riveted to each side, is attached to the hub which is in turn splined to the gearbox primary shaft. The hub is however, free to slide on the shaft.

The flywheel (1) is bolted to the crankshaft rear end flange and its outward face is machined to form a friction surface against which the front face of the driven plate is pressed, when the clutch is engaged.

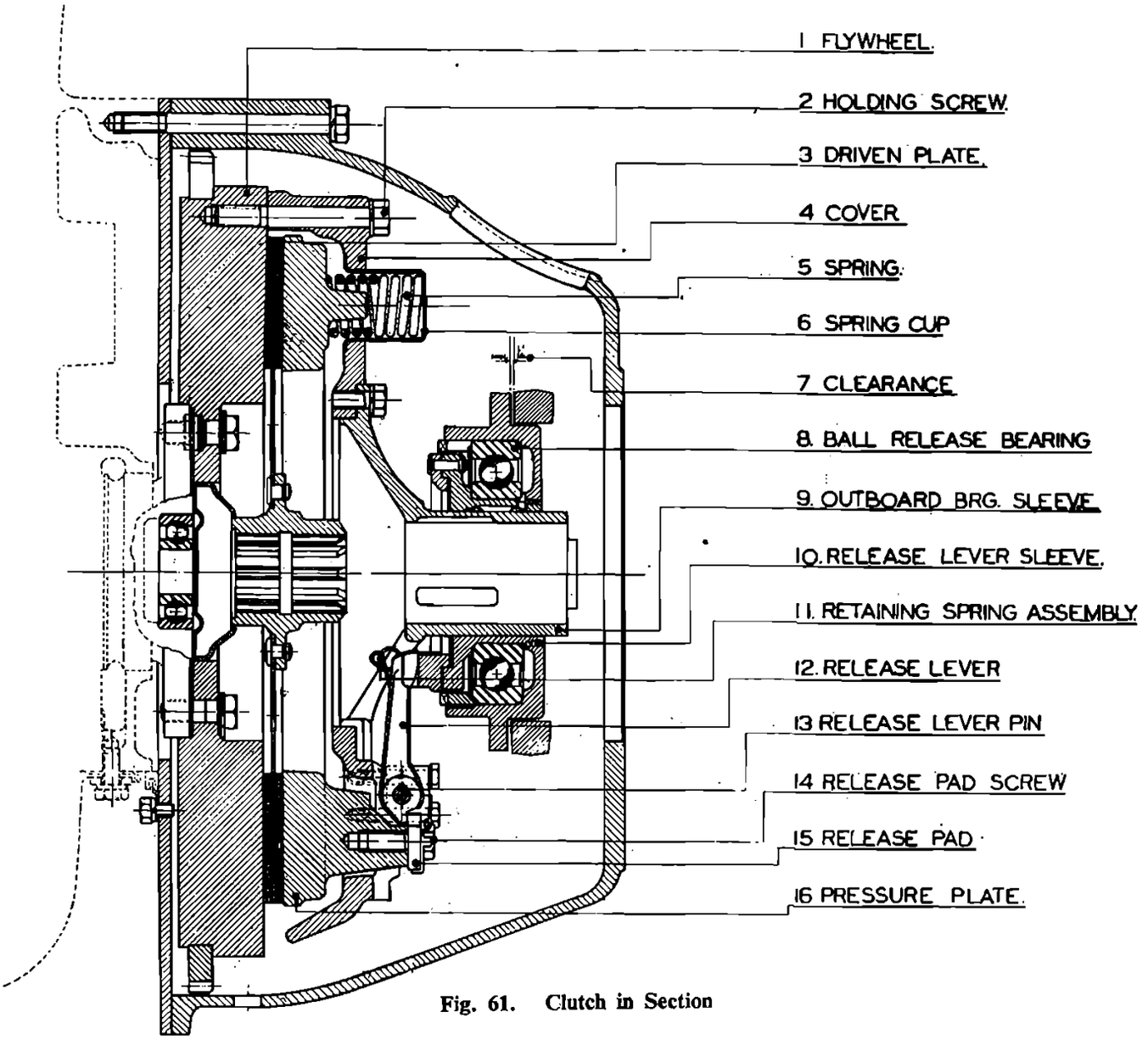


Fig. 61. Clutch in Section

The clutch cover assembly is built up of the pressure plate (16) which is held firmly against the rear face of the driven plate, by the springs (5). These are fitted over ventilated guide lands on the back of the plate and housed in spring cups (6), which register in the cover (4). Consequently, when the cover assembly is bolted in position by the holding screws (2), the driven plate is held firmly between the flywheel and the pressure plate.

It is therefore obvious that some method of driven plate release is necessary, and this is arranged for by fitting three release levers (12) rotating on release pad screws (14).

The short arm of each release lever engages a release pad (15) which is secured in its correct position by a nut and lock washer. The long arm of each release lever engages the release bearing assembly fitted on the out-board bearing sleeve (9) and is free to move along it, contact being maintained by retaining springs (11). The rear flange of the assembly is constructed to engage both arms of the clutch fork which is connected to the clutch pedal shaft.

The release bearing assembly is shown in detail in Fig. 62. It will be seen that the bearing (8) is secured by means of the cover ring (18) in a housing (17) and carried on the release lever sleeve (10). The assembly slides on the outboard bearing sleeve (9).

A grease retaining disc (19) is fitted between the ball bearing and the cover ring.

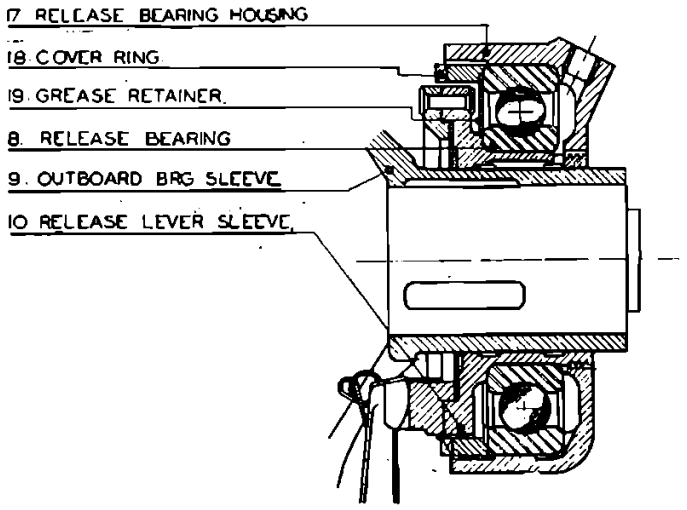


Fig. 62. Release Bearing in Section

Operation.

When the clutch pedal is depressed, the fork exerts pressure on the release bearing assembly which in turn forces the release levers inwards. This movement is transmitted through the release lever shaft arms to the pressure plate which is drawn away from the driven plate, the clutch springs being compressed in this process.

Thus the driven plate is freed of spring pressure and the drive to the transmission is interrupted as the driven plate ceases to revolve. When the clutch pedal is released, the reverse action takes place, and the pressure plate forces the driven plate against the flywheel until the spring pressure is sufficient to transmit the drive. The increase of spring pressure obviously depends upon the withdrawal of the foot pressure from the pedal, so permitting the progressive engagement referred to at the commencement of this description.

PART 2. GEARBOX

The function of the gearbox is to enable the engine to work within the range of maximum efficiency under various loads.

The gearbox permits the driver to select the most suitable gear for the work in hand, high gear for level country and a range of three lower gears for hilly country. The driver's object is to keep the engine revolutions more or less constant at the engine's best working speed.

The main gearbox is the normal four speed type with direct drive on fourth speed. The constant mesh gear on the primary shaft and the third speed gear have helical teeth and in consequence the constant mesh wheel and third speed wheel on the layshaft are also helical gears. The engagement of direct drive and third is by dog-clutch, remaining gears are spur type with straight teeth.

The selector mechanism in the gearbox is controlled through suitable linkage from the driver's compartment and the speed change lever works in a quadrant on the driver's left hand side, while the levers actuating the two gears in the transfer box and the lever working the front axle declutch are on the driver's right.

The gear selector lever is mounted in a spherical housing under the slotted quadrant on the driver's left, a diagram of gear positions is rivetted on the lid of the box on the driver's left as the quadrant is not visible. It is bolted to a bracket on the chassis frame. The motion of the gear lever is carried to the rear of the chassis by suitable linkage, which is joined by a yoke and pin to the selector lever, working also on a ball joint in the cover of the gearbox. This cover contains the three selector levers and locking gear, the selector forks are attached to the levers (see Plate 14).

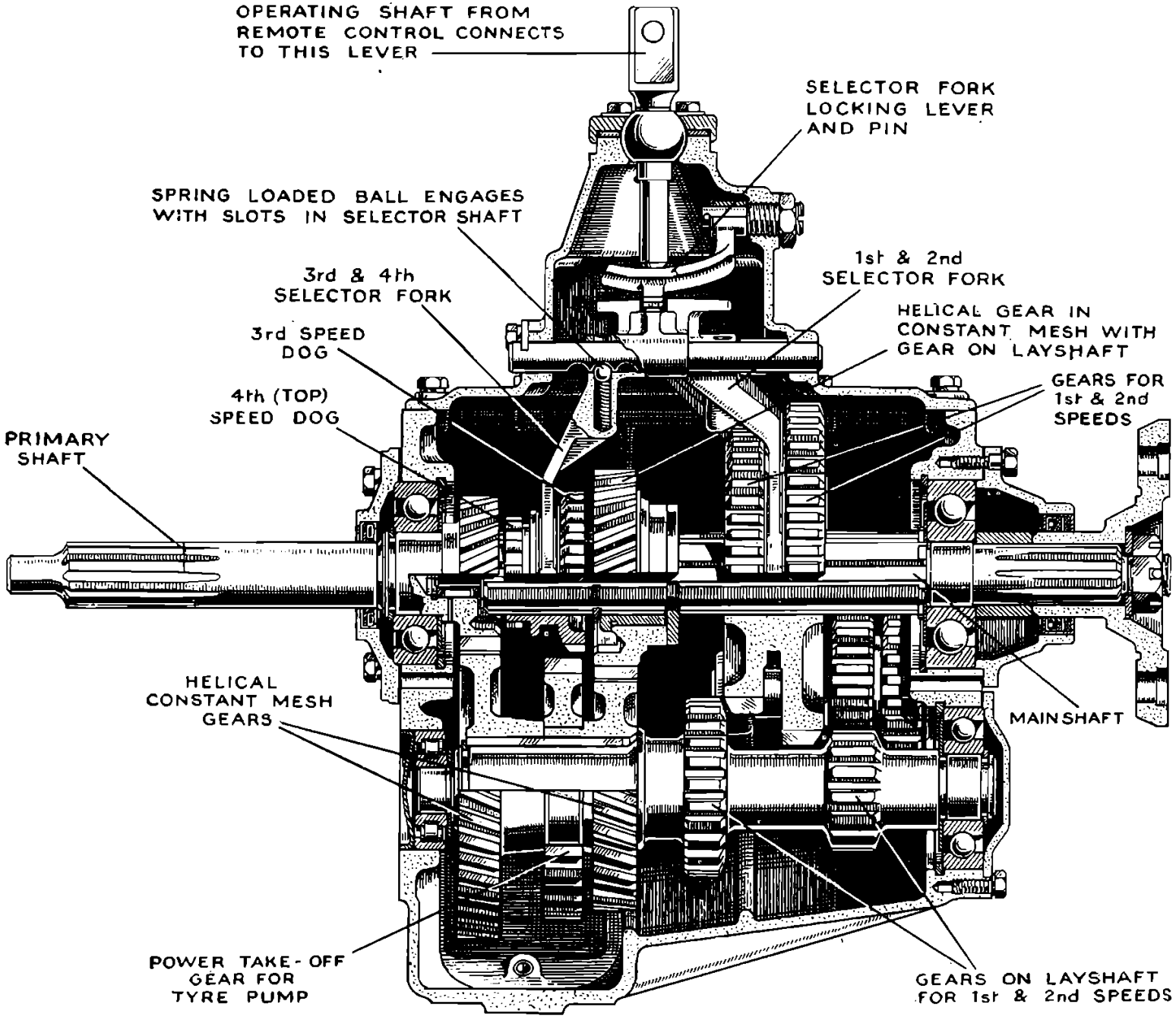


Plate 13. Gearbox—Longitudinal Section

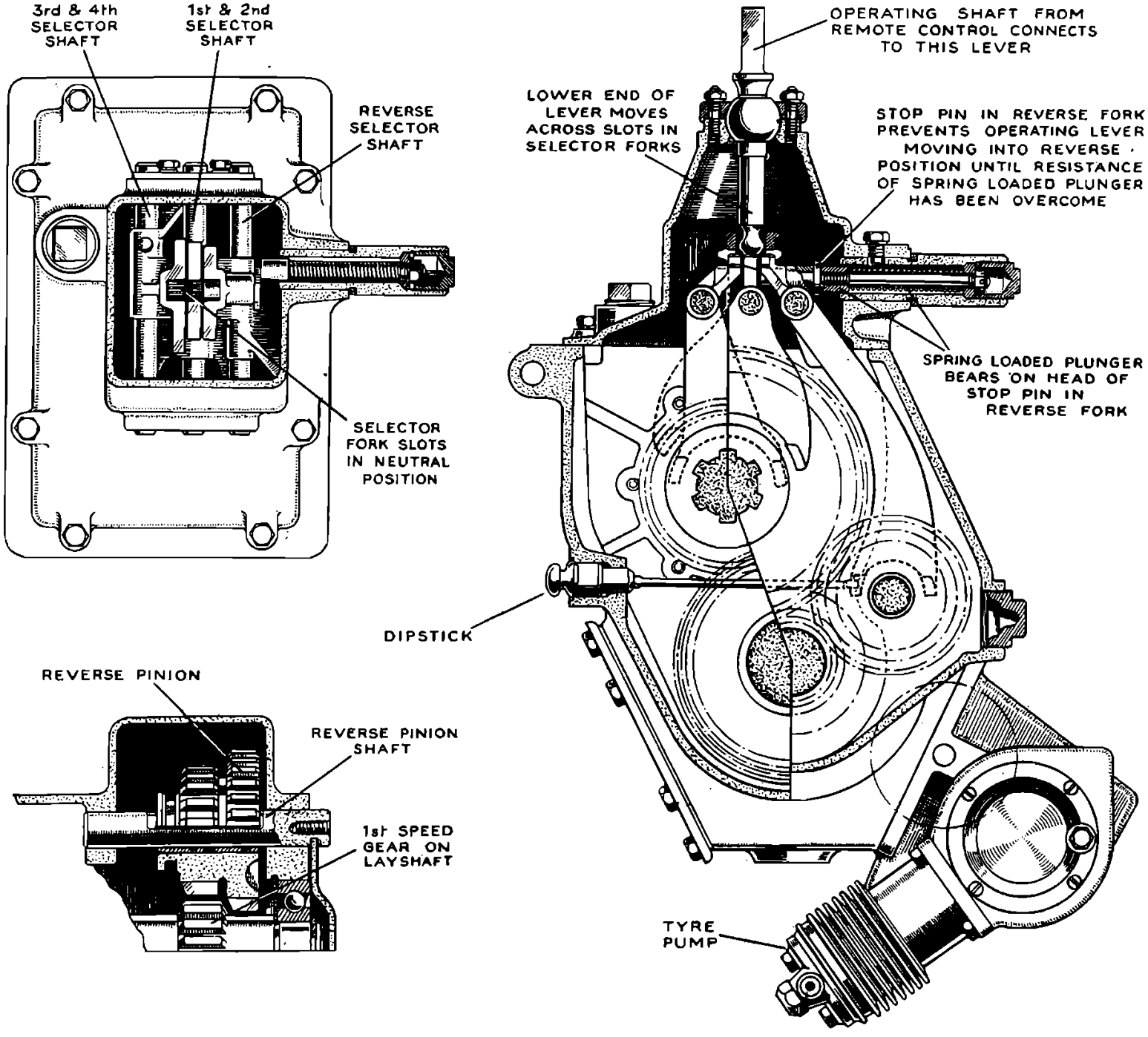


Plate 14. Gearbox—Cross Section

An arrangement is also included in the gearbox to reverse the direction of the drive to the transmission, so that the vehicle can be driven backwards. This is known as a " reverse gear."

This reverse gear is fitted inside the gearbox on the right hand side, looking front, on a short shaft and consists of a pair of integral sliding gears, the larger of which, when " reverse " is engaged, meshes with the first speed gear pinion on the layshaft. The smaller of the two meshes with the first speed gear on the mainshaft. This reverses the rotation of the mainshaft, hence the direction of the vehicle.

Having decided which of the selector forks is to be actuated to give the particular gear required, the gear lever is moved sideways to the necessary position according to the diagram on the battery lid (see X, Fig. 1). The gear must now be engaged and this is done by the forward or rearward movement mentioned.

Referring to Plates 13 and 14 it will be seen that if the lever in the tower is actuated in the sequence mentioned above it will first swivel sideways on its ball and the lower end will then move to the front or rear taking the selector fork along the shaft. This brings the selected gear into engagement and the power of the engine travels through whatever cycle has been decided upon to the remainder of the transmission.

To prevent accidental engagement of the reverse gear a spring loaded plunger is incorporated in the gearbox tower and this bears on the head of a stop pin in the reverse fork. Before the lever in the gearbox can be moved into the slot in the reverse fork, the pressure of the spring has to be overcome and the driver, feeling the resistance, will appreciate that his control mechanism is moving into the position from which reverse gear is engaged.

The selector forks move along shafts fitted in the gearbox tower and spring loaded balls engaging with slots in the shaft, locate them in the various gear positions. To prevent movement by the two forks not in the immediate control of the hand lever, a further safeguard is provided in the form of a locking lever which swings on a pin in the tower.

The swinging portion of this locking lever is in the form of a slot in which the operating lever moves backwards or forwards quite freely but if this latter moves sideways, projections integral with the locking lever engage with the selector fork slots. It will be seen that the projections must always be in engagement with two slots so permitting the movement of only one operating fork and preventing the engagement of more than one gear.

When top gear has been engaged the drive is direct, *i.e.* the power of the engine is transmitted through the primary shaft or stem wheel through the sliding dog to the mainshaft and then to the remainder of the transmission through the coupling at the rear of the gearbox.

When third gear is being employed the drive passes from the primary shaft to the layshaft through helical gears running in constant mesh and from the layshaft it travels to the main shaft through a further pair of constant mesh helicals to the sliding dog through which the gear is engaged.

The remaining gears have straight cut teeth and are brought into engagement by a sliding gear on the mainshaft. The drive in both cases being via primary shaft, helical constant mesh gear; layshaft, straight cut pair of gears (one on layshaft and one mainshaft) and mainshaft.

To reverse the drive it is necessary to carry the power through three stages, *i.e.* from the primary shaft to the layshaft, from the layshaft to the reverse pinion and back from the reverse pinion to the mainshaft. This is done by engaging a pinion having two sets of teeth with the first speed gears on the mainshaft and layshaft, these latter gears of course remaining in the position they normally occupy when the box is in neutral. The path of the drive in reverse will be seen to be primary shaft, layshaft, reverse pinion and mainshaft.

PART 3. TRANSFER BOX

The transfer box allows the transmission line to be arranged so that the drive can be taken to both front and rear axles. It will be appreciated that a line projected through the centre of the engine crankshaft and gearbox mainshaft to the rear axle, would make no provision for the drive to the front axle. It is, therefore, terminated at the transfer box, which lowers it and sends one branch to the front axle and another to the rear axle.

A further function of the unit is to provide a lower range of gears for use under difficult conditions and this is done by incorporating two speeds; the high having a reduction of approximately 1¼ to 1

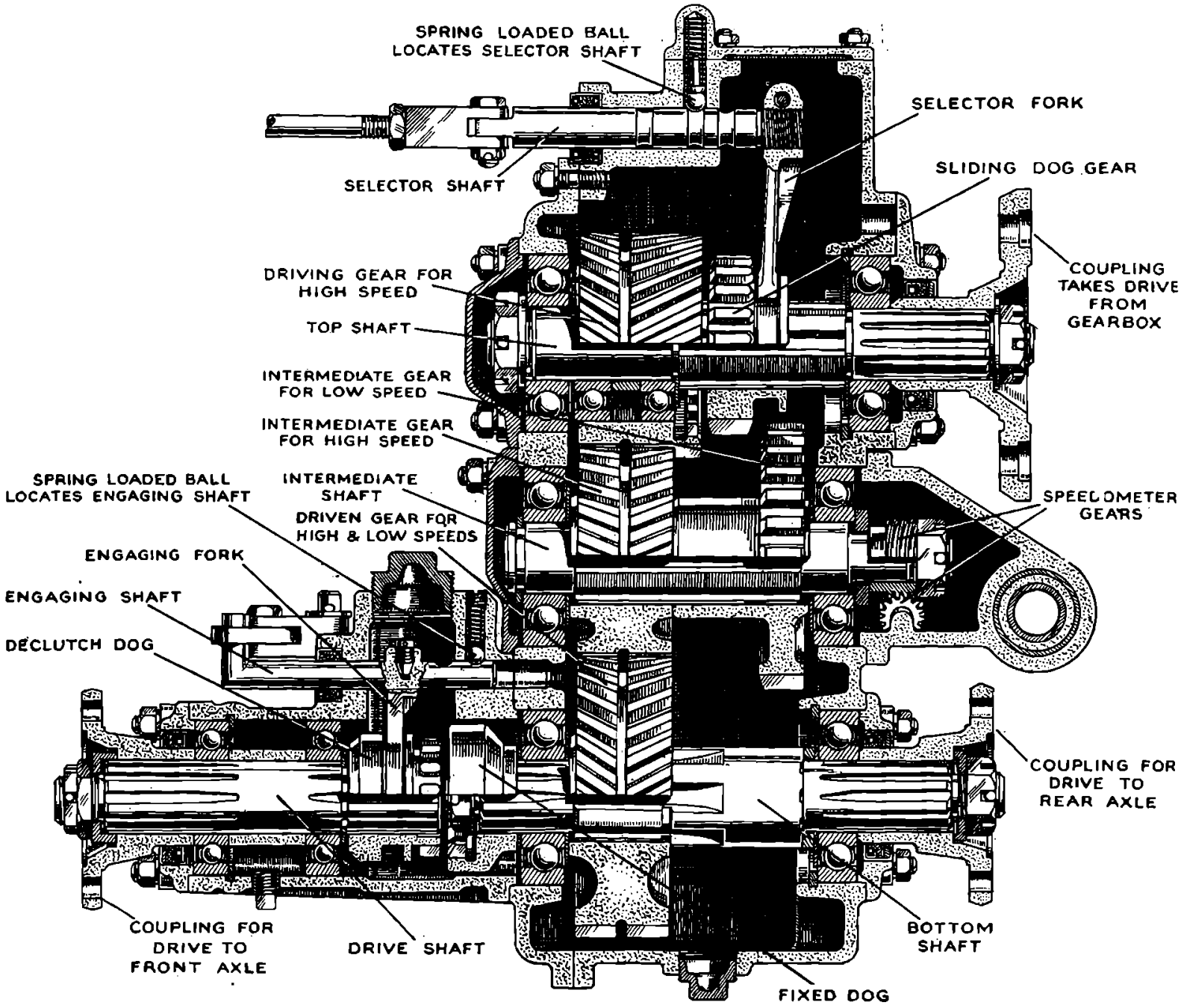


Plate 15. Transfer Box in Section

and the low a reduction of nearly 2 to 1. As the transfer box is situated between the gearbox and the driving axles, it normally follows that the speeds in the main gearbox are affected by this subsidiary unit, that is to say, when the transfer box is in high the four speeds in the main gearbox are higher, as a range, than when the transfer box in is low.

It is also necessary to have a means whereby the front axle can be put into or out of drive and this is provided by a small unit fitted to the front of the main assembly.

As in the case of the main gearbox, operation is by remote control, two hand levers being situated at the driver's right hand side. These are mounted on a bracket fixed to the frame and only forward and rearward movement is permitted.

The inner of the two levers is used for gear selection and has three positions, high, neutral and low. The outer lever controls the front axle declutch and has only two positions, front axle in drive or front axle out of drive.

On Plate 15 the transfer box is shown with the gears in neutral, but if the hand lever is moved into the high position, the dog on the top shaft will be carried, by the selector fork, into engagement with the gear shown mounted on two ballraces. The drive now being via coupling, top shaft, dog and train of three gears to the bottom shaft from where it is relayed to the axles.

If the hand lever is taken into the low gear position, the selector fork will move the sliding dog into engagement with a straight cut gear on the intermediate shaft and from here the drive is relayed to the bottom shaft through two of the gears used when the box is in high.

Although the illustration shows the transfer box in neutral it should always be left in gear, for normally a driver only expects to control the vehicle by means of the main gearbox. In certain circumstances a serious situation may arise if the box is left in neutral and a driver who is unaware of this fact attempts to drive away.

Referring again to Plate 15, the declutch unit will be seen at the bottom front of the transfer box and controlled by a mechanism similar to that used for the gear change. As the hand lever is pulled back the fork brings the declutch dog into engagement with a fixed dog on the bottom shaft and the front axle is brought into drive.

As previously explained in the section " Starting and Driving Instructions " low gear in the transfer box cannot be engaged unless the front axle is in drive. This is ensured by fitting a special long nut to the ball at the foot of the declutch drop lever, so that when the gear change lever is pulled back into the low position it catches this lengthened nut and both levers move together.

Ball bearings are fitted throughout the box and " Perfect " type spring loaded oil seals are used to prevent leakage of lubricant. Owing to the type of gears employed there is no thrust on any of the bearings.

PART 4. PROPELLER SHAFTS.

Propeller shafts are used to transmit power from one unit to another and on this machine are fitted between the gearbox and transfer box, the transfer box and front axle and the transfer box and rear axle. A further function is that they should permit movement between one unit and another, the shaft between the gearbox and the transfer box being fitted with flexible rubber couplings of the " Layrub " type for this purpose while those between the transfer box and the axles incorporate needle roller universal joints.

The " Layrub " coupling (see Fig. 63) comprises a pair of steel pressings having four recesses or pockets in each half, equally spaced both radially and circumferentially. Into each pocket is pressed a resilient rubber trunnion block of special section with parabolic cavities on either side. These blocks are permanently bonded to a special woven screen of high tensile steel wire gauze which when formed into a cylinder is the base round which the rubber is moulded.

The depth of each pocket is equivalent to half the length of the block, so that when the two halves are assembled the block is fully supported by the pressing.

Fitted in the bore of each block, inside the wire screen, is a steel sleeve rigidly mounted to the companion flange and secured by a high tensile steel bolt. Each companion flange has two points of attachment, diametrically opposed, the two companion flanges being at right angles to each other. This allows the joints to work at comparatively wide angles.

All relative movement in the coupling is confined to the controlled displacement of live rubber in the trunnion block.

The needle roller type of universal joints (see Fig. 64) incorporated in the propeller shafts running between the transfer box and axles consist of two forks, one being integral with the shaft itself and the other forming part of a flange which can be bolted to the coupling on the transfer box or axle.

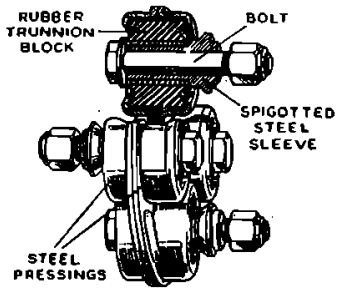


Fig. 63. " Layrub " Coupling

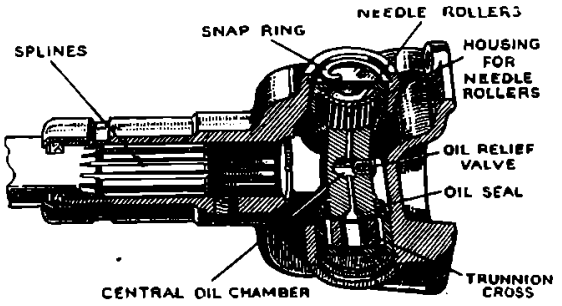


Fig. 64. Needle Roller Joint

The ears of the forks are drilled to take one of the arms of a four pointed star piece (or trunnion cross).

Between the star piece and the fork is a housing containing a circle of needle roller bearings and it is upon these bearings that all movement takes place. The housing is held in position by means of a snap ring and an oil seal is incorporated in the construction of the joint.

In addition to the universal joints at both ends, each propeller shaft is fitted with a sliding joint to compensate for axle movement. The transfer box being mounted on the frame does not move, but the axles work up and down owing to the flexibility of the springs and as this articulation takes place the distance between axles and transfer box will vary.

Splines are employed in the sliding joint to permit telescopic movement of the shaft so that adjustment is possible for the varying distance between transfer box and axle flanges.

PART 5. FRONT AND REAR AXLES

The transmission line runs from front to rear through clutch, gearbox, transfer box and propeller shafts, but before the power conveyed can be applied to the road wheels the direction of drive must be turned across the vehicle and this is carried out in the axles by means of a bevel drive consisting of a crown wheel and pinion. These gears are also used to give a leverage to the power of the engine additional to that which may be brought into action by the gearbox and transfer box. This is known as a final reduction and the ratio is 6.86 to 1, *i.e.* when the vehicle is moving straight ahead the propeller shafts to the axles will revolve 6.86 times to one revolution of the road wheels.

The gears of the final reduction are part of an arrangement known as the differential, the purpose of which is to allow the driving wheels on opposite sides to turn at different speeds. It will be realised that the outer wheels travel a larger circle than the inner when the vehicle is cornering, and if no arrangement was used to adjust their speeds, then they would have to skid to meet the conditions brought about by turning to right or left.

A further function of the axle units is to support the load of the vehicle by providing an anchorage for the springs and shock absorbers. This is accomplished by incorporating in construction a casing in which the whole of the differential and axles shafts are enclosed.

The brakes, which form part of the axle units, are dealt with in Chapter IV A and no further reference to them will be made in this section.

The whole final reduction and differential gearing is carried in a stamping which can be removed bodily from the axle casing after withdrawal of the driving shafts and the gears used are of the bevel and crown wheel type.

The bevel pinion, which is the gear carrying the propeller shaft flange, runs in two taper roller bearings and is extended so that a parallel roller bearing may be used as a pilot. These taper roller

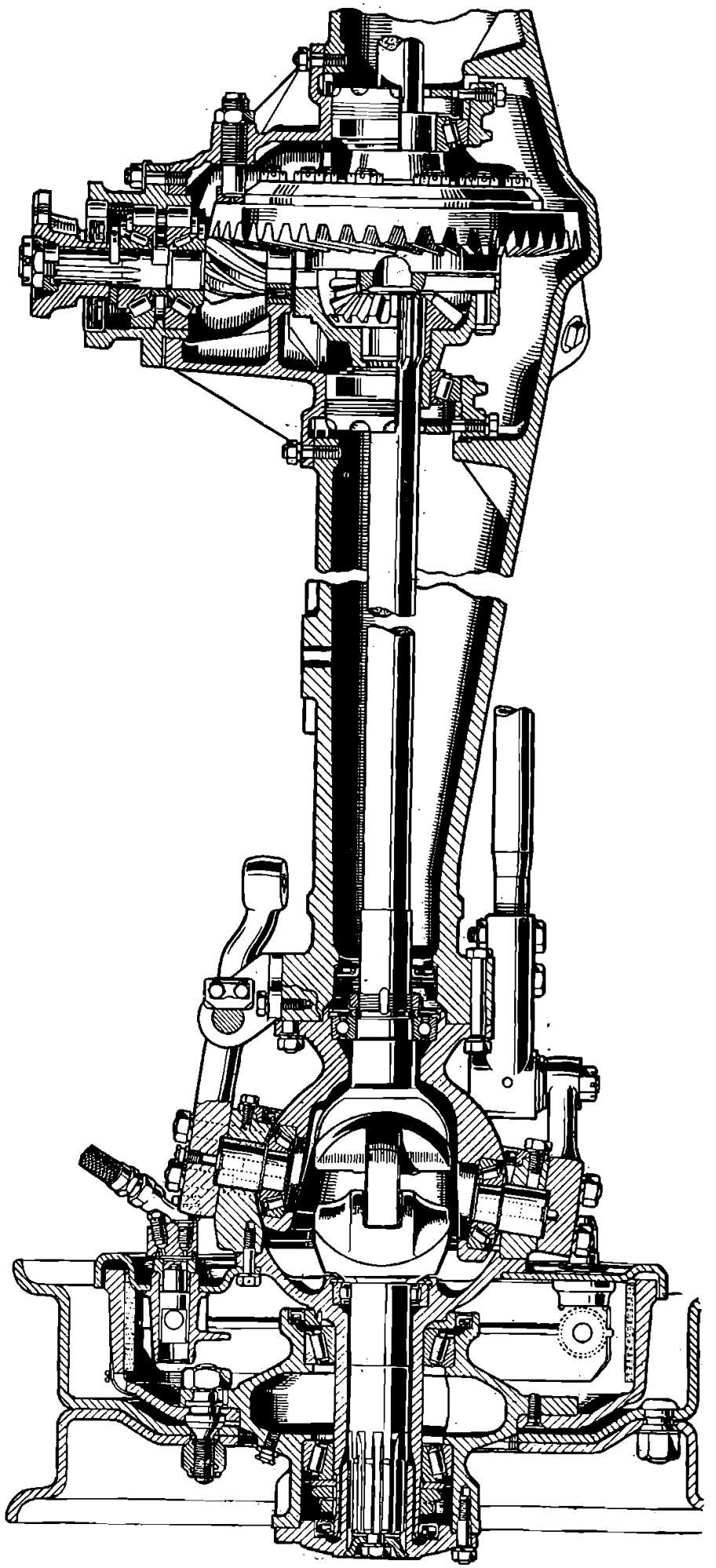


Plate 16. Front Axle Arrangement

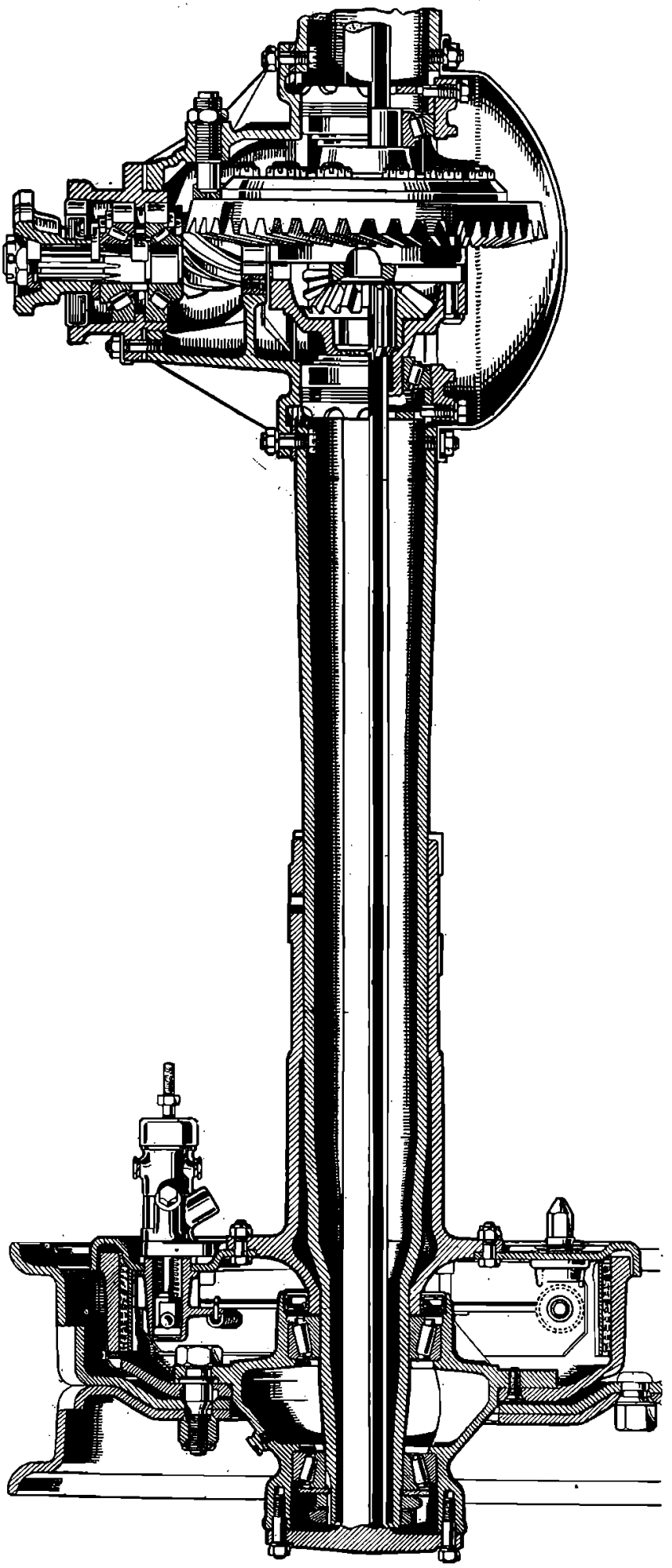


Plate 17. Rear Axle Arrangement

bearings can be adjusted by means of shims fitted between them and the pinion with its two bearings, distance piece, shims, oil seal and propellor shaft coupling are assembled as a small sub-unit in a separate housing.

This housing is bolted to the differential carrier and shims are interposed between to permit the meshing of the pinion and crown wheel to be set in correct relation.

The crown wheel is bolted to a casting made in the form of two halves which contains the differential gears consisting of a four point star (or spider), on each arm of which, is a small pinion meshing with a bevel gear, the inside of which is splined to take the axle shafts.

The crown wheel and bevel pinion unit is carried in two taper roller bearings supported by the differential housing. Two screwed adjusters are provided to allow adjustment and also to permit the crown wheel teeth to be set to correct depth in the bevel pinion teeth.

A special feature of the design is the provision of a thrust pad to support the crown wheel at times of sudden and excessive loads. This thrust plate which takes the form of a phosphor bronze tip on a steel stud, is located in the differential housing directly at the back of the crown wheel where meshing occurs with the bevel pinion. The mean (or average) clearance allowed between the crown wheel and thrust pad is .015".

The inner ends of the axle shafts are splined to fit inside the splines of the differential bevels and the rear axle shafts on the outside are bolted to the hub. This latter runs on taper roller bearings, adjustable for wear by means of adjusting nuts, and the brake drums and road wheels are fastened to it.

The front axle driving shaft, which is supported at its outer end by a ball race, terminates in a fork which mates with a " Tracta " type of universal joint. The other half of the universal joint mates with an outer driving shaft fastened to the hub (Plate 6).

As in the case of the rear axle the hub runs on Timken roller races which can be adjusted by means of nuts and the brake drum and wheel are fastened to it.

The " Tracta " joint is required to permit the wheels to be turned for steering and it is contained in a housing which is machined at the top and bottom to take Timken type roller races which support the swivel pins.

On the swivel pins another housing is carried, to which are attached the steering arms and the bottom pair of these arms are connected by a track rod fitted with ball joints. This track rod has a left hand thread at one end and a right hand thread at the other, so that adjustment can be made for wheel alignment by screwing it in or out of the sockets of the ball joint (Fig. 67).

PART 6. WHEELS AND TYRES

A W.D. type of divided wheel fitted with a " Run Flat " tyre is fitted and they are interchangeable throughout. The full assembly consists of the wheel, outer cover, inner tube and bead spacer.

In use, these tyres operate exactly as any other inflated pneumatic tyre, but are so designed that if punctured by a bullet or any other cause they will permit the vehicle to run at a slow speed and for a certain time with the tyre deflated.

The outer cover is marked with the letters " R.F." in order that it can be distinguished from a standard cover of corresponding size and the bead spacer is a shaped ring fitting between the beads of the outer cover to prevent damage to the inner tube when the halves of the wheel are bolted together.

The wheel consists of halves held together by a circle of standard $\frac{7}{8}$" wheel nuts. These wheel nuts are painted red and in no circumstances must they be released until the tyre is deflated.

PART 7. TYRE PUMP

An illustration of the tyre pump is included as Fig. 28 and it is designed to run only during periods of tyre inflation ; provision being made for disengaging the pump driving gears and locking them out of mesh when the pump is not in use.

The maximum efficiency is obtained at a speed of approximately 1,000 r.p.m. and full instructions relating to the operation of this unit are given in section " A " Part 7.

Lubrication is from the gearbox for the pump and the gears, but the compressor piston is lubricated by splash from a sump to which the oil is metered when the pump is running. This has previously been explained in section " A " to which reference can now be made.

CHAPTER III B

The Suspension

It is essential to be able to drive an armoured vehicle over uneven surfaces, and for this reason the wheels must be able to follow the contour of the ground as freely as possible, and the axles attached to the chassis frame in such a manner as to control the vertical movements, resulting from tyre contacts with uneven ground. These conditions are fulfilled by a combination of pneumatic tyres, steel road springs and shock absorbers, known collectively as the " The Suspension System " and their respective contribution is described separately in the following pages.

The modern pneumatic tyre, operates at very low pressure and is of great value in giving a comfortable ride owing to its capacity to absorb shocks caused by ground surface irregularities producing a thrust in a horizontal direction. It is virtually, an air spring which absorbs or " damps out " these shocks due to the elasticity of the cord and canvas walls. Where the surface conditions cause rebound of the road wheels, *e.g.* by dropping into pot holes, these properties need some additional " damping " to obtain good road holding and this is provided by the steel springs and shock absorbers.

Details of the tyres fitted to this vehicle are given in the section dealing with " Wheels and tyres."

PART 1. SPRINGS

Road springs are flexible beams, that it so say, they carry weight, but are flexible because their function is to absorb road shocks. The springs used on this vehicle are known as " laminated " or leaf springs of the semi-elliptic type. They are attached to the chassis frame at each end and to the axle casings at the centre.

The passage of the vehicle over road inequalities resolves itself into a more or less vertical movement of the axles which are free to move by virtue of the flexibility of the road springs and their method of attachment to the chassis frame. This movement is, of course, due to deflection of the springs and with an ideal spring it would be just sufficient to permit the vehicle to pass over an obstruction or negotiate a pot hole without imparting any rise or fall to the chassis. In practice this is impossible, but generally it may be said that springs with the greatest capacity for deflection under a given load or impact, will affect the chassis least and be the most satisfactory. With high deflection springs a further factor is introduced, as the spring movement does not cease immediately the load or impact, which caused it, is removed. It continues to move as a pendulum does when set in motion and although forces such as internal friction in the springs and their mounting details are acting to bring the springs and axle to rest relative to the chassis, they are too slow in action and must be assisted by some external damping action. This is provided by the shock absorbers and their action is described in the appropriate section.

In addition to supporting the weight of the chassis, hull and crew, the road springs have other important duties. It will be noted that the front ends of the springs are held freely by pins carried in brackets attached to the chassis frame, while the rear ends are held by similar pins fitted in shackles, which are in turn held by pins carried in frame brackets. The rear ends are thus " hinged " and allow for the variation in spring centres resulting from the " flexing " of the springs. With this arrangement the springs also act as radius rods to maintain the axles in a longitudinal position ; that is, they determine the wheel base of the vehicle.

The drive from the axles is taken through the axle fastenings to the top leaves of the springs and thence to the chassis frame, alternatively, the springs have to resist the " winding up " action resulting from brake application. Both front and rear springs are of special design, allowance being made for them to swivel about the shackles, thus relieving the chassis of any sudden stress.

The two thick bottom leaves are the " rebound " plates. They are an additional check and safeguard in the event of a major displacement of the spring when heavily loaded in rough country. In addition rubber buffers are fitted on top spring clamping plates, these would bear on the underside of the frame in event of a big spring displacement.

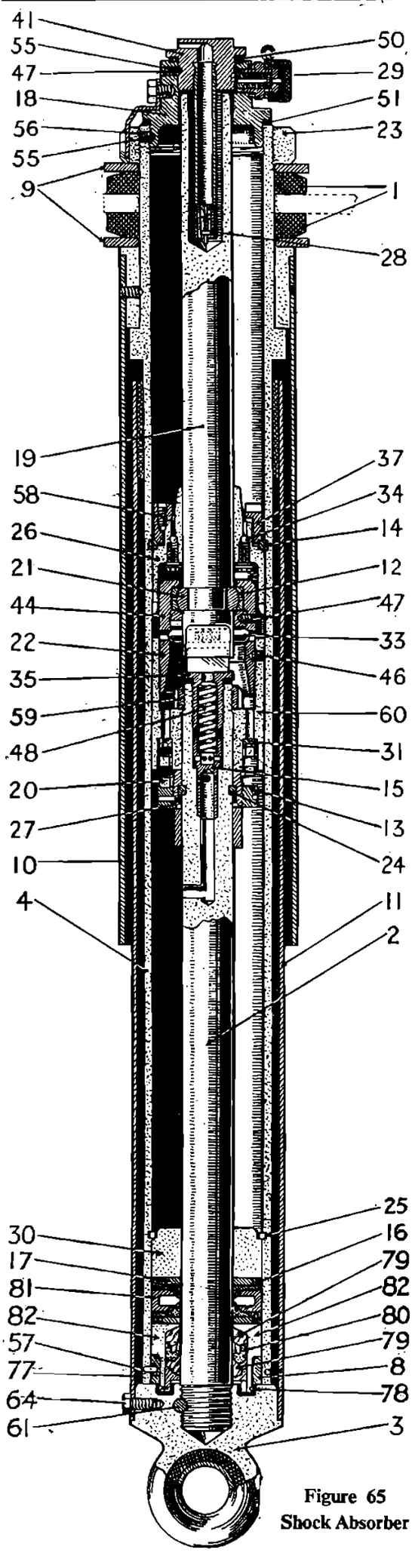


Figure 65
Shock Absorber

PART 2. SHOCK ABSORBERS

Hydraulic type shock absorbers are fitted to the Humber, Mark IV Armoured Car. The shock absorber valves are so arranged that as the spring extends, the oil in the lower chamber of the shock absorber is admitted into the upper extending position through a large valve. When the recoil of the spring commences, the large valve in the shock absorber is closed and the oil is forced through the small valve into the lower chamber of the shock absorber; effectively damping the recoil of the spring.

The absorber is shown in section in Fig. 65 and it will be seen that the cylinder (4) encloses all the working parts, its top end being connected to the body anchorage by means of the two retaining discs (9) and the rubber washers (1) which are chamfered to allow easy angular movement. These are retained by means of the cylinder nut (23), which is again locked by a setscrew, and this end of the cylinder is closed by the cylinder end cap (18) and adjusting plug (41). The bottom end of the cylinder is closed by a gland consisting of nut (8), gland ring (82) and packings.

The cylinder is divided into two parts by a bulkhead called the displacement head (26) which is located by the spring ring (14) and the chamfered nut (37). The part of the cylinder below the displacement head forms a working space for the piston and the part above acts as an oil reservoir. Ball valves (34) in the displacement head keep the working space full of oil from the reservoir.

The piston head (60) is positioned on the piston rod (2) by the piston head nut (59). The spring loaded plate valve (31) works on the compression stroke, the initial spring compression being set on assembly by the adjusting plate (13) which is screwed on to the plate adaptor (27) and locked by a spring ring. The spring loaded piston valve (15) works on the rebound stroke, adjustment being provided by the screw (35). Screwed into the piston head is a coupling (22) which carries, by means of a spherical joint (12 and 21), the extension rod (19). This extension rod mates with the adjusting screw (35) and therefore rotation in relation to the piston rod and piston will turn the adjusting screw and alter the adjustment of the unit. The piston valve adjustment is set on electrically timed apparatus and should not be disturbed. The piston rod (2) passes out through the cylinder via packing to the lower anchorage (3). Dust covers (10 and 11) prevent the ingress of dust.

CHAPTER IV B

Steering and Brakes

PART 1. STEERING GEAR

Steering is by control of the front wheels, through linkage connecting the short swivelling extensions of the fixed axle and operated by hand wheel via a steering gear unit of the cam and roller type, which reduces the physical effort required.

The steering wheel is keyed and secured to the top of the steering column and at the lower end a spiral cam is brazed and pinned. This cam and the peg, which works in the cam, are housed in the steering box (see Fig. 66).

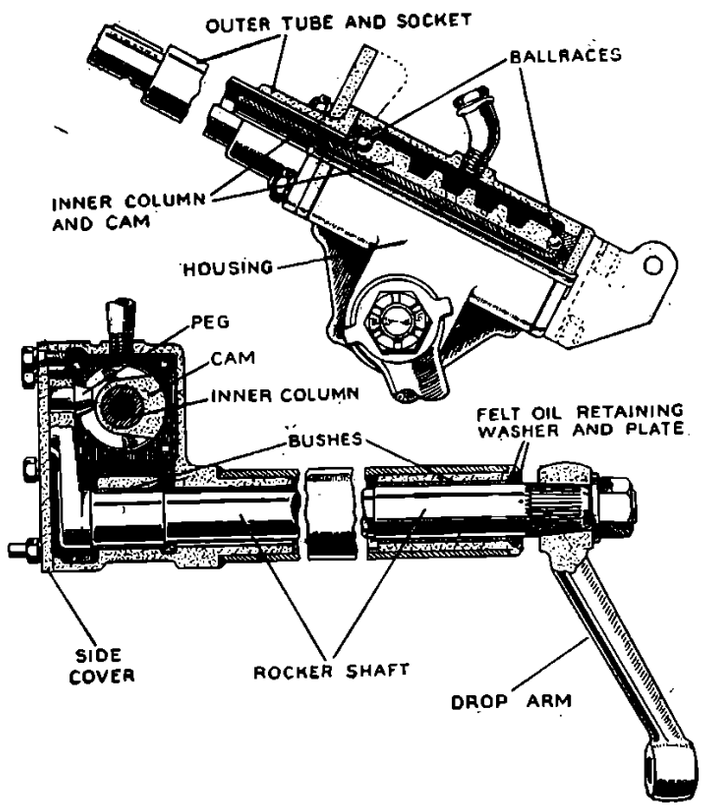


Figure 66. Steering Gear in Section

The cam is mounted on two ball thrust races, one at each end. The end of the cam forms the inner path, while the outer races are formed by cups pressed into the steering box and pegged.

The steering box containing the cam is bushed to carry the rocker shaft (see Fig. 66), the end of which is in the form of an arm drilled to take the peg (or roller). The end thrust of the rocker arm is taken on the inner face of the steering box side cover.

The opposite end of the rocker shaft is tapered and serrated to take the " steering drop arm," which is held in position by a nut, split pin and washer with lugs, to facilitate withdrawal.

When the inner column and spiral cam are rotated by the steering wheel, the peg travels up or down the scroll of the cam and imparts motion to the rocker shaft. This in turn causes the steering drop arm to move backwards or forwards according to the degree of rotation of the steering wheel.

There is a ball pin secured in a taper seating on the bottom of the drop arm, which works in a socket joint with a spring cushion in the side steering rod, the rear ball pin works in the top right hand steering arm. A similar steering arm is fixed to the bottom of the housing in which the top right steering arm is fixed. The lower arm is connected to the left hand steering arm by the track rod (see Fig. 67), which is capable of adjustment so that the wheel tracks can be kept parallel.

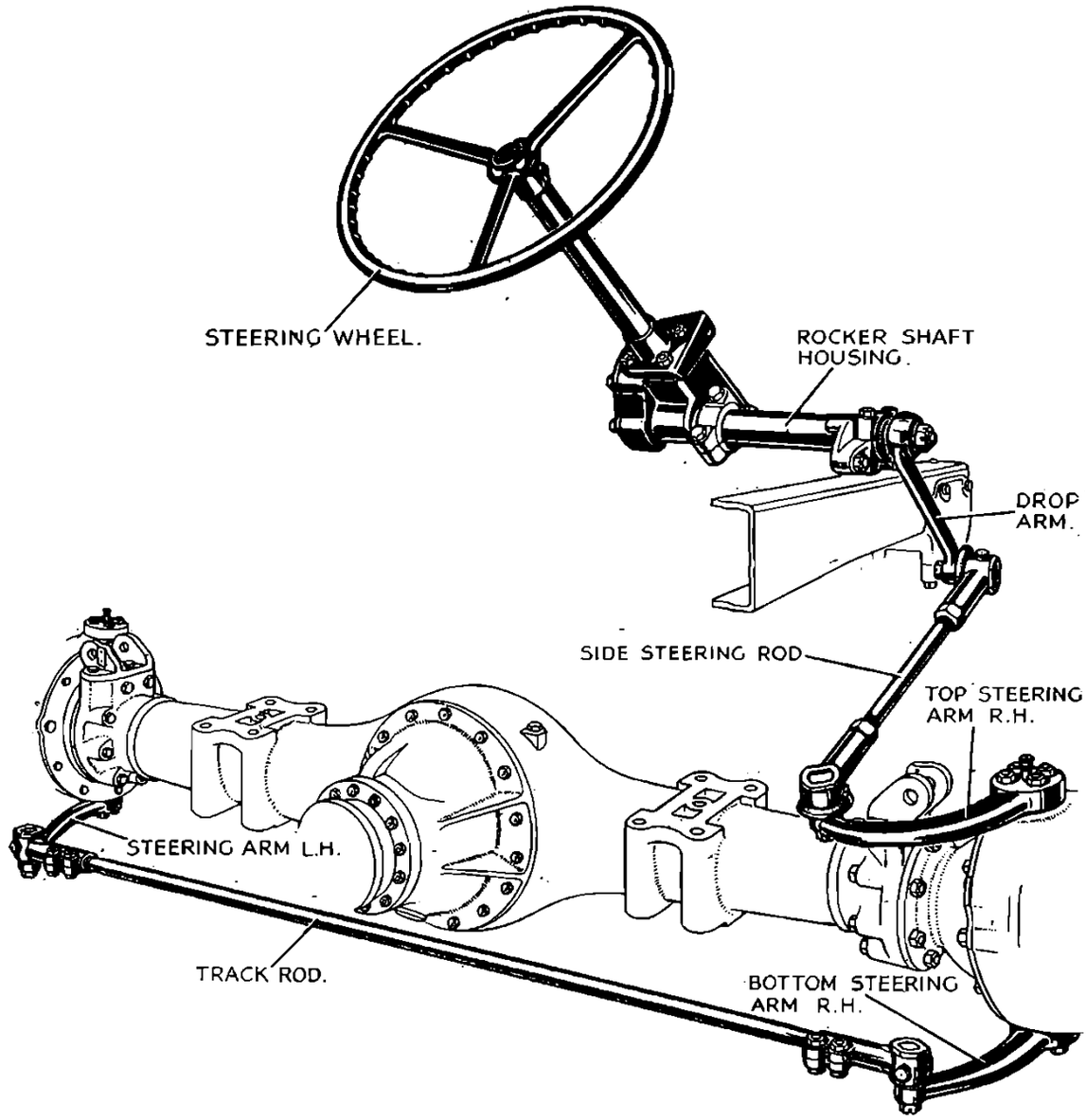


Figure 67. Layout of Steering

PART 2. BRAKE LINKAGE

Brakes of identical dimensions are fitted to all four wheels and are hydraulically operated by foot pedal. A handbrake, applied by rod and cable operates on the rear wheels only.

The system consists of an integral tandem type master cylinder and supply tank, in which fluid pressure is generated, wheel cylinders which transmit fluid pressure to the brake shoes and a pipe line consisting of tubing, flexible hoses and unions connecting the cylinders.

Fluid is incompressible ; therefore, when the foot pedal is operated, the pistons in the master cylinder apply a force to the fluid in the system which causes the wheel cylinder pistons to expand the brake shoes.

When all the brake shoes are in contact with the drums, solid resistance is obtained at the pedal. Further effort on the pedal generates high pressure in the master cylinder and throughout the system, thereby increasing the force applied to the brake shoes.

The pressure generated in the master cylinder is transmitted with equal and undiminished force to each wheel cylinder, thus producing perfect equalisation and efficiency in direct proportion to the effort applied at the pedal.

When the pedal is released, the brake shoe return springs force the wheel cylinder pistons, and therefore the fluid, back to their original positions in the system.

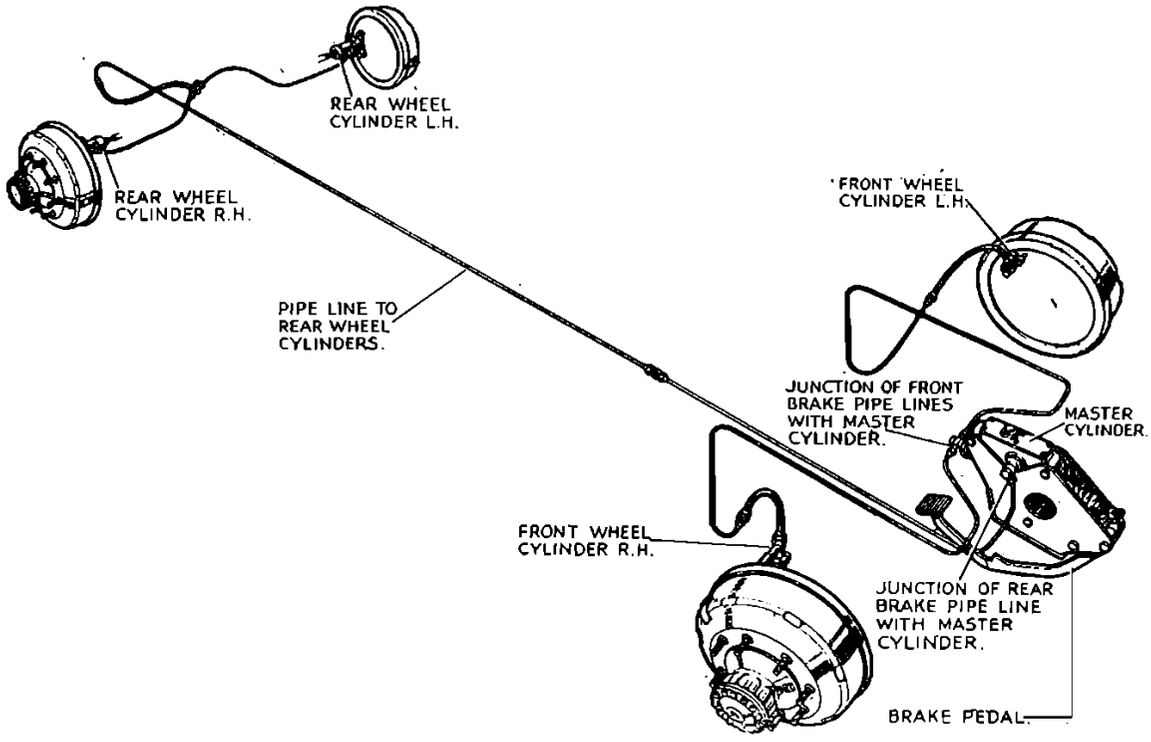


Figure 68. Layout of Brake Pipe Line

For the sake of clarity each unit of the braking system is dealt with individually below.

The master cylinder (Fig. 69) is mounted to the right of the steering column, on a rigid bracket which also includes the fixing for the foot pedal to which the push rod (A) of the cylinder is connected.

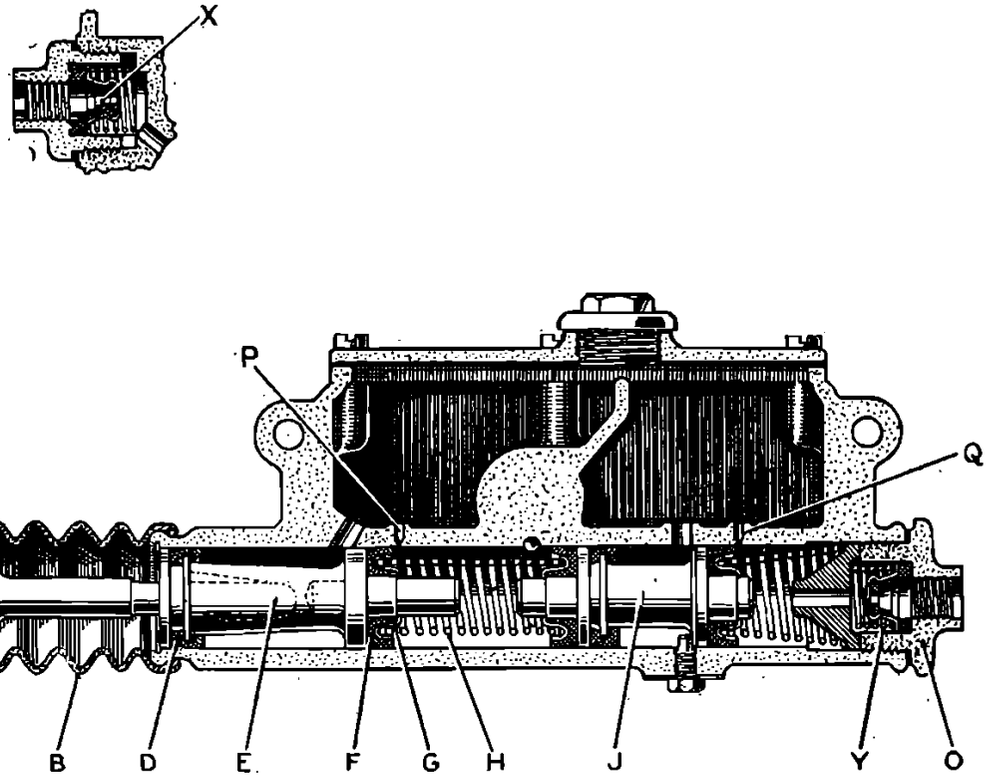


Figure 69. Master Cylinder

Behind the piston is the main cup (F), retainer (G), and the retainer spring (H) and as the piston moves, it forces fluid through the double check valve (X) and the pipe line to the rear wheel cylinders.

Further movement of the piston (E) forces the secondary piston (J), which is a floating piston, to move, and so fluid is forced via the double check valve (Y) through the cylinder head (O) to the front axle brakes.

Immediately behind the piston and at the bottom of the supply tanks are two by-pass ports (P and Q) which allow the system to compensate freely for any expansion or contraction due to temperature changes. They also serve to release excess fluid drawn into the pressure chamber from the annular space formed by the piston skirt after each brake application.

On the release of the brake pedal, a vacuum is created in the pressure chamber by rapid return of the piston (E), which causes the master cup (F) to collapse and fluid to be drawn via the small holes in the piston head. As the system comes to rest, due to the action of the brake shoe return springs, this excess fluid passes freely to the supply tank via the by-pass ports (P and Q).

In the head of the master cylinders are double check valves (X and Y), which consist of a perforated metal body to which is attached a rubber valve seat, and inside the body a small rubber cup which seals the perforations. The function of these valves is to prevent fluid from returning to the master cylinder during bleeding (*i.e.* expelling air when filling the system), thus ensuring a fresh charge is delivered at each stroke of the pedal.

The action of the valves under normal braking conditions is as follows :—On depressing the brake pedal, the piston forces fluid through the perforations in the valve bodies, causing the internal cup to collapse and create a free passage.

On releasing the pedal the action of the brake shoe return springs causes the fluid delivered to the wheel cylinders to be returned to its original position in the system, and the returning fluid lifts the complete valve assemblies to allow free passage, until the pressure it exerts is overcome by the piston return springs, when the valves close.

The open end of the cylinder is fitted with a rubber boot (B) to prevent the ingress of dirt, whilst the piston is fitted with a secondary cup (D) to prevent leakage of fluid into the boot.

The front wheel cylinder (Fig. 70) on first production models consists of an adaptor cylinder and a cap, bolting directly on to the shoe expander housing on the outside of the brake back plate, with a rubber joint ring between the adaptor and the cylinder cap. On later vehicles the cylinder is a one piece housing.

A rubber cup acts as a pressure seal, and on early vehicles there is a button extension on the end of the expander plunger which fits into a recess in the cup and thereby maintains contact between the two. On later models this button extension is not used and a spring is fitted between the cup and housing.

In the uppermost portion of the cap or housing is a bleeder screw which is used when expelling air from the system during the filling operation. The open end of the bleeder screw is sealed by a rubber cap against the entry of mud. Immediately below the bleeder screw is the inlet to the cylinder, to which is connected a flexible hose forming part of the pipe line.

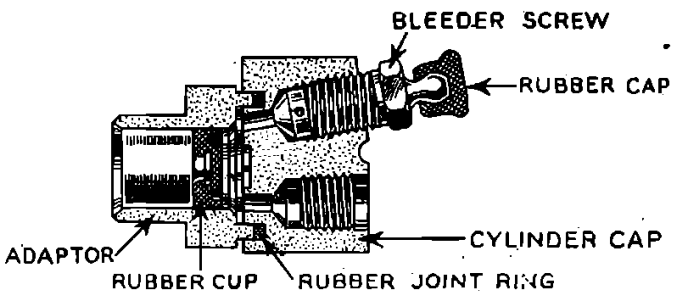


Figure 70. Front Wheel Cylinder

The action of the cylinder is as follows :—On depressing the brake pedal, fluid is forced into the cylinder and pressure is exerted on the rubber cup, thus pushing the expander plunger which in turn actuates the brake shoes. On releasing the pedal the brake shoe return springs cause the expander plunger and cup to return to their original positions.

The rear transverse cylinder (Fig. 71) is bolted rigidly on the outside of the brake back plate, being connected to the shoe expander by means of a draw bar.

The cylinder consists of a cast body (A) which forms the fluid operating chamber and a housing for the draw link assembly (E). The keeper pins (F) prevent rotation of the draw link but allow free endwise movement up to the limit imposed by the circlip (H). The open end of the cylinder is sealed by a rubber boot (G).

The fluid operating chamber is fitted with opposed rubber cups (B) separated by a sleeve (C). One cup is backed by the piston (D) whilst the other forms a seal round the piston stem. Passing through the stem of the piston is the brake expander draw bar which is connected to the draw link assembly (E). The draw bar (J) forms the connection for the hand brake.

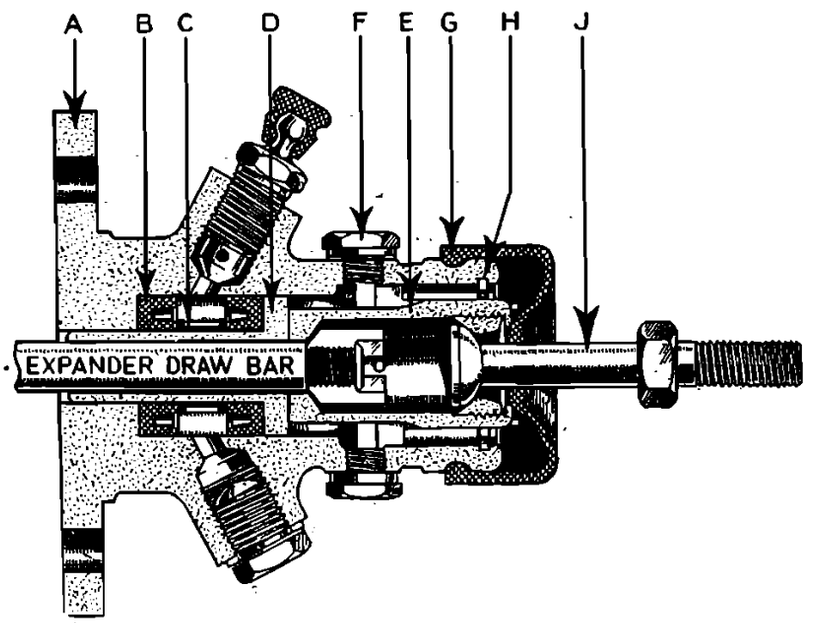


Figure 71. Rear Transverse Wheel Cylinder

The action of the cylinder is as follows :—On depressing the brake pedal, fluid enters the operating chamber between the opposed rubber cups and forces the piston along the bore carrying with it the draw link (E), which in turn pulls the expander draw bar and actuates the brake shoes. This action takes place without disturbing the hand brake draw bar (J).

On releasing the brake pedal, the brake shoe return springs cause the expander draw bar to be retracted, thus returning the piston and draw link to their original positions.

Operation of the hand brake does not disturb the piston (D),

PART 3. BRAKES

It will be seen by reference to Fig. 72 that the shoes are rigidly located only at the opening ends. The floating ends of the shoes are connected by an adjuster and automatically held central in relation to the brake drum by a spring centraliser.

The brake is operated by movement of a ball plunger through the housing, this in turn causes two hardened steel balls to roll down the inclined planes on the ends of the tappets, and by reason of the angle, cause the primary shoe to be pressed against the drum.

The primary shoe is the one directly following the plunger housing in the direction of rotation of the wheel, the secondary shoe obviously being the other shoe in the individual brake assembly.

This system of operation is almost frictionless owing to the use of the hardened steel balls, and as the inclined faces of the shoe tappets have a fixed angle, the leverage is constant irrespective of the position of the plunger in relation to the tappets.

The brakes are completely self-centralising by means of a coiled wire spring, which is held in the steel housing mounted adjustably on the back plate.

Once set, no further attention is required to this device, it always automatically returns the shoe to a central position when the brakes are released.

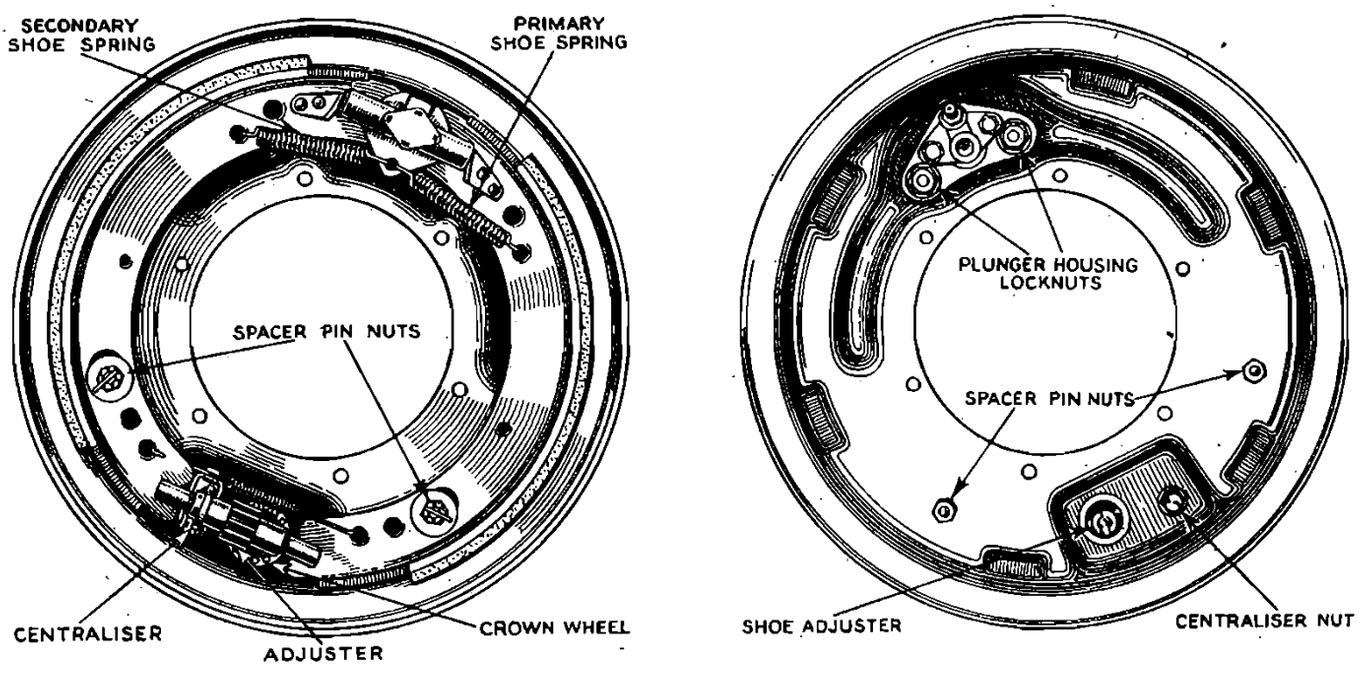


Figure 72. Front Brake—Internal and External Views

CHAPTER V B

Electrical Equipment

The electrical equipment is divided into three separate sections and each is dealt with individually below. This method ensures clarity of description, although it must be borne in mind that in certain cases each unit is so much a part of the whole that no definite dividing line can be laid down.

The three main divisions covered by parts 1, 2 and 3 of this chapter are lighting, starting and charging and the various units used are grouped under the heading to which they are applicable.

PART 1. LIGHTING

Lamps fitted on the exterior of the vehicle comprise a headlamp, two side lamps, a tail lamp and a convoy lamp ; all these being controlled from the main switch box except the convoy lamp which has a separate switch. A spot lamp is also fitted to the vehicle and the switch for this is on the inside of the turret front plate.

Interior lighting is provided by roof lamps in the turret and a lamp fitted to the side of the instrument panel.

Oil and ignition warning lights are also fitted in the instrument panel which is illuminated by interior bulbs. The warning lamps are automatically controlled, but the remainder have separate switches.

The instrument panel is illustrated in Fig. 73 and incorporates a switch board (1) from which connections to the driving lights are taken through the main fuse box. The control switch is of the rotary type and makes contact with the various terminals as it is turned to the positions indicated on the face plate.

The ignition switch when turned to the " on " position connects the ignition coil to the positive battery terminal. It also lights both the warning light (13) and connects the starter push (4) to the positive battery terminal.

Ammeter (8), which is connected directly to control board and battery cut-off switch, is in the main positive circuit and as the panel is used in conjunction with a control board operating on the current voltage control system, the ammeter will register a constant current until the battery is approximately three-quarters fully charged, after which it will fall off gradually until reaching a trickle charge value, as the battery becomes fully charged.

A starter push (4) receives its positive feed through the ignition switch to which it is internally connected. With this arrangement the starter push cannot be operated until the ignition switch is on.

The horn push (5) is connected one side internally to battery positive on switchboard and the sockets for inspection lamp plug (7) are connected directly across battery positive and negative on the switchboard and are not, therefore controlled by any switches in the panel. Festoon lamp (10) is also connected to battery positive and negative, but is fitted with a self-contained " on " and " off " switch.

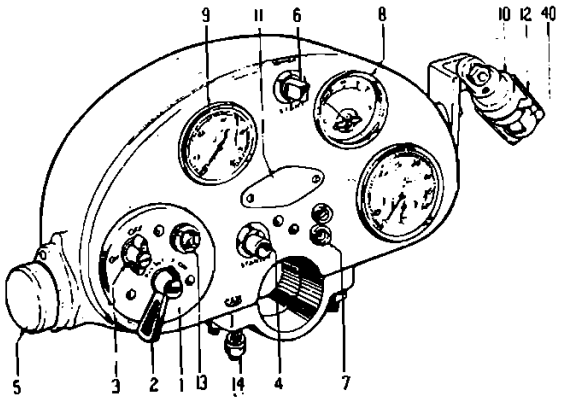


Figure 73. Instrument Panel, Front View

A panel light for internal lumination of the instrument is fitted below the cover plate (11). It is controlled by the switch (6) marked " light " at the top of the panel.

PART 2. STARTER

The starter motor is of simple, robust construction and is specially designed to give the large torque which is necessary for turning an internal combustion engine. It is of four pole design and both the field coils and armature are wound with the large section conductors necessary to carry the heavy currents required for starting. The brushes are of a special copper graphite compound of low resistance in order to reduce losses.

The starter is provided with an extended shaft on which is mounted the drive unit which automatically engages a pinion with the engine flywheel ring when the starting control is operated and which disengages the drive when the engine is running.

The drive embodies a combination of a rubber torsion member and a friction clutch, in order to control the torque transmitted from the starter to the flywheel and to dissipate the energy in the rotating armature of the starter at the moment when the pinion engages the flywheel. It also embodies an overload release mechanism which functions in the event of a very heavy backfire, or if the starter is inadvertently meshed into a flywheel rotating in the reverse direction.

The drive is designed so that the pinion rides directly on the armature shaft instead of being mounted on the screwed sleeve, as on the more familiar types of drive. This allows the pinion to be reduced in diameter and to have a smaller number of teeth, thus giving a greater gear ratio between the starter and the engine. The starter can now operate at a higher speed and give more power with a lower current consumption and a greater efficiency at this higher speed.

The drive is a self-contained unit, being assembled on to a sleeve which may be withdrawn complete from the armature shaft. The torque from the starter shaft is transmitted in the first instance through a key into the sleeve on which the drive is mounted. Projections on a transmission plate locate in slots in the sleeve and the transmission plate is keyed through dogs to the outer tubular member of the coupling. Between this tubular member and the inner sleeve is mounted the rubber torsional bush which is so assembled as to press tightly against the inner surface of the outer sleeve, and the outer diameter of the inner sleeve.

The end of the inner sleeve, remote from the transmission plate, has formed on it two projections which engage with slots in a sleeve, on the outer surface of which is cut a screw thread. The screwed sleeve has, in addition, a further pair of slots into which engage corresponding projections on a steel washer. A control nut which is internally screwed, is mounted on the screwed sleeve and the driving barrel carrying the pinion is secured through dogs to the control nut.

When the starter is energised, the torque is transmitted through the transmission plate, outer sleeve, rubber torsion bush, inner sleeve and screwed sleeve to the driving barrel and pinion.

The control nut travels along the screw thread and the pinion engages with the flywheel in the usual manner. The reaction on the screwed sleeve causes it to move backwards along the shaft and increases the pressure between the steel washer and the outer sleeve of the rubber coupling, between which is mounted a phosphor bronze friction washer. The friction between the steel washer and the outer sleeve, via the friction disc, also serves to transmit torque from the starter to the pinion, so that in addition to the amount of the torque transmitted directly via the rubber bush, a further additional torque is taken through the friction washer.

The drive incorporates a relief spring which enables the pinion to work its way into engagement with the flywheel, should the teeth meet end to end, and a pinion restraining spring to prevent the pinion from being vibrated into mesh when the engine is running.

In order to reduce the length of the starting cable and subsequent voltage drop, a solenoid operated switch is provided which is mounted on the commutator end bracket of the starter and is controlled by a small push switch.

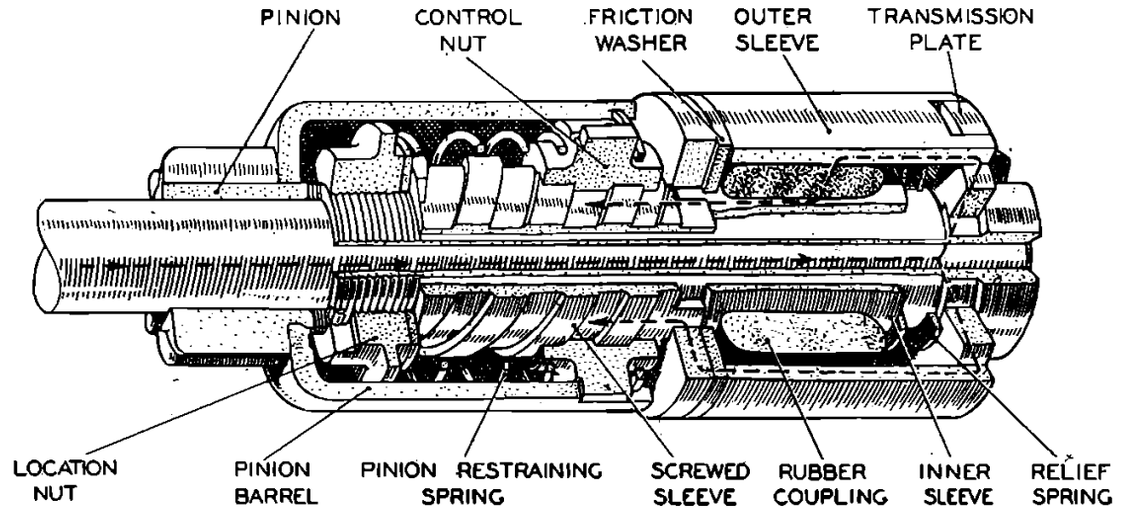


Figure 74. Starter Drive showing Paths taken by Driving Torque

This solenoid switch incorporates an electro-magnet of tubular shape in the centre of which is fitted a cylindrical plunger. A rod is screwed into the end of the plunger and this carries a spring-mounted copper contact disc. Two insulated copper contacts are provided in the bracket of the starter, one being connected direct to the battery and the other to the starter field coils and brushes. When the push button is operated, the electro-magnet is energised and the plunger moves against the influence of a spring so that the contact disc is pressed on to the two contacts in the end bracket and so completes the circuit from the battery to the starter motor. When the push button is released the electro-magnet is switched off and a spring restores the plunger and contact disc to their normal positions.

PART 3. CHARGING

Charging of the batteries is carried out by a dynamo working in conjunction with a control board on the constant voltage system. The system is so called, because a partially charged battery receives a constant current until a certain battery voltage is reached when the charging changes to constant voltage control. It has already been pointed out in Section " A " that a constant charging current will be registered on the ammeter until the battery is approximately three-quarters charged, after which the charging rate gradually falls off until it reaches a figure representing trickle charge.

The dynamo is a 12 volt machine fitted with four brushes in two dual brush holders. Rotation is clockwise looking on the driving end. It has four poles, and is fitted with plain-wound field coils shunt connected in the normal manner.

Two condensers are fitted in the terminal box and connected to the main positive and negative terminals. The second and body connections to the condensers are connected together and earthed to the side of the terminal box. An earth terminal connection is provided on the outside of the terminal box.

The following table shows the dynamo rating :—

Cutting-in speed 600 r.p.m.	Lamp load 25 amps.
Maximum load 33 amps.	Maximum load speed 950 r.p.m.
Weight 60 lbs.	Outside diameter $6\frac{1}{2}$".

Ball bearings are fitted at both ends of the armature. These bearings are packed with grease and do not require any attention during running.

The control board shown on Fig. 75 is fitted with an open regulator and separate cut-out. The regulator operates on the current voltage control system which requires a cut-out (31), current regulator (2) and voltage regulator (1). These latter two are made as one unit.

The function of the cut-out (31) is to connect the dynamo to the battery when the engine speed has risen to such a value that the dynamo voltage is higher than that of the battery and to disconnect it when the speed has dropped to such a value that the battery starts to discharge through the dynamo, thus attempting to drive it as a motor.

When the dynamo is stationary, or generating an insufficient amount through the shunt coil to attract the armature, the cut-out contacts are open. No connection exists therefore, between the dynamo and the battery positive, the battery is not being charged nor can it discharge back through the dynamo.

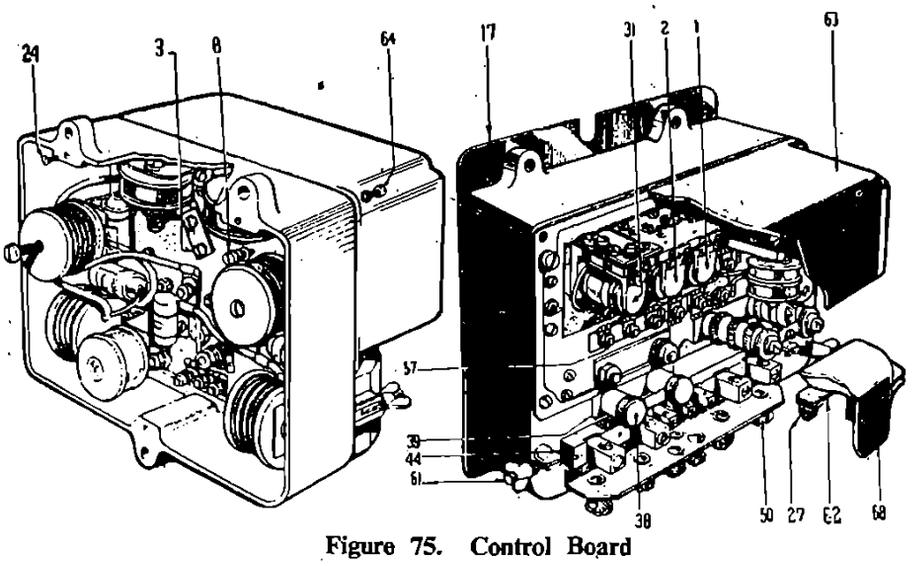


Figure 75. Control Board

When the dynamo speed is increased the shunt coil is energised a sufficient amount to attract the armature and so close the contacts. The dynamo current will take the path of least resistance and pass through the series winding to battery positive.

If the dynamo speed drops, its voltage will eventually become less than that of the battery. At this point the battery voltage overcomes that of the dynamo and current flows in the opposite direction to the previous charging circuit through the series winding. This releases the pull on the armature so that contacts are opened.

With the engine running just above cutting-in speed, the current passing through cut-out and current regulator series windings assists cut-out shunt to hold cut-out contact closed, but is insufficient to attract the regulator armature and so open the regulator points. The dynamo, therefore, has full field strength.

With engine running fast enough to cause the dynamo to generate its full output, the current regulator armature is attracted and the points are opened. The full current is weakened by being diverted through the bucking resistance coil and the charging current is reduced correspondingly. The regulator contacts then reclose and the cycle is repeated rapidly. (Approximately 100 per sec.) The regulator is set to operate under a given load and not under voltage.

When the battery reaches a partially charged condition and the voltage rises, the voltage regulator points commence to vibrate and do not allow the voltage to rise any further. The charging rate commences to fall and the current is insufficient to open the current regulator contacts. The current regulator goes out of action and the dynamo is controlled by the voltage regulator. The current then falls as the battery becomes more and more fully charged until finally a condition of trickle charge is reached.

The strip type fuse is connected in the main dynamo positive circuit.

The battery is a reservoir in which electrical energy is stored during the periods when the dynamo is charging, so that it can be used for operating the starter motor, lights or other electrical apparatus when the engine is not running.

Each battery comprises three separate cells containing a group of positive plates consisting of grids filled with " lead peroxide " joined by a lead bar to a terminal post. Interleaved are negative plates, the grids of which are filled with " spongy lead " and joined to another lead bar and terminal post.

Separators, which are sheets of grooved wood, rendered porous by special chemical treatment, are fitted between the positive and negative plates to prevent them touching and causing an internal short circuit.

The cells are fitted with liquid electrolyte, consisting of pure sulphuric acid diluted by water to the required strength. This strength is known as " specific gravity."

The terminal posts of each group of plates are joined together with lead connectors, the positive of one cell being connected to the negative of the next. This means that as each cell has a reading of approximately 2 volts, then the voltage of the complete battery is 6. Two batteries are joined together in the same way to provide the 12 volts upon which the system operates.

As the battery is discharged, the sulphuric acid combines progressively with the active material in the plates and converts it to lead sulphate. The strength of the electrolyte consequently falls, *i.e.* its specific gravity falls in proportion to the ampere-hours of discharge taken out.

If the battery is discharged too low or is left standing in a discharged condition, the sulphate in the plates will harden and make it difficult to recharge. Discharging at high rates for short periods, however, does no harm.

The nominal capacity of a battery is expressed as the ampere-hours which it will give in 10 hours, starting about 2.0 volts per cell and continuing down to a minimum of 1.83 volts per cell. Thus a 150 ampere-hours battery is one which will give 15 amperes continuously for 10 hours. A slightly greater capacity is obtainable at slower or intermittent rates.

With heavier discharge, the obtainable capacity is reduced, and the voltage is lower throughout the discharge because there is a greater drop due to internal resistance ; both these points are accentuated at low temperatures.

When the battery is recharged, the action is exactly the reverse of that on discharge. Acid is driven out of the plates into the electrolyte. The plates go back to their original composition and the electrolyte recovers its original specific gravity. When the battery approaches the fully charged point, the plates can no longer absorb all the charging current and the excess produces " gassing." This means that electrolysis of the water content of the electrolyte is taking place, *i.e.* it is being split up into oxygen and hydrogen which are given off from the positive and negative plates respectively.

This mixture of gases is explosive. It is, therefore, essential never to bring a flame or spark near the battery at any time, but particularly during or shortly after charge.

An idle battery gradually loses its charge by internal action, to the extent of about 1% of its capacity per day (less than this on a brand new battery, more on a very old one). Hence a fully charged battery, if it is allowed to stand idle for a month, will be only about 70% charged at the end of that time.

To counteract this loss of charge, an idle battery should be given a freshening charge at the normal rate at least once every month. The alternative method of trickle charging continuously at a very low rate is not suitable for the type of battery used on W.D. vehicles, as it causes rapid deterioration if maintained for any length of time.

CHAPTER VI B

The Hull

The hull is made of nickel chrome molybdenum steel and accommodation is provided for three men, the driver, commander/loader and gunner.

The driver is provided with adequate vision facilities and the operation of these facilities has been thoroughly dealt with in section " A." The engine access door jack, by the operation of which rear vision is obtained, is dealt with in detail in this section.

Conveniently situated round the hull is most of the equipment necessary for the vehicle to be kept in battle order, although a certain amount of this material is stowed in the turret.

PART 1. DOORS

Access to the inside of the hull is by means of a door on the left hand side and an internal catch is provided ; an outside detachable key is supplied so that the door can be locked when the vehicle is left unattended.

The right hand door on later vehicles is permanently fastened by means of the spare wheel carrier and those early vehicles not originally constructed in this condition are to be modified in service.

PART 2. THE DRIVER'S WINDOW

The driver's window is hinged at the top and operated by a lever on the inside of the hull. Tension springs are used to balance the weight and provide easy operation.

Two guides are fitted to hold the bullet-proof block or emergency screen containers. A thumb catch is fitted to enable these containers to be changed with the utmost speed.

On the outside is a visor plate which is actually a hinged bullet-proof shield and can be dropped in front of the vision orifice. Six slots are cut in this plate to provide vision and at the same time the driver is afforded full protection.

PART 3. THE ENGINE ACCESS DOOR JACK

The hydraulic system for operating the engine access door consists of a hand pump and a separate feed tank, situated on the right hand side of the driver, together with a ram fitted at the rear of the engine compartment.

Its operation is such that when the pump handle is worked, fluid is drawn from the supply tank through a filter (A) (see Fig. 76) in the pump cover into the pump itself, where it is forced by the action of the handle into valve chambers (B and C), via non-return ball valves (D and E). The ball valves are duplicated in order to prevent any possibility of dirt rendering the pump inoperative. The valve chambers are interconnected into a release chamber (F). By this means the fluid delivered into either valve chamber can pass via the release chamber into the opposite valve chamber.

The fluid then passes through another filter (G) into the pipe lines and so to the jack itself.

When the ram is fully extended, excess pressure developed in the pump passes into the pump body through a spring loaded relief valve (H).

When the release valve on top of the pump is opened, the fluid from the jack passes back into the valve chambers through a return flow valve. This valve is fitted with a rubber sleeve which prevents any fluid from flowing through the pump when the delivery line has been disconnected.

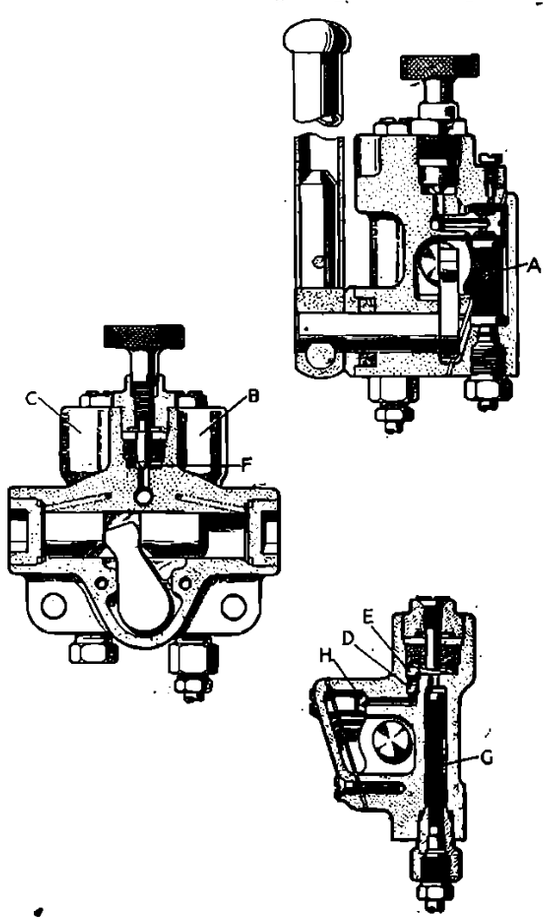


Figure 76. Engine Access Door Jack

CHAPTER VII B

The Turret

The turret, which is situated amidships, is made of armour plate and welded construction is used throughout. It is mounted on large ball bearings and there is no restriction on rotary movement.

PART 1. HEADFLAPS

Observations flaps are provided for both the commander/loader and the gunner, and these serve as look-out points when the vehicle is not in action. The flaps are formed in two pieces, hinged in the middle and a torsion bar is fitted in the main hinge so that, when the catch holding them in an open position is released, they partially close automatically. This improves the speed with which they can be closed and will be found very necessary should surprise action be engaged.

PART 2. PERISCOPE

The periscopes (Fig. 40) are mounted in the turret top plate, one being provided for the commander/loader and another for the gunner. They are made up of two independent parts, namely the eye-piece and the objective piece. The eye-piece, which is one with the periscope mounting, is fixed, whilst the objective piece is easily interchangeable.

The eye-piece is situated in a mounting attached to a trunnion by a hinge and a locking piece. The objective piece is placed in the housing provided in the trunnion and the locking piece is then closed. The periscope is then ready for observation.

Looking through the opening of the eye-piece, the panoramic image is seen, which reaches the periscope through the opening of the objective piece projecting through the roof of the turret. The trunnion moves in upper and lower bearings, allowing the periscope to be inclined in the vertical plane to enable observations to be made in the fields of view at more or less remote distances. The trunnion can be locked by means of lateral setscrew. The trunnion and its bearings rotate in a flange, allowing the periscope to be turned through 360° in the horizontal plane by means of two handles. This movement can be locked in any position by means of a vertical setscrew.

A shield of bullet-proof steel protects the projecting part of the instrument against the effect of projectiles. This shield is mounted on the upper trunnion bearing by means of two fixing screws and has a recess in the direction of the opening of the objective piece. The objective piece is thus only exposed to the projectiles arriving from the line of vision.

In the event of damage, the objective piece can be easily and rapidly replaced by a spare, six of which are carried in each vehicle. The shield is provided with a cover to protect the instrument against rain and dirt.

An additional sliding prism is fitted on the eye-piece mounting for observation to the rear without the necessity of the observer turning round.

CHAPTER VIII B

Turret Traverse

The traverse gear shown on Fig. 41 is a single speed type, manually operated, and is designed to operate with an internal spur turret ring. It has a reduction ratio of 69.4 to 1 and is operated by means of the trigger (G) which, when squeezed, disconnects the plunger (E), allowing the drive to be taken through the gears H, J and K to the internal spur turret ring.

Immediately the trigger is released, the plunger (E) is thrust into engagement with one of the countersunk holes in the locking ring (F) by means of the spring (M) and the gearing is locked.

The whole of the unit is mounted on a fixed bracket and is spring loaded at (B) to keep the driving gear in mesh with the internal ring (D) so providing an easy means of adjustment to the centre distance of the gears.

CHAPTER IX B

The Guns

THE 37 M/M GUN

The 37 m/m gun (M.6) is a flat trajectory Q.F. gun adapted from the field gun type for use in armoured fighting vehicles. High explosive or armour piercing fixed cartridges are used, firing projectiles which weigh about two pounds. The gun is semi-automatic in that the breech block is actuated by breech operating mechanism to open and eject an empty round and is automatically closed upon manual insertion of a round into the breech, by a closing spring.

The barrel (see A, Fig. 77) is a one-piece forging with rifled bore threaded externally to screw into the breech ring (B).

Two bearings, one near the breech end and one at mid-length, support the barrel and align it in the yokes (C), (D) of the sleigh.

The front bearing is threaded for a lock nut (E) to secure the barrel in position. Keyways engage keys in the yoke to prevent rotation of the barrel.

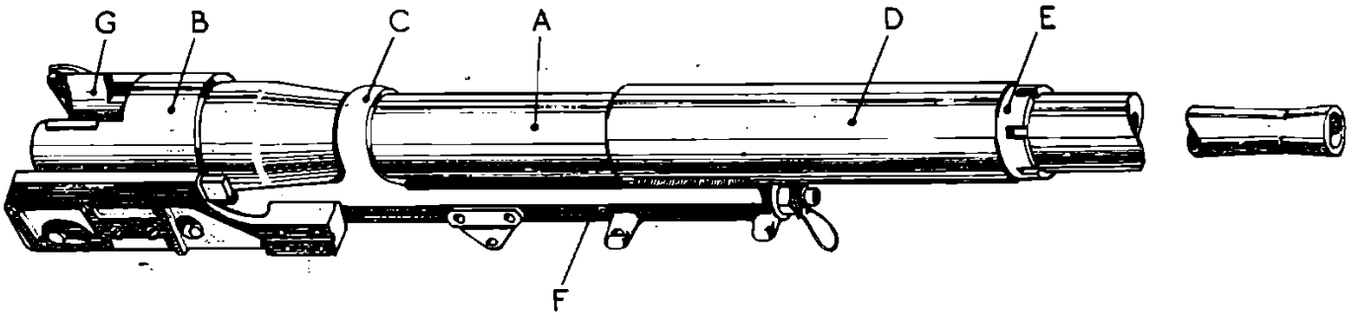


Figure 77. The Barrel Group

The breech ring (B, see Figs. 77 and 45) is bored and threaded in front to receive the barrel (A), which is secured and located by a locking key. The lugs (B, Fig. 45) on the bottom of the breech ring, provide means for attaching the breech ring to the recoil mechanism (F). A further pair of lugs on the breech ring (C, Fig. 45) are bored to receive the lever arm shaft.

The rear half of the breech ring (B) is slotted vertically to receive the breech block (G). The rear of the breech ring is U-shaped to facilitate loading. The cylindrical studs (A, Fig. 45) inside the ring serve as extractor pivots. The hole through the lower left wall forms a bearing for the trigger and an inner counter-bore provides a pocket for the tripper.

The lower part of the breech ring is recessed on each side of the bore to form extractor pockets, and each pocket has a recess to hold the extractor springs and plungers.

The closing spring housing (F, Fig. 42) is formed on the left forward end of the breech ring.

The extractors (see F, Fig. 44) are positioned against the side walls of the breech ring recess. The lips (G) of the lower upper arms lie in pockets on each side of the chamber and engage the flange of the cartridge.

Lugs (H) on the lower arms project inward to engage cam surfaces of the breech block (A, Fig. 78). The lugs are held to the front by the extractor plunger springs (D, Fig. 44) and lock the breech block in the open positions by engaging the locking studs (B, Fig. 78) on the face of the breech block. Two holes in the rear face of the breech ring (see Fig. 45) contain the extractor springs and plungers.

The breech block (see Figs. 78 and 44). The large centre passage (J, Fig. 44) in the breech block houses the firing pin guide assembly and firing springs (K). The breech block bushing (C, Fig. 78) is screwed into the forward end of the passage and machined off.

The interrupted collars formed within the passage form a bayonet joint to hold the firing spring retainer (L, Fig. 44) and prevent rotation. Grooves in the passage receive and guide the cocking and sear lugs (M) of the firing pin guide.

The bottom of the breech block is cut from front to rear by a T-slot (D, Fig. 78), which inclines downward to the rear. The crank trunnions (N) slide in the T-slot to raise and lower the breech block. The top of the block is U-shaped to guide the shell into the chamber and presents a bevelled frontal surface to force the shell home as the block rises. The left side of the block is recessed and bored to receive the sear arm (E, Fig. 44) and sear spring. A further recess is formed at upper left side of the block to receive the cocking lever. A hole in the rear face of this recess, houses the cocking lever plunger and spring. Portions of the right and left sides of the breech block are cut away to reduce weight. Locking studs (B, Fig. 78) are provided on the breech block face to hold the breech block in the open position. Two stopping lugs (E) on the rear base of the breech block stop its upper movement.

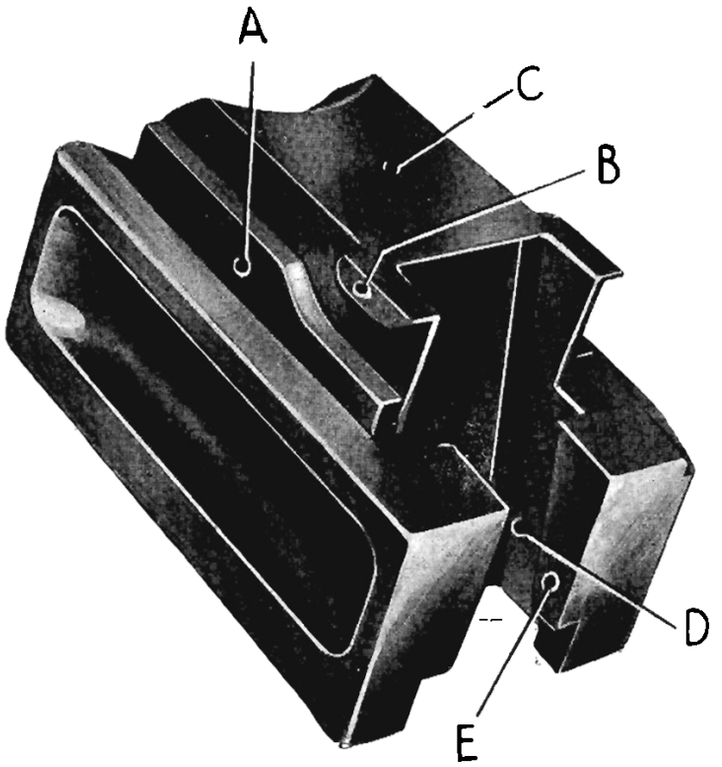


Figure 78. Breech Block

Firing Mechanism (see Fig. 43). The firing spring (C) bears rearward on the retainer (A) and forward on the stop (J) of the firing pin guide assembly (H).

The sear (K) is notched for engagement of the sear lug (L) of the guide and, with its spring, is passed transverse through the breech block and secured.

The cocking lever pivots in a hole in the upper left side of the breech block. The upper arm projects from the block and terminates above the rear wall of the breech ring. The lower arm terminates in a lug which engages and forces the firing pin guide rearward to cock the mechanism.

A plunger (M) and spring (N) return the lever to position as the upper end thereof is released.

The tripper (O), trigger (P), trigger plunger and spring are supported in the breech ring. The operating arm of the tripper extends upward and has a cam surface for actuating the sear. The lower arm of the tripper has a horizontal safety lug, which, in the idle position of the trigger and tripper, extends inward below and forward of the left lower edge of the breech block. When the block in lowered its lower edge takes up a position behind the lug of the tripper and prevents its actuation when the breech is open. The trigger is mounted on the hub of the tripper.

The trigger consists of a tapered arm with a hollow cylindrical hub which enters a hole in the breech ring. The trigger plunger and spring which are seated in the cheek of the breech ring, retain the trigger in position and return it after firing.

Closing spring assembly (see Fig. 43). The closing spring (Q) is mounted on a rod (R) and disposed with a housing (S), the rod being connected by a link (T) to the lever arm shaft (Fig. 45) which in turn is keyed to the bearing sleeve of the operating crank. The spring is placed under compression when the breech block is lowered and automatically raises the breech block when the latter is released by the introduction of a round into the breech.

Action of the mechanism

First phase—loading. As a round is inserted into the breech the cartridge rim strikes the lips of the extractors and rotates them forward into the pockets in the breech face of the barrel. At the same time, the lower arms of the extractors are disengaged from the breech block and the block moves up to the closed position under action of the closing spring. With the breech closed, the lower arm of the cocking lever projects forward clear of the cocking lug on the guide.

Second phase—action of trigger actuator. Actuation of the pistol grip of the firing gear moves the cable, through its flexible housing, so as to force the actuator plunger to the rear. The actuator plunger contacts the lower portion of the trigger arm and moves the trigger to the rear. Upon release of pressure on the pistol grip, the actuator plunger spring forces the actuator plunger to return to its forward position.

Third phase—trigger action. As the lower arm of the trigger is forced to the rear, the trigger hub operating on the tripper shaft, moves the upper arm of the tripper forward. As the tripper arm moves forward it forces the sear to the right until the sear notch is in line with the sear lug on the firing pin guide and the sear lug can then move forward through the sear notch.

Fourth phase—operation of firing pin guide assembly. The firing spring being compressed between the base of the stop and the retainer, forces the firing pin guide assembly forward. The prongs of the stop strike the breech block bushing and stop the action of the firing spring. The firing pin and guide, since they are locked together by the guide pin, continue forward under inertia to strike the primer and fire the piece. During this movement the retracting spring is being compressed between the base of the stop and the head of the firing pin. The striker end of the firing pin strikes the primer and stops the forward movement of the guide just before it contacts the breech block bushing. The retracting spring which has been compressed then retracts the guide and firing pin to their normal position with the firing pin point flush with, or slightly in rear of, the front face of the breech block.

Fifth phase—backward movement of barrel assembly. The action of the powder gases on the breech block at the moment of discharge causes the recoil of the barrel assembly and drives it rearward about 8 inches. The recoil is resisted, its speed regulated, and the movement stopped by the action of the recoil mechanism which is attached to the barrel assembly by the coupler and coupler pin. As the piston head in the recoil cylinder moves to the rear with the piston rod, two forces resist the movement, the two countercoil springs are compressed and the movement of the piston head is resisted by the oil in the cylinder. The oil follows two courses as it flows to the front of the piston head :

(*a*) It forces the piston valve back against the resistance of the piston valve spring and flows through the holes in the piston head which are uncovered as the valve moves away from the piston.

(*b*) It passes through the ports, thence through the hollow portion of the forward end of the piston rod and out around the tapered buffer. As the barrel assembly moves backward the piston rod moves away from the tapered buffer (which is gradually opened) thus the oil is restricted greatly at the instant of discharge and restricted less and less as the barrel assembly moves to the maximum length of recoil. The combination of the resistance of the counter recoil springs and the restriction of the oil stops the rearward movement of the barrel assembly at the maximum recoil without appreciable shock to the gun.

As the barrel assembly moves to the rear, the lower arm of the trigger is forced to the front by action of the trigger spring and plunger. This motion of the trigger causes the upper arm of the tripper to move to the rear, withdrawing the safety lug on the lower arm of the tripper from under the lower surface of the breech block, thus permitting the breech block to open. A bevel surface on the lower left guide of the breech block also forces the tripper forward should the trigger spring be broken.

Sixth phase—automatic opening of breech. During recoil, the lug (P, Fig. 44) on the right hand side of the crank is moved by the crank cam (Q) of the breech operating mechanism (R). This movement causes the trunnions of the crank to slide downwards in the T-slot to open the breech. As the crank rotates, the lever arm which is keyed to the crank rotates to the rear and brings with it the link and the closing spring rod and compresses the closing spring. The downward movement of the breech block is stopped by the impact of the stop surface of the crank hub on the shoulders of the breech block ring.

Seventh phase—action of extractors. As the breech block nears its lowermost position, the cam shoulders on the front face of the breech block contact the round cams on the lower ends of the two extractors. This imparts a sharp rearward throw to the extractor lips on the upper arm of the extractor. Since the extractor lips are behind the rim of the shell, the case is extracted from the chamber and ejected clear of the breech end of the gun. The breech is then open ready for loading. The camming

lugs on the bottom of the extractors are held to the front by the extractor spring plungers and lock the breech block in the open position by engaging the locking studs on the face of the breech block.

Eighth phase—cocking action. As the cocking lever is carried down with the breech block, the projecting arm of the cocking lever is forced forward by the cam surface inside the rear wall of the breech recess. The lower arm is rotated rearward to engage the cocking lug on the firing pin guide and to move the guide towards the rear. This rearward movement of the firing pin guide assembly compresses the firing spring sufficiently to permit the engagement of the sear. As the guide is moved to the rear, the sear lug cams the sear to the right. When the sear lug clears the sear, the sear springs to the left and in front of the sear lug under the action of the sear spring and holds the firing pin guide assembly to the rear in the cocked position.

Ninth phase—forward movement of recoiling parts. Recoil being stopped, the recoiling parts are instantly moved forward by the action of the compressed counter recoil springs against the piston bracket. The piston valve, by the action of the valve spring, closes the holes in the piston head as the counter recoil starts. The oil has only one course to follow through the hollow end of the piston rod and the ports in its walls to the rear of the piston head.

The added restriction during the counter recoil causes the barrel assembly to move slowly back into the mounting.

The final movement is stopped by the action of the counter recoil buffer entering the hollow end of the piston rod. The counter recoil buffer, due to its tapered construction, progressively closes the hollow portion of the piston rod through which the oil must flow. This action throttles the flow of oil and permits the gun to return to battery without appreciable shock.

Recocking. The firing mechanism can be cocked without opening the breech by rotating the projecting arm of the cocking lever forward and releasing it.

Safety features of firing mechanism

(*a*) Tripper. As the breech block is lowered, the left shoulder of the block passes immediately to the rear of the safety lug on the lower arm of the tripper, thus preventing the operation of the tripper and holding the trigger in the forward position until the breech is closed.

When the breech block starts to open the bevel on the front of the lower left guide forces the tripper forward if it has not already been forced forward by the action of the trigger spring and trigger.

(*b*) Cocking lever. The offset lower arm of the cocking lever engages the cocking lug of the guide early in the downward movement of the breech block and remains in the path of this lug until the block is returned to approximately its closed position. This eliminates the possibility of having the firing pin move forward to strike the cartridge, due to the premature release of the sear or other failure on the part of sear, to hold the mechanism cocked until the breech is fully closed.

(*c*) Alignment of firing pin. As the breech block is lowered it carries the firing pin down with it, thus the firing pin will not be aligned with the primer of the shell except when the breech is fully closed.

Ammunition—37 m/m

The more important ammunition issued for use with the 37 m/m tank gun M.6 is listed in the table below, which identifies the ammunition as to the type and model of the projectile.

Nomenclature	*Fuse*	*Weight of projectile*
Service ammunition—		
Shell, fixed, H.E. M.63, with fuse, BD M.58	Non-delay	1.61 lb.
Shell, fixed, H.E. Mk. II, with fuse, BD M38A1 ..	Non-delay	1.24 lb.
Shot, fixed, A.P. with tracer ..		1.92 lb.
Target practice ammunition—		
Shot, fixed, T.P. M.51 with tracer ..		1.92 lb.
Blank ammunition—		
Cartridge, blank, 10-gauge ..		
Drill ammunition—		
Cartridge, drill, M.13		1.92 lb.

The blank ammunition (see Fig. 79) requires adaptor, shot shell (10 gauge) M.2 which consists of a standard cartridge case (A) with the addition of a liner (B) chambered for a standard 10 gauge shot gun shell (C).

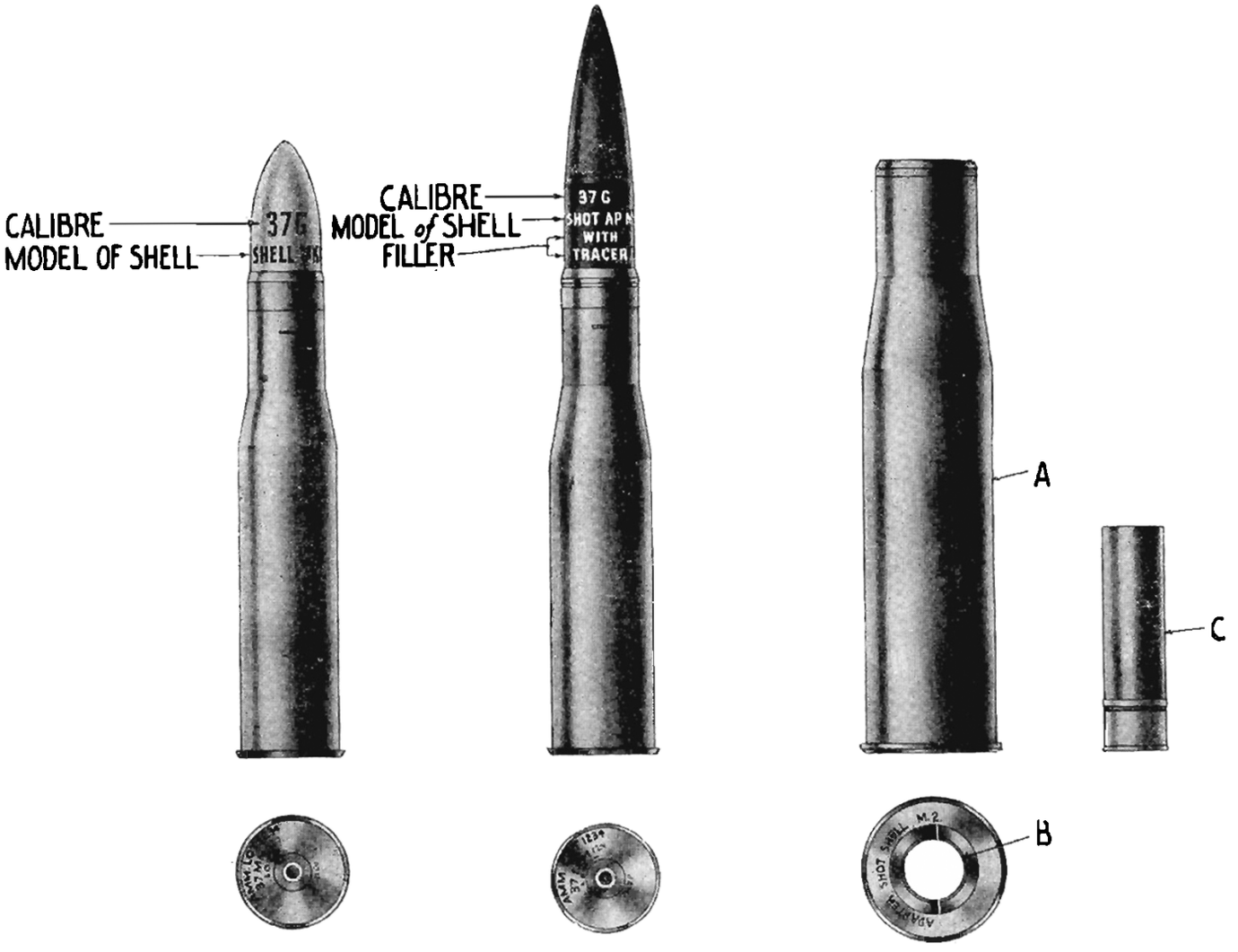


Figure 79. Ammunition 37 m/m

Drill and blank ammunition are provided for special purposes, and the blank ammunition may be used for firing salutes.

Ammunition, when manufactured, is assigned a lot number in accordance with specifications and the lot number is stamped or marked on each complete round, on packing containers and on an accompanying data card. The lot number should be referred to in all records or reports concerning conditions or accidents in which the ammunition is involved.

Rounds are packed in sealed metal lined boxes which contain twenty rounds. Each round without packing material weighs 3.4 lbs. and twenty complete rounds in the packing box weigh 100 lbs., the overhaul dimensions of the box being approximately 17 x 12 x 17 ins.

Projectiles are painted to prevent rust and the colour identifies the type.

Armour piercing	Black	Practice	Blue
High explosive ..	Yellow	Dummy or drill ..	Black

The practice cartridges may be inert or may contain a live fuse with a spotting charge.

A blue band painted on the packing box indicates practice ammunition.

The following information is stencilled on the projectile :—

(*a*) Calibre and type of cannon in which fired.

(*b*) Kind of filler.

(*c*) Mark or Model of projectile.

(*d*) Lot number of loaded projectile. (This lot number is covered by the neck of the cartridge case).

The following information is marked on the base of the cartridge case :—

(*a*) Ammunition lot number. (*b*) Model of projectile.

(*c*) Manufacturers initials.

GUN, MACHINE, BESA 7.92 M/M

The Besa 7.92 m/m machine gun, Mark III* (see plate 18) comprises the following main groups :— body (see Fig. 80), piston and breech block (see Fig. 81), barrel (see Fig. 82), trigger guard (see Fig. 83) and cover (see Fig. 84).

Reference numbers on figures illustrating the Besa gun, are, for identification purposes, common to the instruction book for Armourers and drawing D.D. (E) 2631. Not all such references are referred to in the following text.

A brief description of the main differences from guns of the preceding marks will be given at the end of this description.

The body (2, Fig. 80) forms a protector and front support for the barrel (41, Fig. 82) and a housing for the breech mechanism. The base of the body is of dovetail cross-section to slide in the gun mounting, a transverse groove in the base receiving the recoil bolt to retain it. Immediately above the mounting base of the M.G. are a pair of trunnions for attachment of the cover plate (83, Fig. 84) which closes the top rear half of the body and protects the breech mechanism. A carrying handle (46, Fig. 82) is fitted into either of two recesses dependent upon the position it is desired to carry the gun, *i.e.* horizontally or vertically. A feed block (19, Fig. 80) is fitted to the right-hand side of the body and provides an entry for the cartridge belt which, after extraction of the cartridges during its passage through the M.G. leaves the body by way of a belt guide (5, Fig. 80). A slide on the underside of the body extends from the rear to the ejection opening, carries and guides the trigger guard (53, Fig. 83) during the cocking action, which is effected by sliding the trigger guard to the front, and then back to its normal position at the rear.

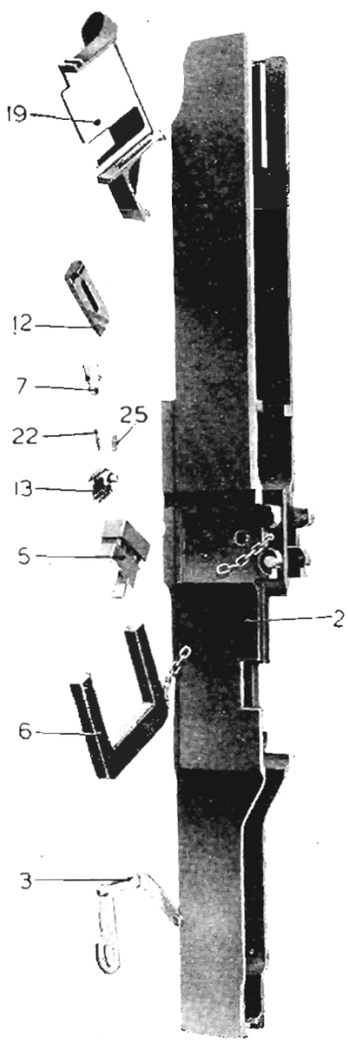


Figure 80
The Body Group

Piston and breech block. The piston is formed in two parts, a piston (32, Fig. 81) and a piston extension (26, Fig. 81), the piston stem at its front part being cylindrical to fit a gas cylinder (48, Fig. 82) and threaded at its rear end to engage the piston extension. The piston extension at the rear half has a longitudinal passage for the reception of the return spring (33, Fig. 81), the front half of the extension being slotted for the passage of the empty cartridge cases. Longitudinal ribs are provided at each side of the piston extension to fit grooves in the barrel extension (27, Fig. 81) permitting the piston to slide to and fro during firing. The upper part of the piston extension towards the rear has a piston post which, at the front strikes the firing pin (38, Fig. 81) and at the rear part constitutes an unlocking cam. The piston breech block (31, Fig. 81) fits the top of the piston extension in front of the piston post, a raised locking cam being formed at the rear top surface of the piston extension.

The breech block is of the rising and falling type, actuated by the cams on the piston extension, the movement of the breech block in the barrel extension being controlled by guide ribs. A central longitudinal hole in the breech block houses the fixing pin and spring, the underside is recessed to receive the extractor (30, Fig. 81), extractor stay (28) and spring, and the centre hollowed to accommodate the piston post. A rib on the top of the breech block feeds the cartridge from the belt into the breech chamber. The rear upper part of the breech block is formed with a lug which is raised into engagement with a locking shoulder on the barrel extension, and subsequently lowered by the locking and unlocking cams of the piston extension.

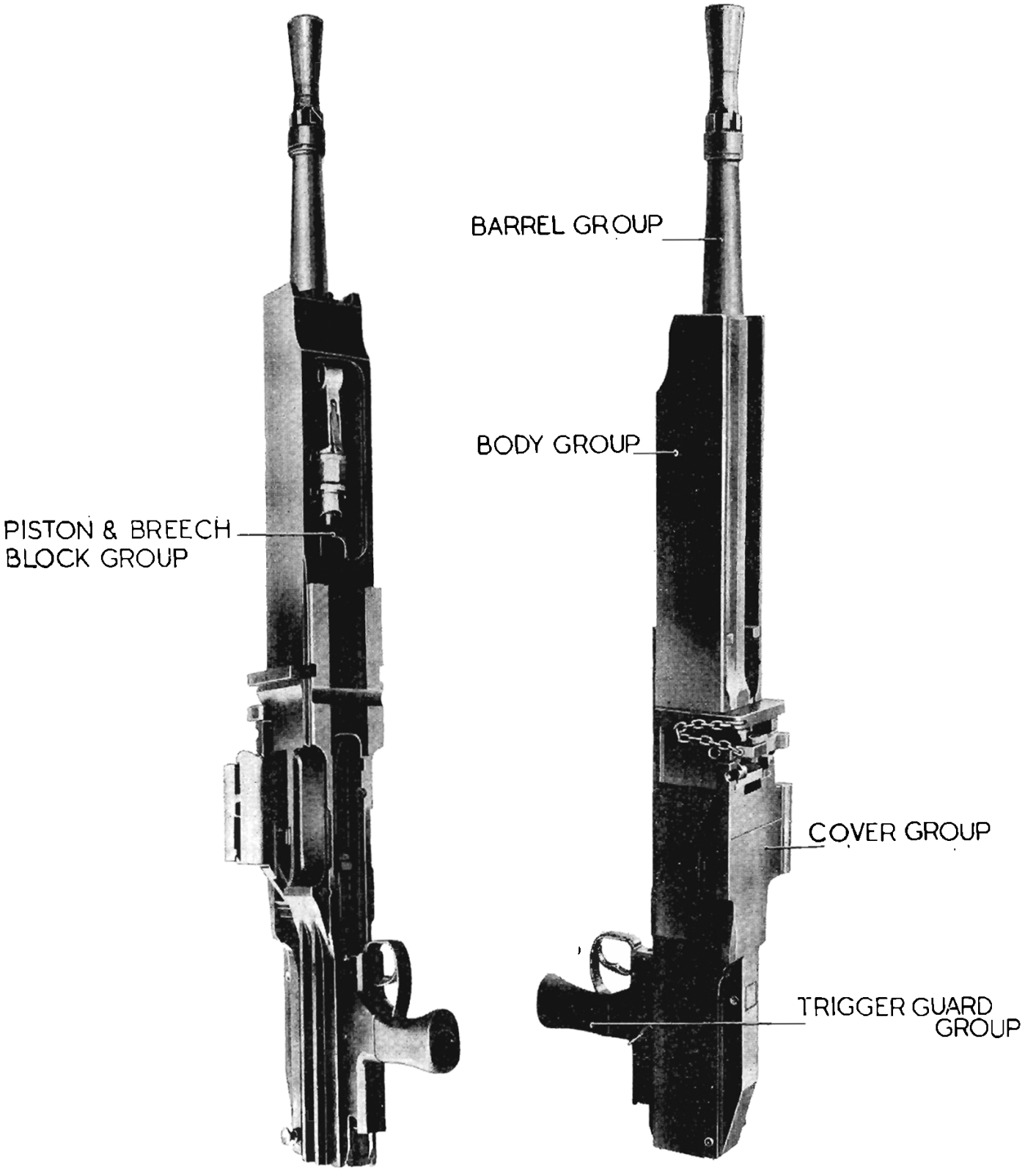


Plate 18. 7.92 m/m Besa M.G. Mark III

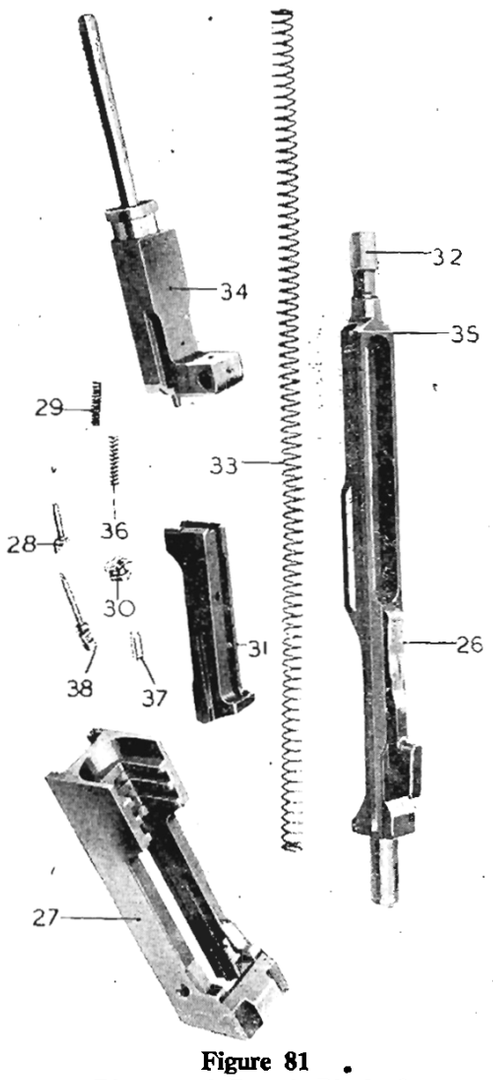


Figure 81
The Piston and Breech Block Group

The barrel (41, Fig. 82). The breech end of the barrel has a series of tenons which engage slots in the barrel extension (27, Fig. 81) to lock the barrel. A steel barrel sleeve (40, Fig. 82) pressed over the barrel to absorb heat of firing, is fitted at the front with a flash eliminator (39) and at the rear with a barrel retainer (44) which locks with slots in the body. A carrying handle (46), attached to the barrel retainer is used for operating and locking the retainer and removing the barrel when hot. The barrel is supported at the front on guides in the body. The gas cylinder (48), sleeve (51) and the gas regulator (52) are fitted to the underside of the barrel sleeve.

The barrel extension, which receives the breech end of the barrel, is slotted, full length, on the underside to provide a slide for the piston extension (26, Fig. 81) and the centre hollowed out to receive the breech block (31) which is controlled in the forward movement, imparted by the piston post, by ribs which slide in channels in the barrel extension. Two internal studs give the breech block its initial rising movement. A bridge portion at the rear of the barrel extension forms the locking shoulder against which the breech block abuts when lifted by the piston extension.

The gas cylinder (48, Fig. 82) has a knuckle front end which fits a housing in the barrel sleeve and is recessed to receive the gas regulator (52). The rear end of the gas cylinder is given a lead for the entry of the piston and is cut at an angle to deflect escaping gases downwardly. A port adjacent to the gas regulator directs gases from the barrel to the regulator, which then travel to the front of the cylinder to exert pressure on the piston to initiate the action of the gun.

The above cylinder (48) is held in place by a gas cylinder sleeve (51) which embraces the gas cylinder and fits a slot in the underside of the barrel sleeve.

The gas regulator (52, Fig. 82) is of cylindrical shape to fit the housing in the gas cylinder and is held in place by a lug and slot device. Ports of different sizes are drilled through the regulator and may be placed in corresponding positions to align with the gas port in the barrel.

The trigger guard (53, Fig. 83) is carried in a slide on the underside of the body and is held by a cocking catch (55). The trigger (56), trigger shaft (64), sear (76), cocking catch and associated components, are housed within the trigger guard which may be removed complete as a unit after raising the trigger guard catch at the rear of the body. The thumb-piece (68) of the cocking catch is on the left-hand side of the trigger guard. A pistol grip (67) is bolted to the base of the guard.

The cover (85, Fig. 84) closes the rear half of the body and protects the breech mechanism, two hooked projections at the front, hinging on trunnions on the body. A locking pin (94) holds the cover in place. A transverse channel is provided on the underside to accommodate the

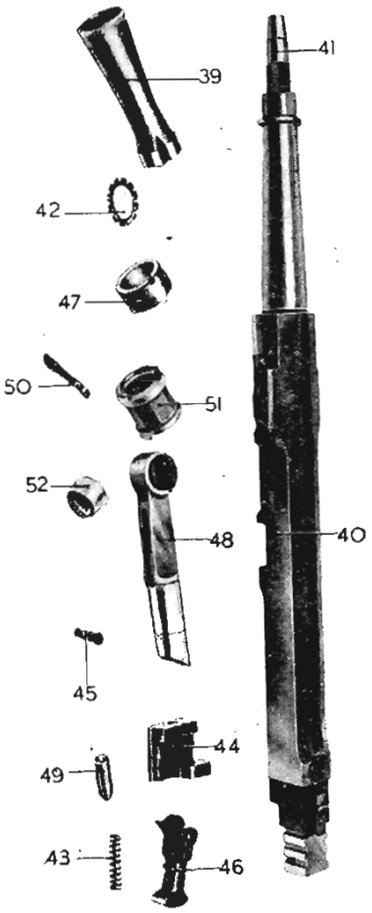


Figure 82
The Barrel Group

cartridge guide (89) which has ribs to slide in slots in the sides of the channel. Front and rear recoil spring casing (86 and 98) are also fitted on the underside of the cover and a reaction block (101, Plate 6) is secured by a pin to the cover to form a stop for the rear recoil spring casing (98, Fig. 84).

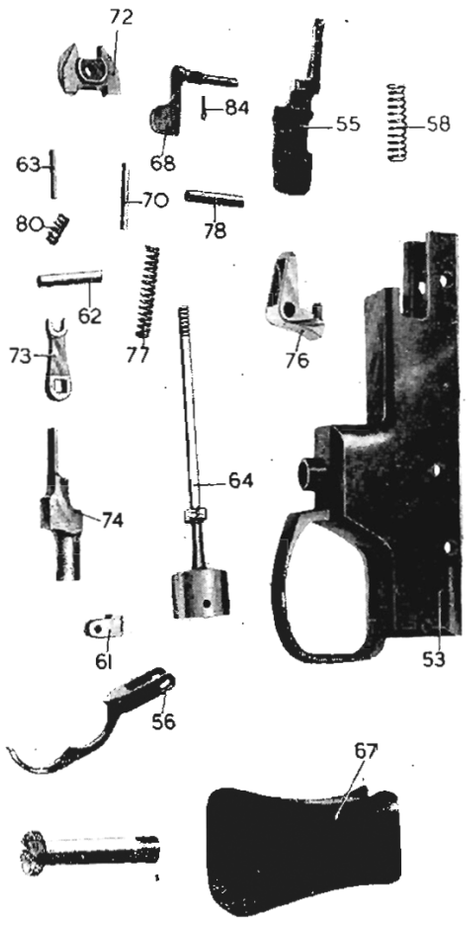


Figure 83. The Trigger Guard Group

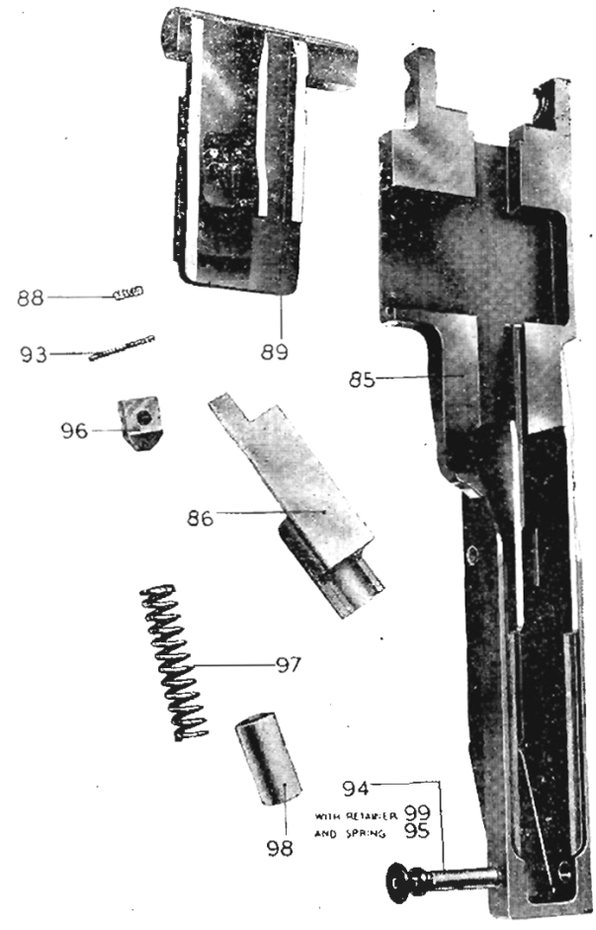


Figure 84. The Cover Group

The cartridge guide co-operates with the feed block body (19, Fig. 80) to form the entry for the cartridge belt and for controlling the empty belt as it leaves the gun through the belt guide (5).

The cartridges are guided into position by a pair of ramps on the underside of the cartridge guide, the retaining pawl (96, Fig. 84) and spring being housed in a depression between the ramps.

The feed block body (19, Fig. 80) is slotted to fit a gap in the right side of the body (2), carries the feed slide (13) and provides an upper bearing for the feed lever.

The feed lever (3, Fig. 80) has a vertical spindle which pivots in the body and the feed block. An arm is provided at each end of the spindle, the lower passing under the piston extension and engaging a camway on the underside by means of a stud, and the upper having a slot to engage a stud on the feed slide.

The recoil spring (97, Fig. 84) is housed in the two tubular recoil spring casings, and reacts to return the ports to the forward position, after compression, upon recoil of the barrel.

The return spring (33, Fig. 81) housed within the piston extension, is guided by a return spring guide (34) consisting of a block and rod. The block is slotted to engage locating ribs in the body. The cover locking pin extends through the block, and the lower part of the block is recessed to receive the end of the return spring. The rod is secured to the block and extends through the centre of the spring to form a guide.

The baffle plate (6, Fig. 80) slides into slots in the body in front of the carrying handle lugs and serves as a protection against a splash.

The foregoing description concerns the Mark III* Besa M.G. The following description covers the main differences between the Mark III* and the preceding Marks, *i.e.* I, II*, III.

Mark I, Mark II and Mark II*. The Mark I guns are converted from ground pattern guns for use in armoured fighting vehicles. Mark II are manufactured as A.F.V. weapons. The difference between the Mark I and the Mark II series is manufacturing details. The Mark II* is the transitional pattern between the Mark II and the Mark III, all three Marks I, II and II* embody accelerator mechanism. The Marks I and II only, have a safety catch.

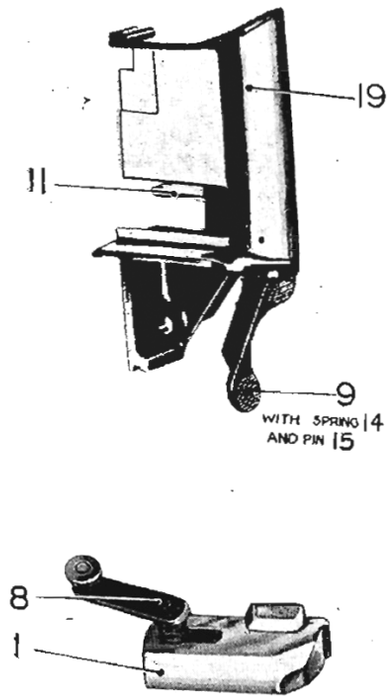


Figure 85. Accelerator, Mark II

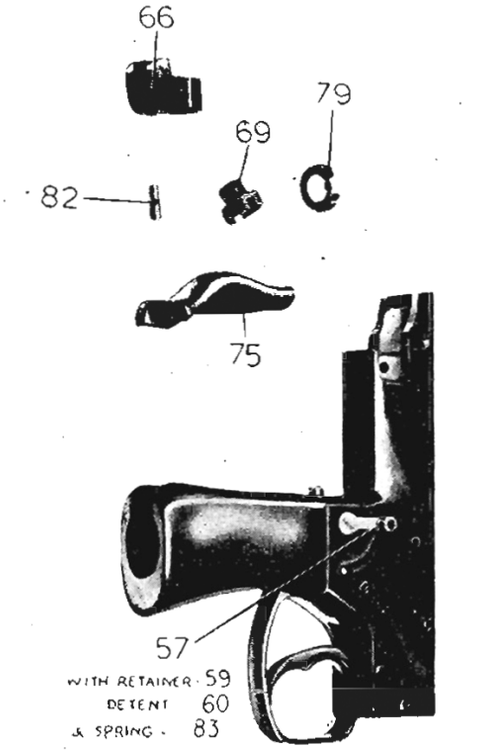


Figure 86. The Trigger Group, Mark II

The accelerator on the Marks I, II and II* guns consists of a hollow casing (1, Fig. 85) which houses an inner (20, Plate 6) and an outer (23) accelerator spring. The casing is supported in the rear of the body by a crank arm (8, Fig. 85) and may be placed in or out of the path of the piston extension which strikes it at the end of its rearward travel, and as a result increases the rate of fire due to the additional reaction of the accelerator springs.

The safety catch (54, Plate 6) fitted to the Mark I and Mark II is embodied in the trigger guard and consists of a pivoted three-armed catch which engages the sear (76), the sear trigger (74) and a safety catch rod in turn engaged by a safety catch lever (75, Fig. 86) mounted in the pistol grip.

There are a number of minor constructional differences between the several Marks, to simplify the construction and modifications arising due to redesigning.

Mark II* embodies components of simplified pattern, but all are fully interchangeable with those of the Mark II gun. In addition, the following are omitted from the Mark II* :—

Cover catch (92, Fig. 87)
Feed pawl depressor (11, Fig. 85) } and associated components (87, 90, 100, Fig. 87)
Safety catch (54, (Plate 6). Accelerator (1, Fig. 85).

Mark III. The components omitted from the Mark II* are also omitted from this gun. Mark II belt guides (5, Fig. 80) are fitted without a catch. Mark I belt guides and Mark II gas cylinders will assemble to a Mark III gun.

The Mark III gun has no safety catch and associated components, and the gas regulator has two ports only. No accelerator is fitted, but in its place two buffer springs (102 and 103, Plate 6) are fitted in the return spring guide block, to speed the forward movements of the working parts and maintain a high fixed rate of fire of 750 rounds per minute.

Due to the fitting of inner and outer accelerator springs and a sleeve (104, Plate 6) in the return spring guide, a shorter return spring is necessary, *i.e.* the Mark II (free length 485 m/m = 19⅛ in. approx.).

Mark III* has the same modifications as the Mark III except for a reduced rate of fire, obtained by fitting the return spring guide block (105, Plate 6).

Operation

Forward stroke. When the trigger (56, Plate 6) is pressed, the sear (76) is disengaged from the piston extension (26), which is then driven forward by the return spring (33). The breech block (31) also rides forward by engagement with the piston extension. As the breech block moves forward, the feed projection drives a round out of the belt into the chamber. The rear of the breech block is lifted by ramps on the sides of the block riding over studs inside the barrel extension (26), to be finally engaged with the resistance face of the barrel extension. During the final closing movement of the breech block the extractor (30) grips the groove of the case. The continued movement of the piston actuates the firing pin (38).

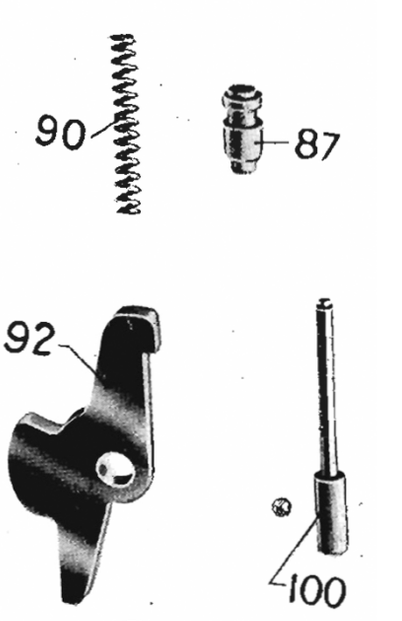


Figure 87
Cover Group, Mark II

Backward stroke. Expansion of the cartridge on firing, seals the breech. The force of the explosion on the breech block forces the latter, the piston extension, barrel extension, and barrel (41) all locked together, to the rear, the action compressing the recoil spring (97) which upon expansion, drives the barrel and barrel extension forward.

Some of the gases produced on explosion escape through the gas vent into the gas cylinder (48) and force the piston extension to the rear. The rearward movement of the piston extension precedes the unlocking of the breech, which is effected when the inclined ramp on the piston post pulls down the breech block out of engagement with the barrel extension.

After the breech block has been carried to the rear, the empty case which is gripped by the extractor is withdrawn from the chamber and ejected by striking the ejector on the belt guide, passing through the piston extension and out of the ejection opening.

Compression of the return spring is effected during backward movement of the parts.

Action of the accelerator (when fitted). With the accelerator set at " low " the gun fires at the normal rate, which is increased when the accelerator is set " high." The backward stroke of the piston extension is limited by contact with the accelerator (1), thereby compressing the springs (20 and 23), the additional action of which speeds the forward stroke of the piston extension and increases the rate of fire.

Action of feed

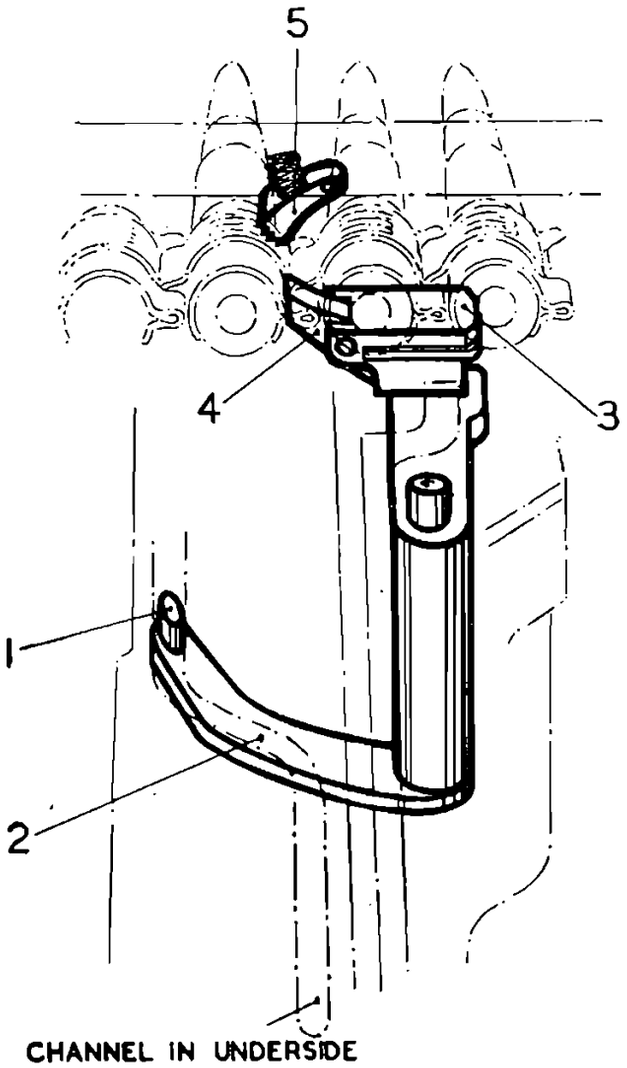
During forward stroke. As the piston extension moves forward, the stud (1, Plate 19) on the lower arm of feed lever (2) engaged in the bottom of the piston extension, causes the upper arm feed slide (3) and feed pawl (4) to move to the right, so that the feed pawl is depressed by the next round in the belt until it rises and engages behind a link, the belt being held in position by the retaining pawl (5) during the action.

During the backward stroke. The piston extension acting on the lower arm of the feed lever (2), moves the upper arm and feed pawl (4) to the left, whereby the belt moves to the left due to its engagement with the feed pawl. During this movement, the front of the round is deflected downwards by the cartridge guide ramps, with the bullet pointing towards the breech. The retaining pawl (5) engages the upper surface of the link which is held by the feed pawl.

Cover, Muzzle, Besa 7.92 m/m

No. 1 Mark I. Of waterproof canvas, tubular in shape and closed at the front end. It fits over the flash eliminator of the gun, and is secured by a cord.

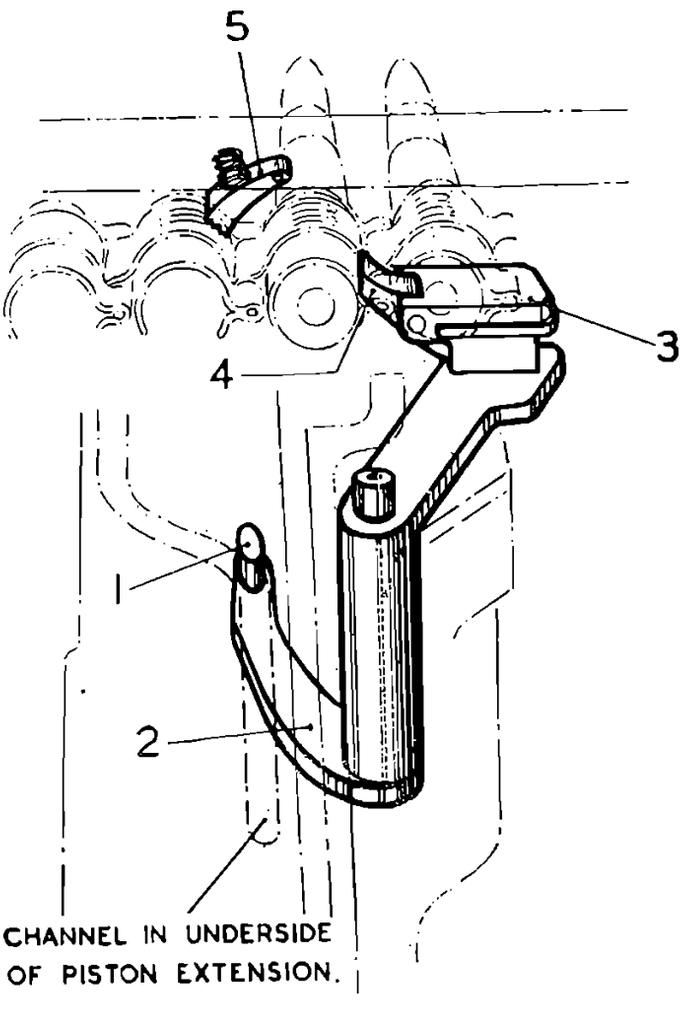
No. 2 Mark I. Of waterproof canvas. It fits over the barrel and the front part of the body of the gun. The front part is tubular, with a closed end, and the rear part of rectangular cross-section. It is secured at the front and rear by cords.



CHANNEL IN UNDERSIDE
OF PISTON EXTENSION.

COCKED POSITION

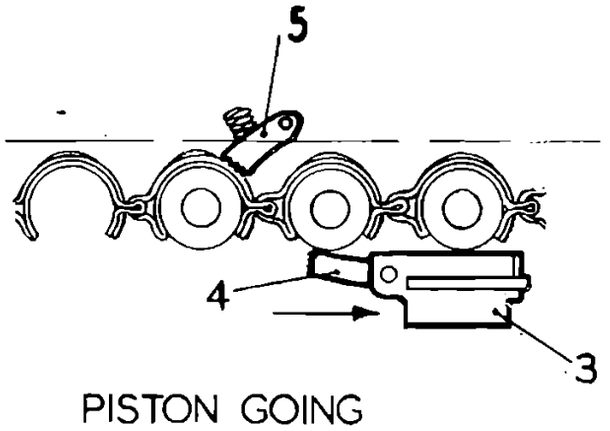
PISTON EXTENSION TO THE REAR.
ROUND READY TO BE CARRIED
INTO CHAMBER & FIRED.



CHANNEL IN UNDERSIDE
OF PISTON EXTENSION.

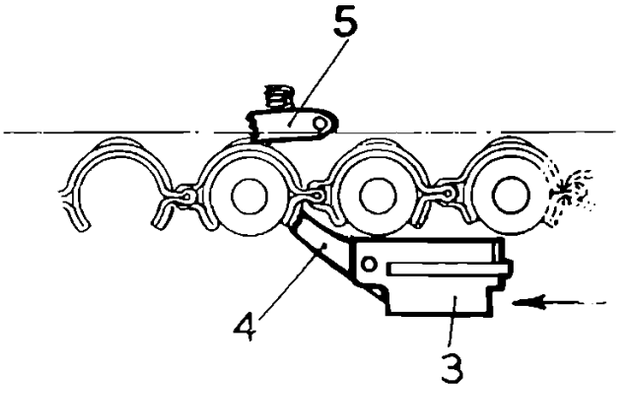
ROUND FIRED.

FEED PAWL READY TO BRING FORWARD
THE NEXT ROUND.
PISTON EXTENSION FORWARD.



PISTON GOING FORWARD TO FIRE.

FEED PAWL RIDES UNDER NEXT ROUND.



DURING RECOIL.

FEED PAWL
BRINGING NEW ROUND INTO POSITION
RETAINING PAWL OVER RIDING THE ROUND.

Plate 19. Feed Operation

The No. 1 cover is used in cases where only the barrel protrudes from the mounting and the No. 2 where the front of the body is also exposed.

Deflector cartridge case, Besa 7.92 m/m No. 1 Mark I

The deflector consists of a canvas tube at the top end of which are two metal attachments, the forward one fitting the front end of the ejection opening in the gun body and the rear one having two spring-loaded catches which engage the two studs on either side of the fore end of the trigger guard body. On the left side is a rectangular hole fitted with a metal chute, designed to pass the spent belt in to the deflector after leaving the belt guide. At the lower end are four studs for the attachment of the mouth of the spent cartridge bag by means of " press-the-dot " fasteners. The top end is stiffened by means of spring cord sewn into the hem.

Ammunition Cartridge, S.A. Ball, 7.92 m/m

Mark IZ. The cartridge consists of a brass case containing a charge of approximately 45-gr. N.C., a percussion cap and bullet.

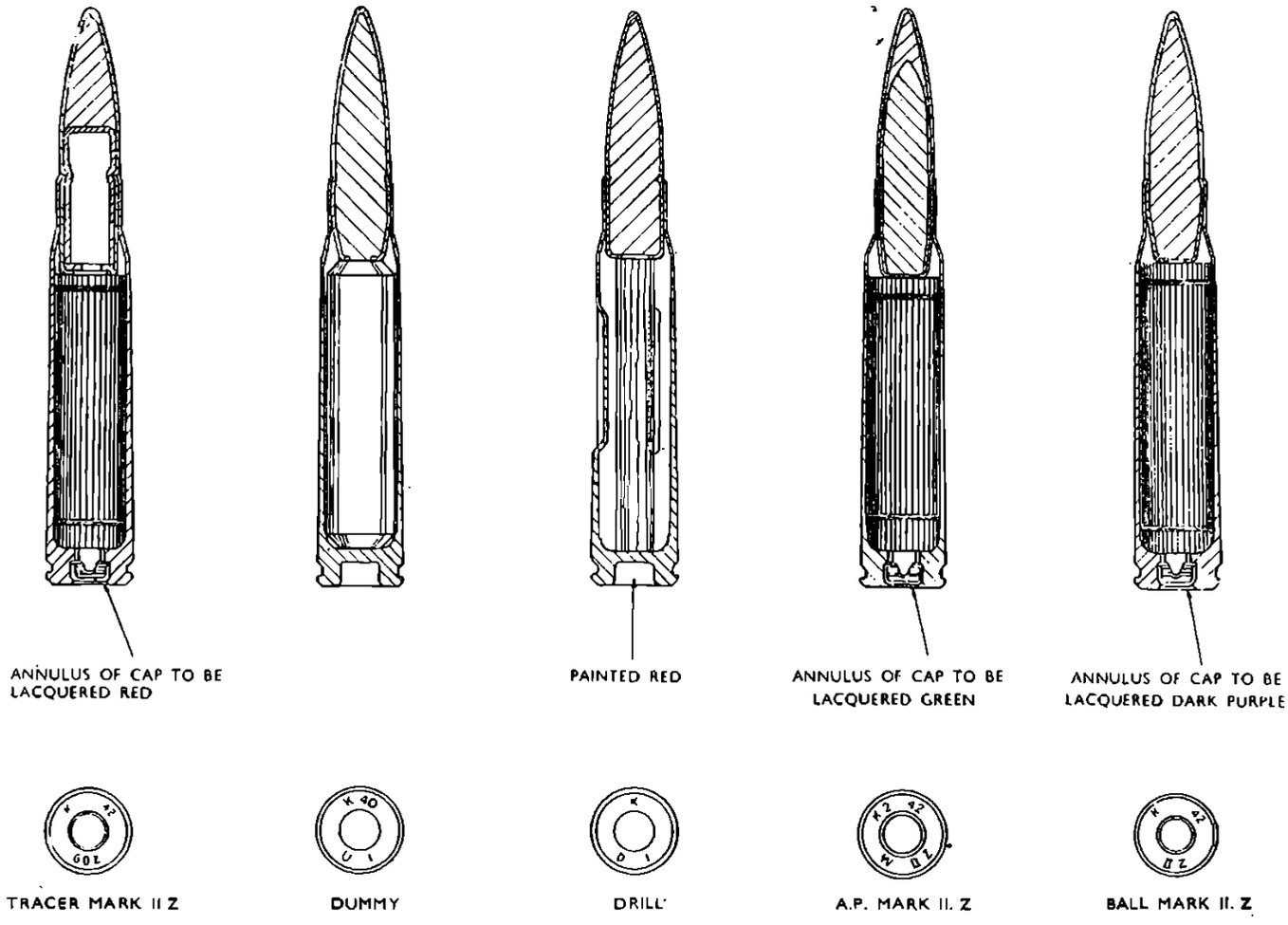


Figure 88. Cartridge, Besa 7.92 m/m

The case is of the rimless type, tapering slightly towards the mouth and bored out at the base to form an anvil and a chamber for the percussion cap. Two fire holes connect the cap chamber to the interior of the case. The cap may be secured in its chamber by " ringing in."

The cap is of brass and contains about 0.5 gr. of cap composition covered by a lead-tin foil disc.

The bullet is streamlined and has a steel envelope coated with gilding metal or cupro-nickel, and a lead antimony core. The base of the bullet is stamped with the contractor's initial or trade mark.

The bullet is secured in the mouth of the case by coning or crimping the latter into a groove formed round the bullet.

The annulus of the cap is lacquered dark purple. The lacquering was omitted from cartridges of early manufacture.

The base of the cartridge is stamped with the mark, contractor's initials or trade mark and the last two figures of the year of manufacture.

Mark IIZ. Similar to the Mark IZ cartridge, except that it has the Mark II bullets, as this has been found to give greater accuracy in worm barrels, and therefore a longer barrel life.

The Mark II bullet is identical to the Mark I except that the nose is somewhat fatter and the parallel portion, which is engraved by the rifling, is longer.

The markings are similar to the Mark IZ, except for the Mark.

Early Mark IIZ cartridges are stamped " IZ " but the boxes are labelled " Mark II BULLETS."

Cartridge, S.A., Armour piercing, 7.92 m/m

Mark IZ. The cartridge consists of a brass case, containing a charge of approximately 46 grains N.C. cord or granules, a percussion cap and an armour piercing bullet.

The case and cap are similar to those of the ball cartridge.

The armour piercing bullet consists of a special hard core with a lead antimony sleeve in an envelope of steel, coated with cupro-nickle or gilding metal, and is secured in the mouth of the case by coning or crimping the latter on to the bullet.

The annulus of the cap is lacquered green.

Mark IIZ. Similar to the Mark IZ cartridge, except that it has the Mark II bullet which is slightly longer than the Mark I and has a flatter tip.

Cartridge, S.A. Tracer, 7.92 m/m G

Mark IZ. The cartridge is generally similar to the ball cartridge, but differs in being assembled with a tracer bullet.

The tracer bullet is not streamlined, It has a steel envelope, coated with gilding metal or cupro-nickel, and contains a lead-antimony tip, a copper tube filled with red tracer composition, and a brass washer. The length of trace is 900 yards approximately.

The annulus of the cap is lacquered red.

Mark IIZ. Similar to the Mark IZ, except that it has a **Mark II** bullet.

Cartridge, S.A., Incendiary, 7.92 m/m B

The annulus of the cap is lacquered blue.

Cartridge, S.A., Drill, 7.92 m/m D

Mark I. The cartridge is made up with a brass case, a bullet consisting of a cupro-nickel envelope with an aluminium core and a wood distance piece. The bullet is not streamlined.

The distance piece is placed inside the case and the bullet is secured in the mouth of the case by crimping or coning the latter into a groove formed round the bullet.

The case is chromium-plated and has a recess in the base and three longitudinal indents, which are painted red in order to show definitely that the cartridge is for drill.

The letter " D," the Mark and contractor's initials or recognised trade mark are stamped on the base of the cartridge.

These cartridges are liable to break up with repeated use. When unserviceable, they should be exchanged and not repaired. Use of the D.P. return spring in the gun for instruction and demonstration will prolong the life of the cartridges. Drill cartridges must be kept separate from service ammunition.

Belt, 7.92 m/m 225-round

The cartridges for the 7.92 m/m Besa M.G. are fed into the gun by means of a 225-round belt.

Mark I. Consists of 225 metallic links with a tag and eyelet, connected together by 225 pins. The links are pressed from spring steel sheet, folded to shape and spot-welded. They fit round the cartridges, which are retained by the small bulge at the rear projecting into the extractor groove in the cartridge case. The pins are a tight fit in the twin loops at the right of the link and slack in the single loop on the left, thus allowing the belt a certain degree of flexibility. The part of the link below the twin loops is serrated on the surface to assist the grip of the feed pawl. The tag is of sheet steel with two loops at one end for attachment to the link and one loop at the other for the eyelet. The eyelet is of twisted wire with a finger ring at the end. The tag and eyelet are passed through the feed block on loading the gun to enable the belt to be pulled into position and to lead the belt into the metal chute on the side of the cartridge case deflector.

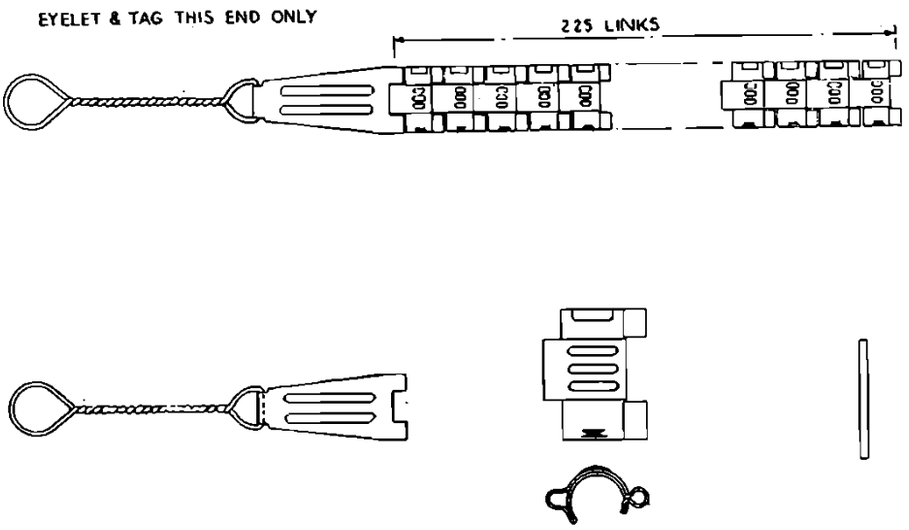


Figure 89. Belt, Cartridge, Besa Mark I

Mark I*. This differs from the Mark I pattern by the fitting of a flexible webbing extension with a wire loop in place of the metal tag and eyelet.

Marks I and I* belts are surface-treated against corrosion.

These belts are commonly known as " metal " belts. They are used both for factory-packed ammunition and also for instructional and demonstration purposes. For the latter, fired belts from factory-packed ammunition, shortened to about 50 links, are most suitable.

Mark II, 225-round. This belt differs from the Mark I and Mark I* in the length of canvas webbing used to carry the clips. The belt comprises 226 clips each formed by top and bottom members, which are locked together to clamp the canvas webbing, the last clip having a wooden plug to prevent the belt hamming upon leaving the gun. The entry end of the belt is riveted to a steel tab by two brass eyelets, and linked to a rectangular wire handle of mild steel or brass. The tab is marked with the manufacturer's initials or trade mark, month and last two figures of the year of manufacture, number of rounds (225), calibre 7.93 and Mark II.

The cartridges are retained by a small bulge in the bottom clip, which engages the extractor groove in the cartridge case.

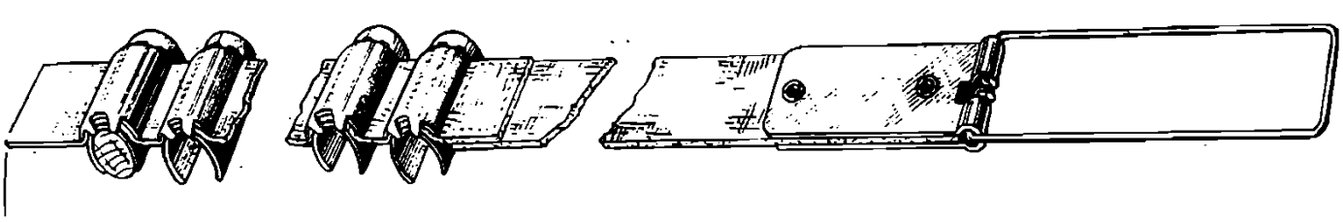


Figure 90. Belt, Cartridge, Besa Mark II

Filling belts. To load a cartridge into the belt, enter the nose of the bullet into the rear of the link and press forward until the small retaining bulge in the link " clicks " into the extractor groove in the cartridge case. The base of the cartridge should be flush with the rear edge of the link. There is no belt-filling or cartridge positioning machine issued, and since ammunition is supplied factory-filled, it is seldom that belts have to be filled by units, the chief exception being the preparation of belts of drill cartridges.

To remove a round from the belt. Twist the nose of the round downwards out of the link. Take care not to tear Mark II belts when doing this.

Ammunition Boxes and liners. Filled ammunition belts are packed and stored in belt boxes, from which the gun is fed direct.

Boxes, ammunition S.A. H.29. These are made of wood, and each contain two Mark I tinned plate boxes (*i.e.* 450 rounds in two belts).

Mark I. The sides and ends are nailed together and the bottom secured to them by screws. The lid is battened and secured to the body at each end by an iron clamp. One clamp is a fixture, and the other can swing, the latter being secured in position by a split pin passing through the clamp, lid and end of the box.

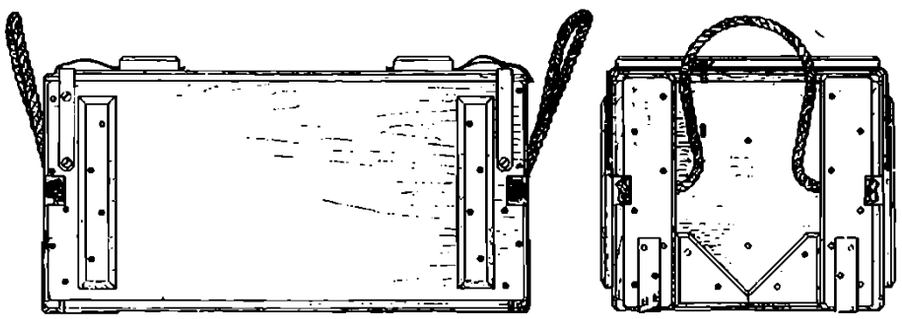


Figure 91. Ammunition Box, S.A. H29

A length of cotton webbing secured in position by vertical end battens is provided to form handles at each end and one side.

The box is stained bluish-green.

On each end is nailed a " V " shaped piece of wood indicating belted ammunition to assist identification at night.

Raised metal figures and/or letters are screwed on to both ends for the same reason, the indications being :—

7 ..	Ball
G.7	Tracer
M.7	Mixed
X ..	Special ammunition or packing

Examine labels carefully.

Stowage dimensions (max) :—

Length ..	16.9 ins.
Width	10.75 ins.
Depth	9.25 ins.

Weights :—

Empty	18 lbs.
Filled	53½ lbs.

Mark IE. Differs from the Mark I pattern in being a simpler form of manufacture for emergency use.

Stowage dimensions (max) :—

Length ..	16.55 ins.
Width ..	10.1 ins.
Depth ..	8.9 ins.

Weights :—

Empty ..	14¼ lbs.
Filled	50¼ lbs.

Boxes, tinned-plate, Mark I. Known also as " expendible liners " or " linings."

The box is provided at the top with a central bridgepiece, and a tear-off lid on either side. Each lid is fitted with an iron or steel handle and a third handle is fitted to one end of the box for carrying purposes.

To facilitate removal from the wood box, a handle is formed at each side by a length of sisal twine joined to form a continuous loop passing through four guides situated at each side near the ends and top.

The bridge is embossed with the outline of a cartridge and at one end are stamped the contractor's initials or recognised trade mark and year of supply.

The box which is filled from the bottom, contains a belt of 225-rounds, folded into layers. The bullets in each layer are separated from those in the next by a felt strip. There are also two felt packing pieces, one at the top and one at the bottom of the box. The box is hermetically sealed at the factory.

The belt may be filled with one of the following four combinations. The actual proportions vary.

1. Ball.
2. Ball and tracer.
3. Ball, tracer and A.P.
4. Ball, tracer, A.P. and incendiary.

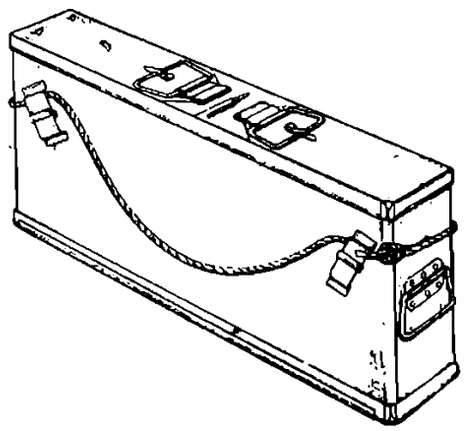


Figure 92. Liner Expendible

DISCHARGER, SMOKE GENERATOR, 4 in. No. 2 MARK II

The discharger consists of a barrel mounted on the exterior of the turret, into which a No. 8 smoke generator is inserted and a rifle action by means of which it may be fired from within the A.F.V.

The barrel is a steel tube (A Fig. 93) with a base (B) screwed and welded to one end. The base is cupped internally and has threaded hole through a boss at its centre, for the chamber portion (C) of a rifle barrel. A screw (D) engages in a hole in the supporting bracket to restrain the discharger from turning. The chamber portion is formed from the breech end of a rifle barrel, which, in addition to the normal screwed portion for assembly to the action, is threaded at its front and to screw into the base of the barrel and in the centre, for the clamping nut. The hexagonal clamping nut (E) secures the discharger to the supporting bracket on the vehicle.

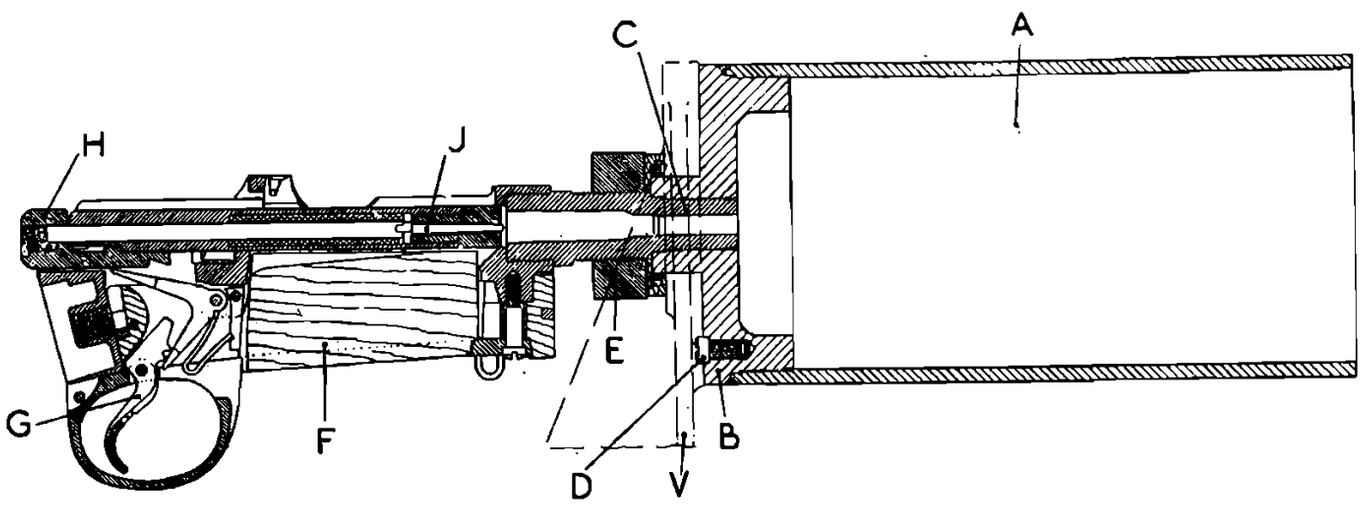


Figure 93. Discharger Smoke Generator 4 in. No. 2 Mark II

The action is a No. 1 short magazine Lee Enfield Rifle action. The lever and catch portion of the magazine catch have been removed to allow the fitting of a wooden block (F) in the magazine opening in the body. The discharger is mounted in such a manner that the trigger action (G) is inside the A.F.V.

Action. The smoke generator is placed in the barrel of the discharger with the lifting strap outermost, the bolt (H) withdrawn and the cartridge inserted in the chamber and the bolt returned. The discharger is then loaded and ready to fire. To fire, squeeze the trigger which will release the striker (J) to ignite the cartridge and propel the generator a distance of 125 yards approximately; it must be emphasized, however, that the *range is considerably reduced if the interior of the barrel is wet.*

Ammunition. The cartridge used for firing the discharger is Cartridge S.A., Rifle Grenade or Smoke Discharger, .303-in., Ballistite, ' H ' Mark IZ.

The smoke-generator is the Generator, Smoke, No. 8, Mark IV. This consists of a steel body (A, Fig. 94) with a lifting strap (B) welded to it, containing a smoke composition (C) with a layer of igniter composition (D) spread evenly over it and covered by a primed muslin disc (E). Two strawboard discs (F) centrally apertured, a cellulose acetate disc (G) and a steel closing disc (H) also centrally apertured are then inserted and the body turned over at the edge. The joint is watertight. The exterior of the generator, with the exception of the exposed cellulose acetate, is painted light green with SR 269 stencilled on the side and the contractor's markings, date and lot number marked on the base. The generator weighs 4½ lbs. approximately and emits smoke continuously for a period of 1¼ to 1¾ minutes, commencing from a few seconds of firing the discharger.

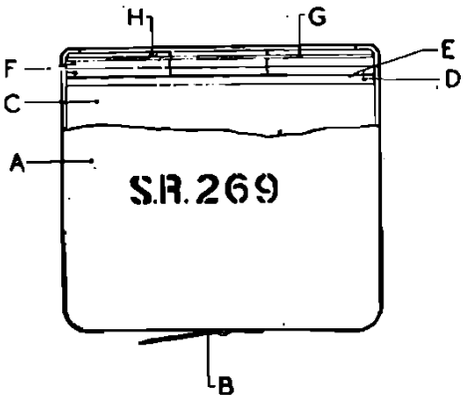


Figure 94
Generator Smoke, No. 8, Mark IV

TELESCOPE, SIGHTING, NO. 30, MARK I AND MARK I.A.

These telescopes (see Plate 20) are for use with the 37 m/m M.6 Tank gun and Besa co-axial mounting, they have a magnification of 1.9, a field of view of 20° and direct reading range scale.

The telescope body (A) is tubular and contains the optical components, a key (B) being fitted to the underside to engage a corresponding locating keyway in the telescope mounting, a detachable eye-guard (C) is fitted to the rear end of the telescope. The optical components comprise a pair of object glasses (D), an erector lens (E) fixed and movable range scale diaphragms (F) and (G) respectively and an eyepiece (H). The object glasses are protected by means of a removable object glass protector (J), embodying a glass disc (K) and an expanding spring (L) by means of which the protector is held in the open end of the telescope body. The Mark II object glass protector is used.

The erector lens (E) is mounted within inner and outer eccentric erector lens tubes (M) and (N) and are relatively movable for line and elevation adjustment by means of a pair of keys (O) which are inserted into recesses (P) and (Q) in the erector lens tubes after removing the erector lens cover (R). The fixed diaphragm is graduated on the left in ranges indicating 0, 600, 900, 1,200, 1,500 and 1,800 yards for use with the 37 m/m gun and on the right are readings 0, 600, 900, 1,200 and 1,500 yards for use with the Besa gun. The sliding diaphragm (G) is movable vertically by means of a knurled head (S) which operates in conjunction with clicker mechanism (T). The sliding diaphragm has cross-lines and divisions at 30 minutes and one degree from the vertical cross-line for " laying off," the horizontal line can be set at any desired range graduation on the fixed diaphragm. The knurled head is engraved to agree with the diaphragm readings.

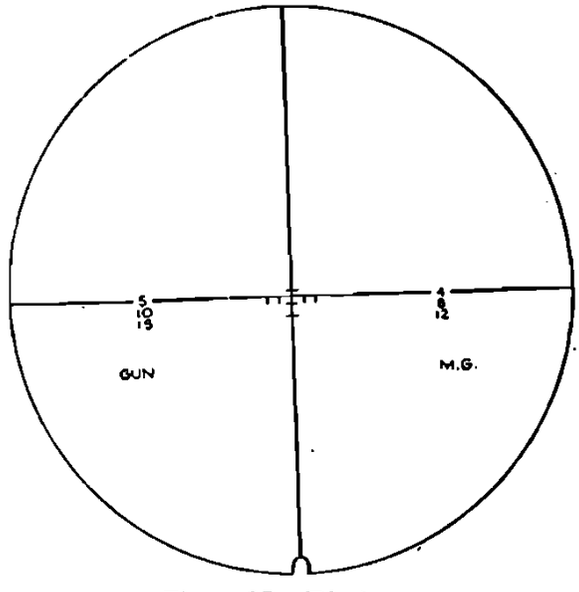


Figure 95. Diaphragm

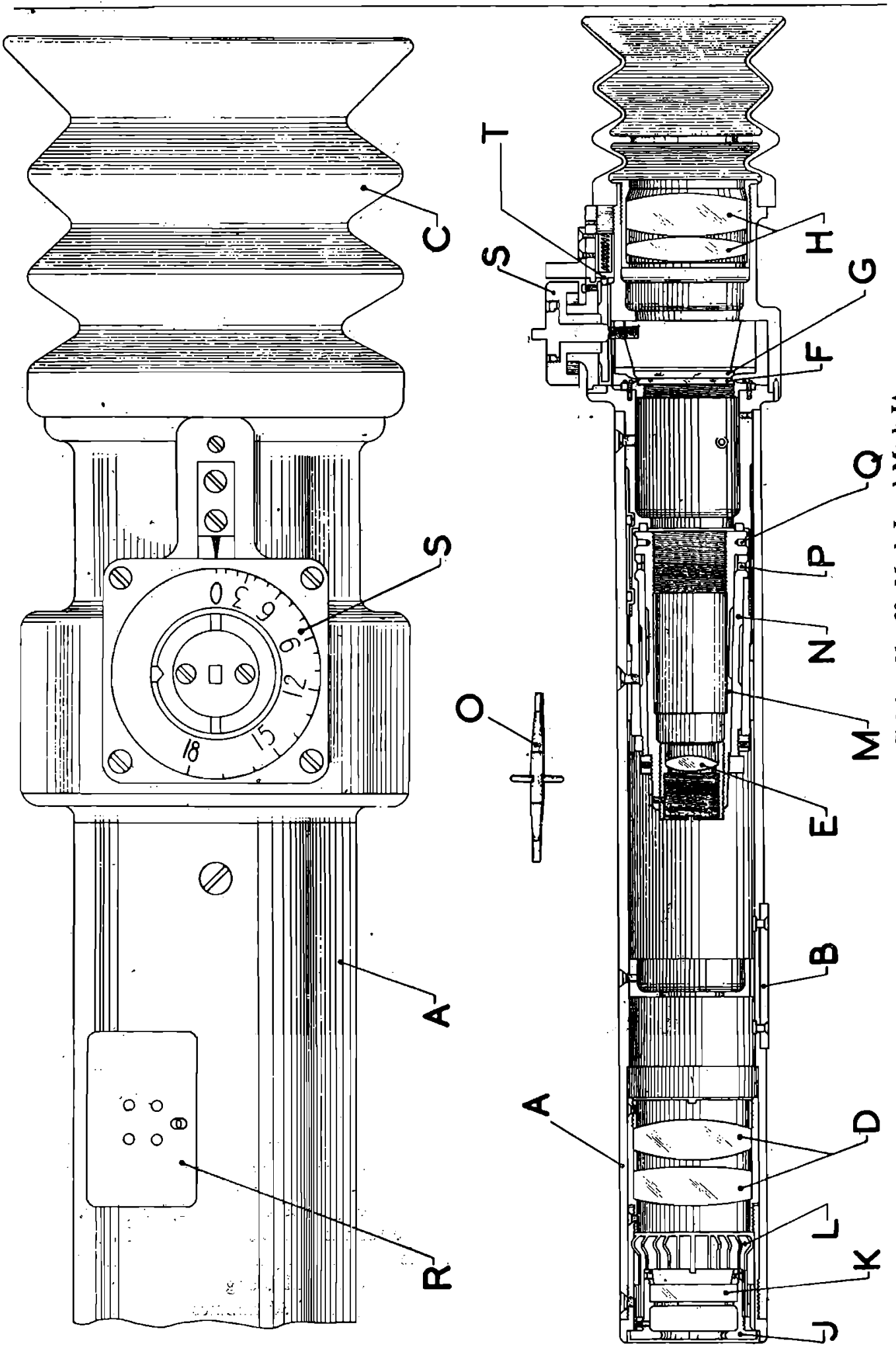


Plate 20. Telescope, Sighting, No. 30, Mark I and Mark IA

TELESCOPE, SIGHTING, NO 33, MARK II. S.

Telescopes must not be tampered with and must not be taken apart except by qualified artificers.

This telescope is similar to the No. 33, Mark I.S., except for the locking device for the antagonistic screws which is dispensed with. It is also similar to the No. 39, Mark I.S. except for the graticule scale. It gives a field view of 21° and a magnification of 1.9 diameters. It consists principally of a body (A, Fig. 96), diaphragm box (B), object glass (C), erector lens (D), diaphragm (E), eye-piece (F) object glass protector (G) and eye-guard (H). The body is tubular to hold the components and is positioned in the mounting bracket by a key (J) fixed to its underside. At the eye end, the diaphragm box fits into the body, secured by four screws. Inside the body, the erector lens (D) in its cell (L), is held in an adaptor (M), which is positioned by a tube (N) screwed to the adaptor at one end, and the diaphragm box at the other. In the other end of the diaphragm box, the eye-piece (F) is screwed, and contains the lenses (O). Between the eye-piece and the erector lens is the diaphragm (E), held by four screws (P) and an adaptor (Q), the screws (P) being drilled and tapped radially, and held by four finger screws (R) passing through the diaphragm box. Fibre washers under the heads of the finger screws, seal the holes in the diaphragm box. By operating the screws antagonistically, the diaphragm is moved to collimate the telescope. The corrugated rubber eye-guard (H) fits over the end of the eye-piece in a groove. The object glass (C) is held and positioned by a tube (S) fitting into the other end of the body. The object glass protector (G) fits into the end of the telescope, and is known as the No. 3, Mark I. This comprises a cell holding a glass disc. It is inserted in the end of the telescope by compressing the retaining springs, which seat in an internal groove in the object glass tube.

The whole telescope is dust proof and watertight.

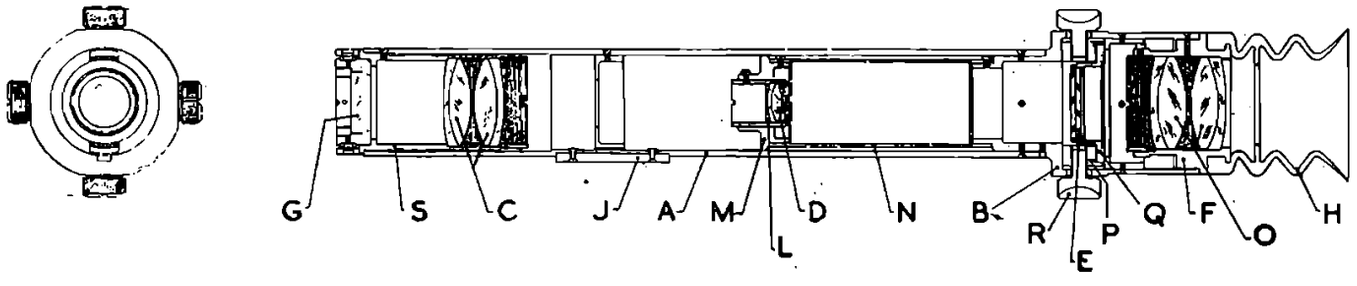


Figure 96. Telescope Sighting No. 33, Mark IIS

The diaphragm. This consists of the cell and two glasses, one graduated with the range scale (see Fig. 97), the other a cover glass, held in a recess in the cell by a spun over edge. The range scale is graduated to represent ranges, marked as numerals in hundreds of yards. Thick cross-lines are used, except where the graticules are marked, the horizontal line, marked 13 minutes below the centre line giving a range of 500 yards for the gun or 400 yards for a machine gun. The horizontal centre line is shown as a short marking above the cross-line. Other range markings shown, represent ranges for the gun of 1,000 and 1,500 yards with comparable ranges for a machine gun of 800 and 1,200 yards. The range scale for the gun is shown on the left, and for a machine gun on the right of the vertical centre line. The graticules marked along the horizontal cross-line are at angles of 30 minutes and are used for " aim-off."

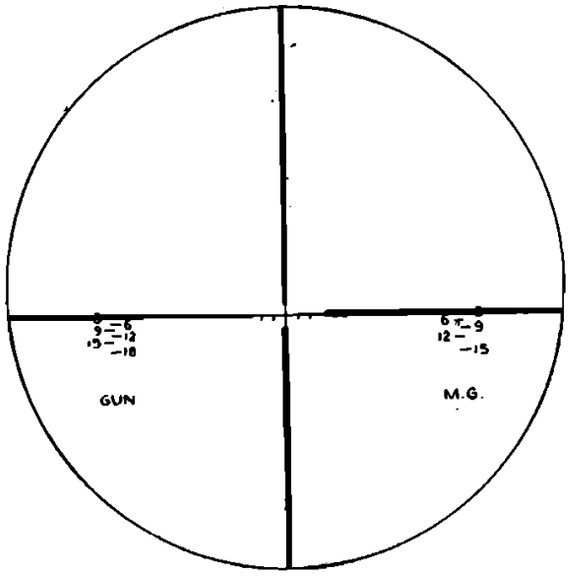


Figure 97. Diaphragm

CHAPTER X B

Gun Mounting

MOUNTING, 37 M/M AND MEDIUM BESA NO. 1., MARK 1

The mounting (see Plates 21, 22 and Fig. 98) is suspended in trunnions (1) from the front plate (2) of the turret. Elevation is free, that is, obtained by pressure on a shoulder-piece (3) and traverse is obtained by rotating the turret. Plates (4) welded to the turret front plate, form a splash protection round the mounting, the side ones having brackets (5) welded to them to receive the trunnions on the inner cradle (6). The cradle (6) is a manganese bronze casting with three frontal apertures for mounting the 37 m/m gun (A), Besa M.G. (B) and the sighting telescope (C). The 37 m/m gun (A) is held in a slipper (17) operating on a slide (8) formed on the body of the buffer which extends through the right aperture in the cradle and is bolted in place. The M.G. (B) is mounted to project through the centre aperture of the cradle and the left is used for sighting. To allow for discrepancies in the welding of the turret plates and trunnion brackets, shims are fitted over the trunnions between the brackets and cradle. The bullet-proof outer mantlet (9) is fabricated with projections (10) and (11) to cover the slipper and buffer and the mechanism of the M.G. respectively, the frontal face of the

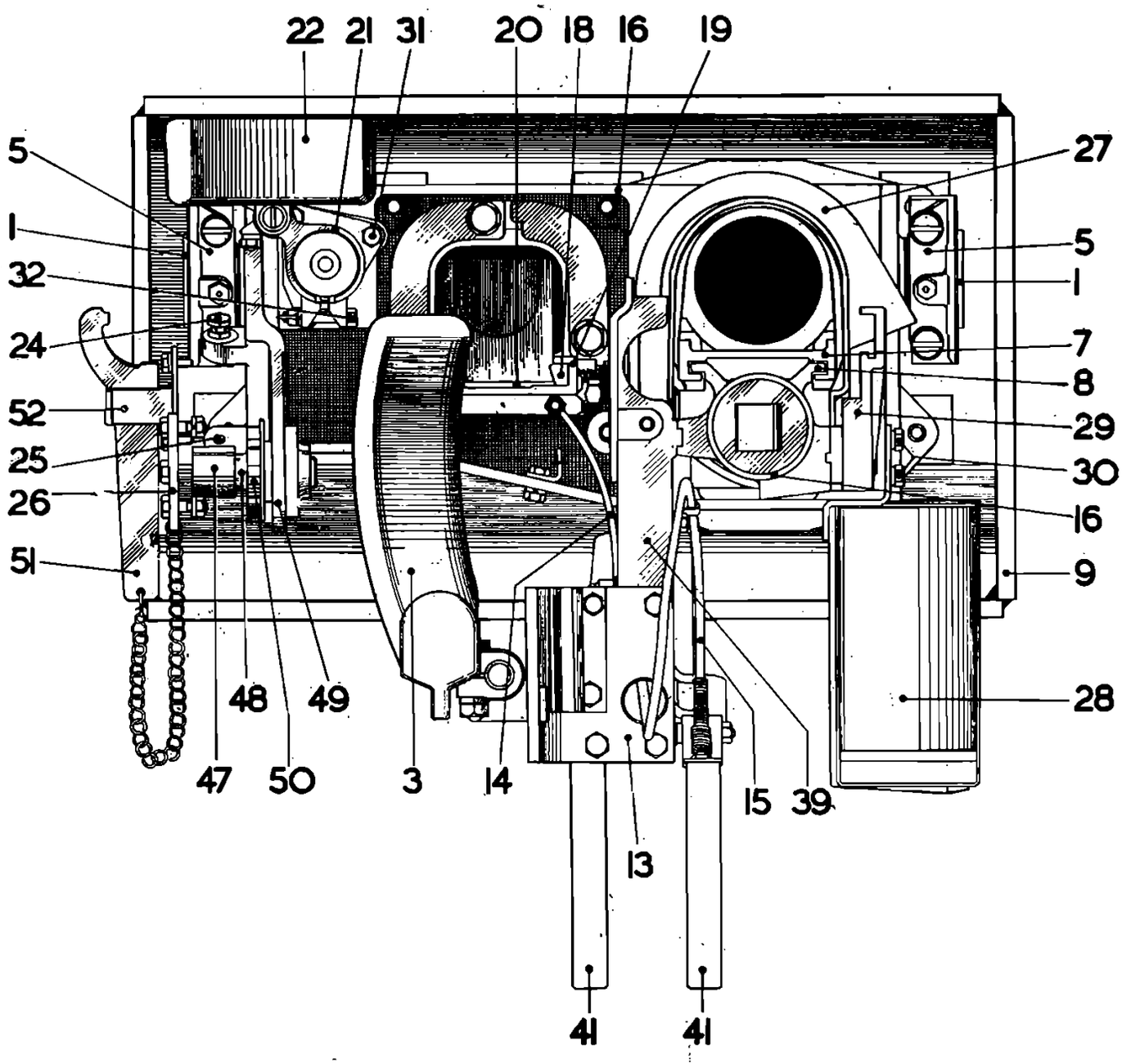


Figure 98. Mounting 37 m/m and Med. Besa No. 1 Mark I. Rear View

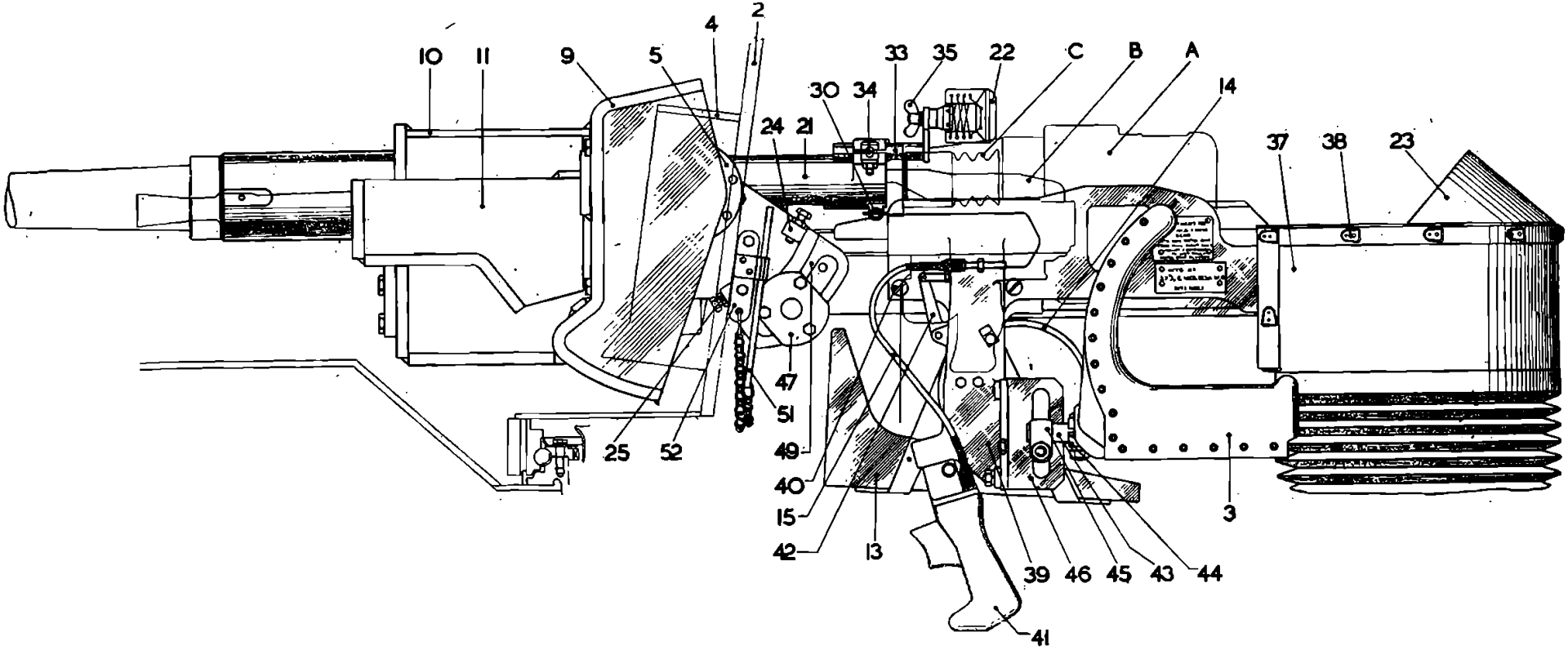


Plate 21. Mounting 37 m/m and Med. Besa No. 1, Mark I. Side View

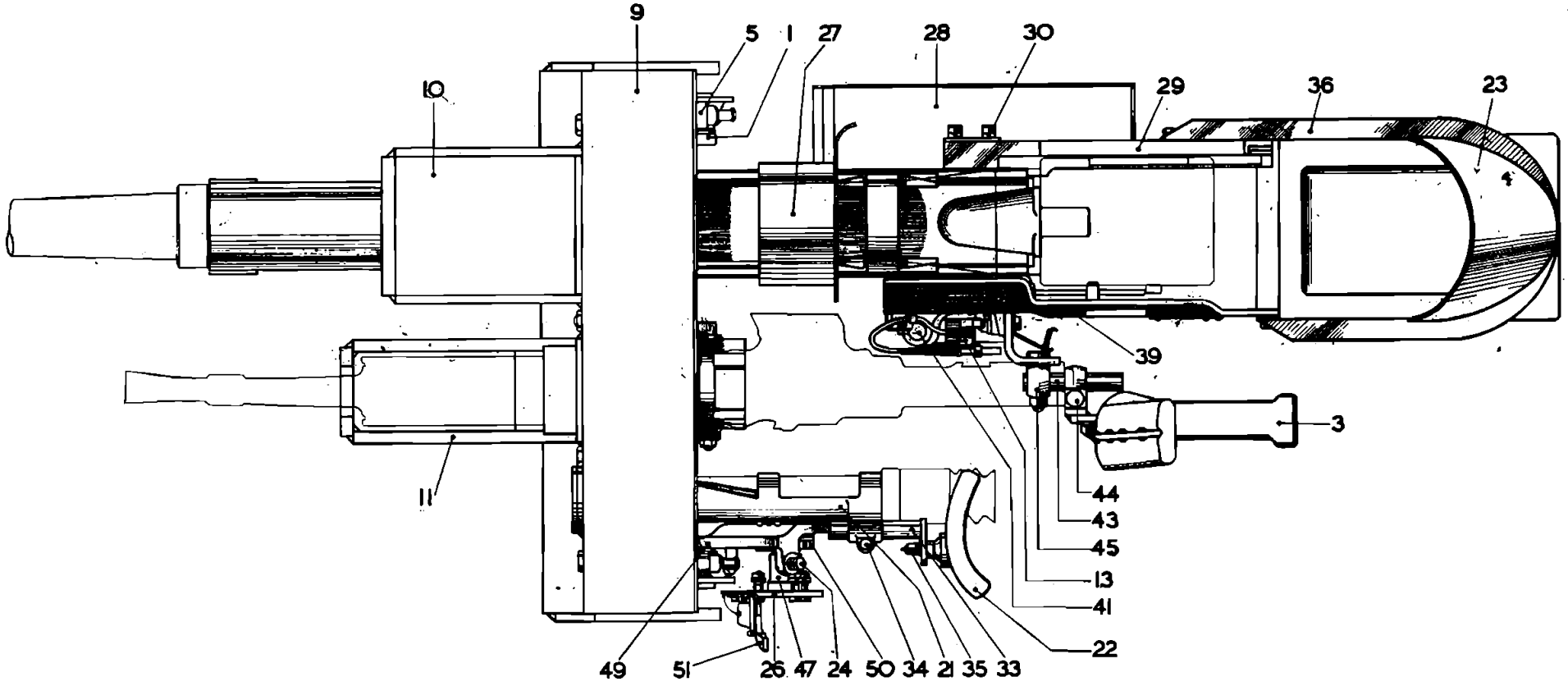


Plate 22. Mounting 37 m/m and Med. Besa No. 1, Mark I. Plan

mantlet being dished so that the edges overlap the splash plates (4) welded to the front turret plate (2). The mantlet (9) is bolted to the front of the inner cradle (6) by eight set bolts (12). To the underpart of the cradle are fitted remote control firing gears (13) of the pistol grip type, the cable (14) from the right hand grip connecting to the firing lever of the 37 m/m gun and the cable (15) from the left, to the M.G. The recoil system (16) is bolted to the cradle and is provided with the slide (8) to guide the slipper (7) during the recoil of the 37 m/m gun. The slipper holds the gun in two bearings, one (17) near the breech end and the other midlength along the barrel. A flange and locknut on the gun, secure it in the front bearing of the slipper, a key in the bearing engaging a key-way in the gun to prevent rotary movement. The M.C. cradle is similar to that used on other tank gun mountings, a loose strap (18) clamping on the slide (19) of the gun and a recoil bolt (20) with a flat along its length, retaining the gun in position. A No. 30 or No. 33 sighting telescope, held in a mounting bracket (21) fitted to the left aperture of the cradle is graduated to suit the 37 m/m gun and the M.G. A browpad (22) is fitted to give stability to the gunner when using the telescope, with provision for adjusting it to suit the individual.

The rear of the mounting carries a deflector (23) and the movement of the mounting about its trunnions is limited, by adjustable depression and elevation stops (24) and (25) respectively, the stops being associated with a clamping gear (26) by means of which the mounting may be locked, for example when travelling.

A belt guide (27) bridges the 37 m/m cradle and directs the M.G. ammunition belt to the Besa M.G. from an expendible liner which is supported by a feed tray (28) at the right hand side of the mounting.

RECOIL SYSTEM

The recoil system (see Figs. 99 and 100) comprises a hydraulic buffer and a recuperator spring mounted within a recoil cylinder. The buffer assisted by the compression of the spring, absorbs the energy created upon recoil of the gun and the spring returns the gun to the run-out or firing position, the final movements of the gun being braked by the gradual restriction of passages through which oil, within the buffer cylinders, is caused to flow during recoil and run-out. The working length of the recoil is 8".

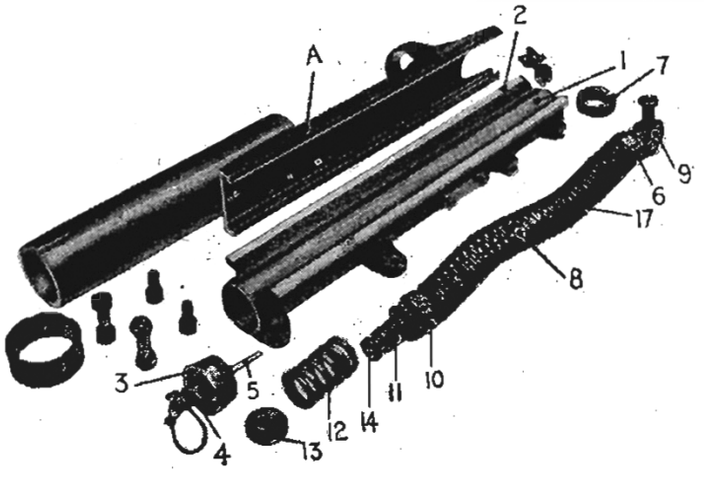


Figure 99. Recoil System

The recoil cylinder (1) is bolted to the cradle of the mounting and is furnished at the upper part with slides (2) which co-operate with the sleigh (A) which carries the 37 m/m gun. The front of the recoil cylinder is closed by a head (3) which embodies a filling aperture, closed by a plug; (4) the head carrying a buffer (5) through a port in which oil enters the cylinder from the filling aperture. The rear end of the cylinder is fitted with a housing (6) held in place by a closing follower (7) and through which the piston rod (8) extends to be coupled by a coupler (9) to the 37 m/m gun. The piston rod is connected to a piston (10) by webs, between which oil can flow from one side of the piston to the other, under the control of a valve (11) slidable on the piston rod under the action of a spring (12) between a nut (13) secured to the end of the piston rod and a valve seating formed on the piston. A cylindrical recess (14) is bored axially in the end of the piston rod and to which the tapered buffer (5) enters as the piston rod returns upon run-out. The recess (14) is in communication with the cylinder, by means of ports (15). The recuperator or run-out spring (16) is mounted between the housing (6) and a collar (17) secured to the piston rod.

Recoil Action.

The 37 m/m gun upon recoil, moves to the rear applying a tractive force to the piston rod through the coupling connection (9). This action causes the piston (10) in its movement to the rear, to force oil from the right hand side of the piston to the left hand side, through the ports (15) and the recess (14), in addition the pressure of the oil created upon displacement of the piston, maintains the valve (11) open approximately .022-in. for a predetermined period until the spring (12) reasserts itself and closes the valve. This action taking place towards the end of the movement of the piston so that the oil is restricted to the passage via the ports (15), hence a retardation effect is obtained and the end of the piston movement of the gun brought smoothly to rest without appreciable jar. During the recoil action the run-out spring (16) is being compressed, and serves to apply a braking effort to the movement of the piston.

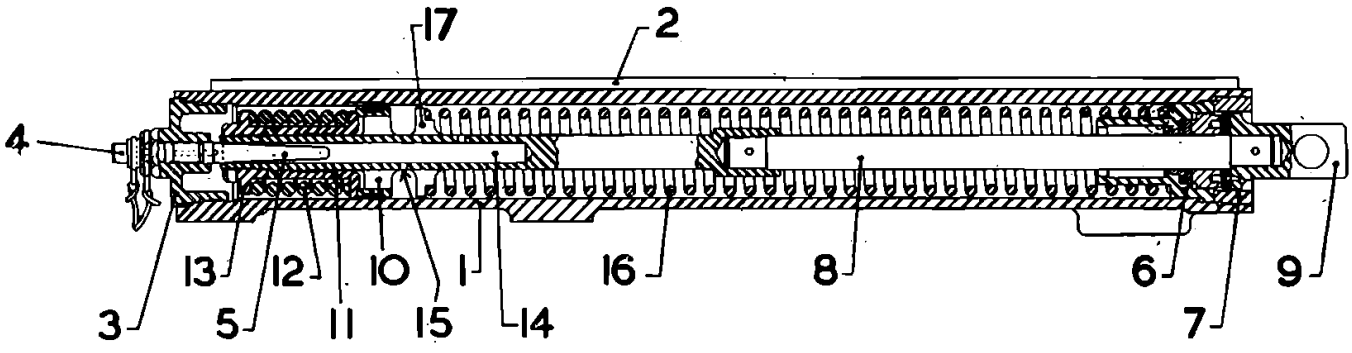


Figure 100. Recoil System in Section

Run-Out Action.

At the termination of the movement of recoil, the spring (16) reasserts itself and returns the piston to its normal position, causing the oil at the left hand side of the piston to pass to the right hand side by way of the recess (14) and the ports (15), the valve (11) remaining closed. When the piston is approaching the end of its movement the buffer (5) enters the recess (14) in the piston rod (8) and due to its taper form gradually restricts the flow of oil, from the recess thus applying a braking effort whereby the gun is brought to its final run-out position without appreciable jar.

CRADLE

The cradle (see Fig. 101) is bolted to the outer mantlet and mounted by means of trunnions (1) supported in trunnion bearing housings (1, Fig. 102) bolted to the splash plates, and pivots about a horizontal axis when the guns are being elevated or depressed. The recoil cylinder is bolted to the cradle through the intermediary of the bolt holes (2, Fig. 101) and in turn supports the 37 m/m gun sleigh, the Besa M.G. being mounted in the slide (3) and retained by a recoil bolt (4). The telescope housing (5) is bolted to the left of the cradle and carries a browpad (6). A clamping gear quadrant (7) co-operates with a locking pin (8) and nut (9) to hold the cradle stationary when desired.

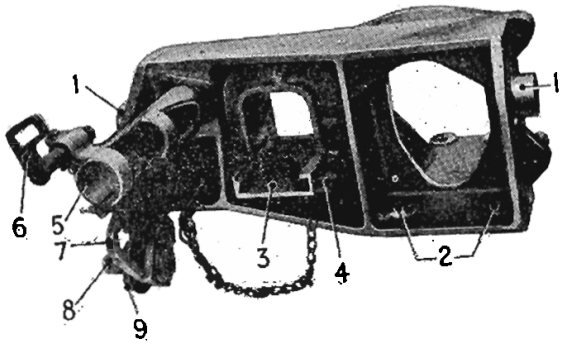


Figure 101. Cradle

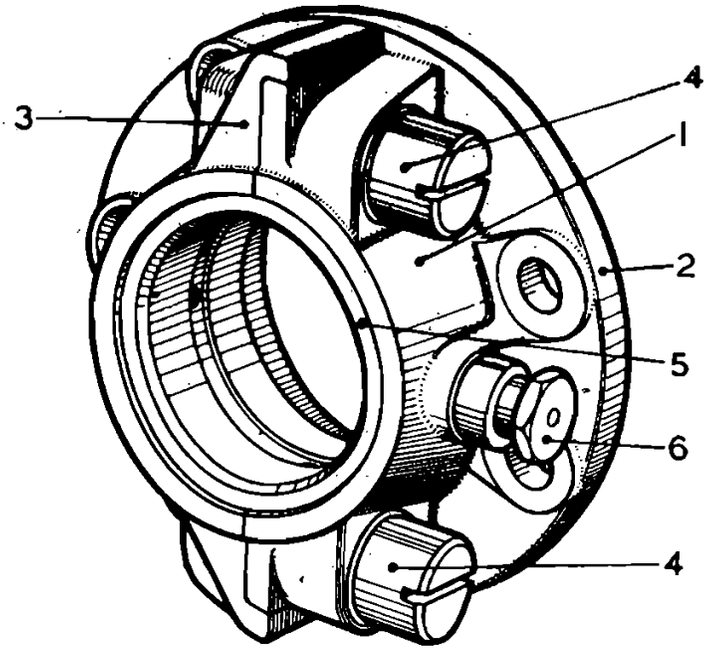


Figure 102. Trunnion Bearing

TRUNNION BEARING

The trunnions of the mounting are rotatably supported in a pair of trunnion bearing housings (1) (see Fig. 102) one on each side splash plate to which their base faces (2) are bolted. Each housing embodies a trunnion bearing cap (3) secured in place by the setbolts (4) and a floating bush (5). Lubricant for the bearing is introduced by means of Tecalemit lubricators (6).

SEMI-AUTOMATIC GEAR

The semi-automatic gear or breech operating mechanism, comprises a bracket (29 Plate 22) bolted to the 37 m/m gun cradle by bolts (30). The bracket is fitted on the inner side with a cam (Fig. 43), which co-operates with an operating lug on the crank to cause the trunnions thereon to open the breech.

TELESCOPE BRACKET AND BROWPAD

The mounting bracket (21) (See Plates 21, 22 and Fig. 98) which receives the telescope (C) is bolted to the inner cradle (6) by bolts (31) the telescope being removable and held in place by the clamping bolt (32). The bracket supports the browpad (22) by means of a browpad arm (33) clamped in position by a clamping bolt (34), which permits the browpad to be adjusted relatively to the eye-piece of the telescope. Further the browpad is pivotally mounted on a bolt provided with a wing nut (35) so that further adjustment can be effected at this point.

DEFLECTOR

The deflector (23) (See Plates 21, 22 and Fig. 98) is secured to the rear of the cradle, by a bracket (36) which also supports a deflector chute (37), into which empty cartridge cases are deflected upon ejection. The deflector chute is of canvas stiffened at the upper part where it is attached to the bracket by " Lift the dot " fasteners (38). The base of the chute is secured to a frame formed with a handle.

FIRING CONTROL AND SHOULDER PIECE ASSEMBLIES

These two assemblies are mounted on a housing bracket (39 See Plates 21, 22 and Fig. 98) common to both assemblies. The bracket is bolted to the cradle of the 37 m/m gun by the bolts (40) in a position between both guns and supports the two pistol grips (41) and the shoulder piece (3). The left hand pistol grip controls the firing of the Besa M.G. by means of the Bowden cable (15) and the right hand pistol grip controls the firing of the 37 m/m gun by the Bowden cable (14) and crank (42) which actuates a control rod, mounted in bushes in the housing, bearing on the trigger of the 37 m/m gun. The shoulder-piece (3) is shaped to fit the shoulder and adjustably mounted on an arm (43), by a clamp (44), the arm being held in a clamp (45) adjustable in a slotted bracket (46), bolted to the firing control housing.

CLAMPING GEAR

Provision whereby the mounting may be locked in position, consists of the clamping gear which comprises a bush secured to an extension of the front turret plate and a clamp bolt (48). (See Plates 21, 22 and Fig. 98) associated with a quadrant slot formed in an extension (49) of the inner mantlet. The clamp bolt rotates in a recess in the bush and can be clamped to the extension (49) by a clamp nut (50) by means of a spanner (51) anchored by a chain and held in an out of use position in a clip (52).