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ALLIED LAND FORCES HEADQUARTERS

S W P A

TECHNICAL INTELLIGENCE SUMMARY

No 4

JULY 1943

GSI LHQ

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ALLIED LAND FORCES

HEADQUARTERS

S.W.P.A.

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G.S.I., L.H.Q.

JAPANESE LIGHT TANK.

1. General Description.

A Japanese tank captured during the operation at Milne Bay has been brought to Australia and submitted to thorough examination at the Directorate of Armoured Fighting Vehicles Production.

For purposes of examination the vehicle was dismantled Photographs were taken and assembly drawings made of important units. These are included in this Summary, together with a description of each assembly.

The vehicle, which is classed as a light tank, had been put out of action by damage to one of the rear track idlers, and probably to one track, which was missing. Penetration of the armour by anti-tank rifle fire at several places may have incapacitated the crew before capture, particularly in the case of one shot which entered the hull in such a manner as to penetrate the driver's head.

The general condition, for examination purposes, was unsatisfactory, because, although little deterioration or corrosion had taken place and almost all the moving parts were quite free, considerable equipment had been removed. This included practically the whole of the electrical gear and instruments, all the armament, and a portion of the stowage. This should be kept in mind when reading the report since it has rendered the work proportionately incomplete.

The most notable features of the tank are :-

(a) Exceedingly cramped fighting compartment.

(b) High quality of workmanship and material. Excellence of design generally.

(c) Solidly constructed Cardon-Lloyd type suspension with the weight of the vehicle supported by horizontal compression springs, protected by curved 4 mm. armour plate.

(d) Adequate provision of exits for all personnel.

(e) Exceptionally fine workmanship on all transmission components with extravagant use of self-aligning ball bearings.

(f) All gears are profile ground, and mating surfaces of gear boxes and housings hand-scraped for accuracy. Transmission gears are not case-hardened, but are heat-treated to an average hardness of 540 Vickers D.P.H.

(g) Ball races are either of German manufacture or else have no name or type number imprinted on them.

(h) Combined rivetted and welded construction of hull, the whole being built around a channel and angle-iron frame.

(j) Design generally very light. Aluminium and light alloys extensively used.

(k) Lightly armoured. Maximum thickness of armour 12 mm. even for vertical plate at rear.

(l) Insulation of the engine compartment against heat from outside sources and against penetration of engine heat into the crew's compartment.

(m) Woven asbestos paddings, separated from the inside surfaces of the tank by an air space, to prevent direct radiation from the hull to the crew in hot climates, and to guard the crew against injury when travelling over rough ground.

(n) Numerous vision slits at strategic points, but unprotected by glass visor blocks except directly in front of the driver.

(o) Robust air cooled diesel engine.

(p) High power-weight ratio (25 H.P. per ton).

Figures 1 and 2 are photographs taken on receipt of the vehicle, and show its general appearance from the three-quarter front, and three-quarter rear angles. Figure 5 is a side elevation drawing giving the leading overall dimensions. Figure 6 shows the front and rear elevations. Figure 7 is a sectional elevation along the longitudinal centre line and shows the disposition of the engine and transmission components in the vehicle. An "X-ray" drawing (Figure 8) assists in guaging the relative positions of various components throughout the vehicle. From Figure 6 and 7 it can be seen that the engine compartment, which also houses batteries, fuel tank, oil cooler, and air cleaners, occupies the rear third of the hull and is isolated from the driving and fighting compartments by a heat insulating bulkhead. Access to the engine compartment is obtained through doors in the bulkhead. These insulating components are constructed from a pressed wood fibre substance impregnated to resist fire. The material will smoulder so long as heat from an outside source is applied, but will not burn by itself. The medium is approximately $1\frac{1}{4}$" thick for the bulkhead, and 1" thick on the walls of the engine compartment. It is held in a framework of steel sections, and protected from damage by fine mesh heavy gauge wire gauze. A report on its composition by the C.S. & I.R. is given in Appendix 1.

The six cylinder, in-line type, air cooled diesel engine transmits its power through a multiple plate dry type clutch to a transfer box, the output shaft of which is on the centreline of the tank. A belt pulley attached to this output shaft takes power for a generator mounted in the floor of the tank and forms one yoke of a needle roller type universal joint which drives the cardan shaft. This shaft, which is only $16\frac{3}{8}$" long, passes through the fighting compartment enclosed in a tunnel and drives the input shaft to the gear box through a second needle roller type universal. The gear box is built integral with a bevel gear drive and is located in the front of the tank. The output from the bevel drive is taken to each track through clutches, an internal gear reduction and a plain

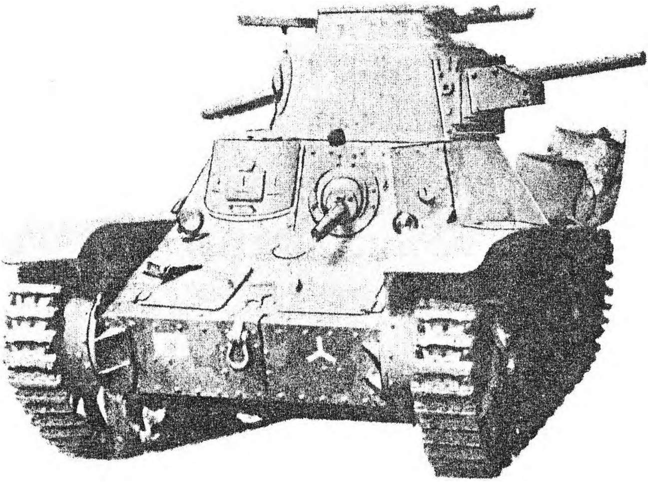


Fig. 1.
Three-quarter front view.

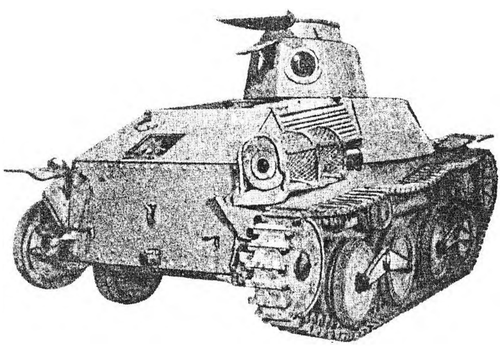


Fig. 2.
Three-quarter rear view.

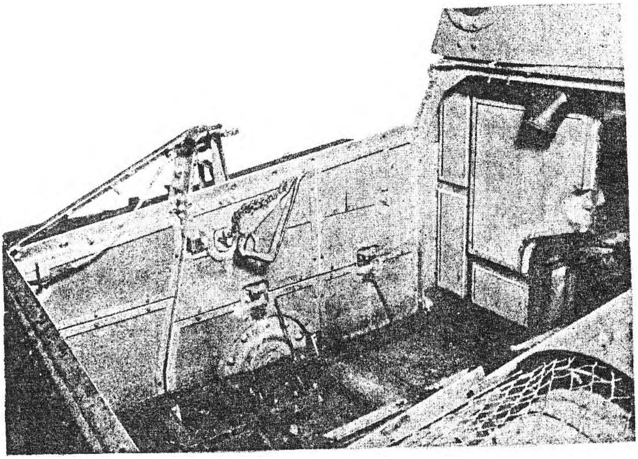


Fig. 3.
Insulation of Engine Compartment.

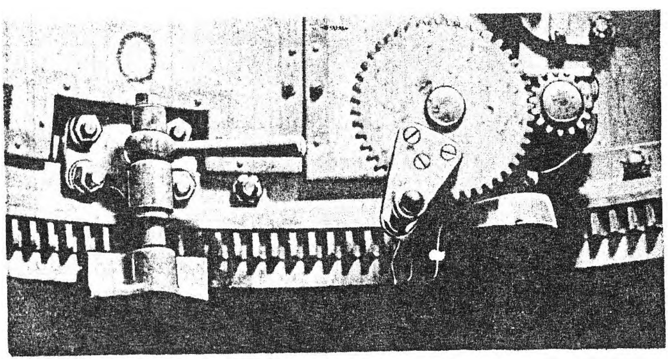
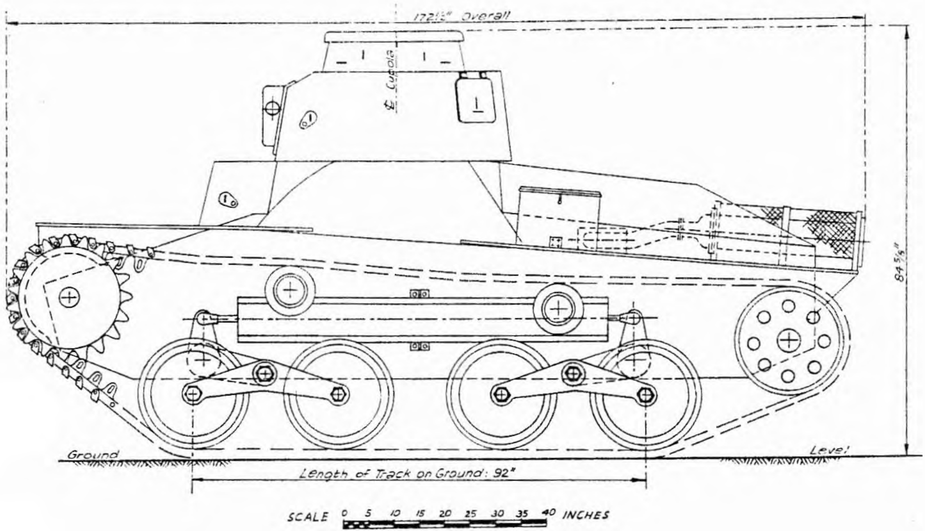
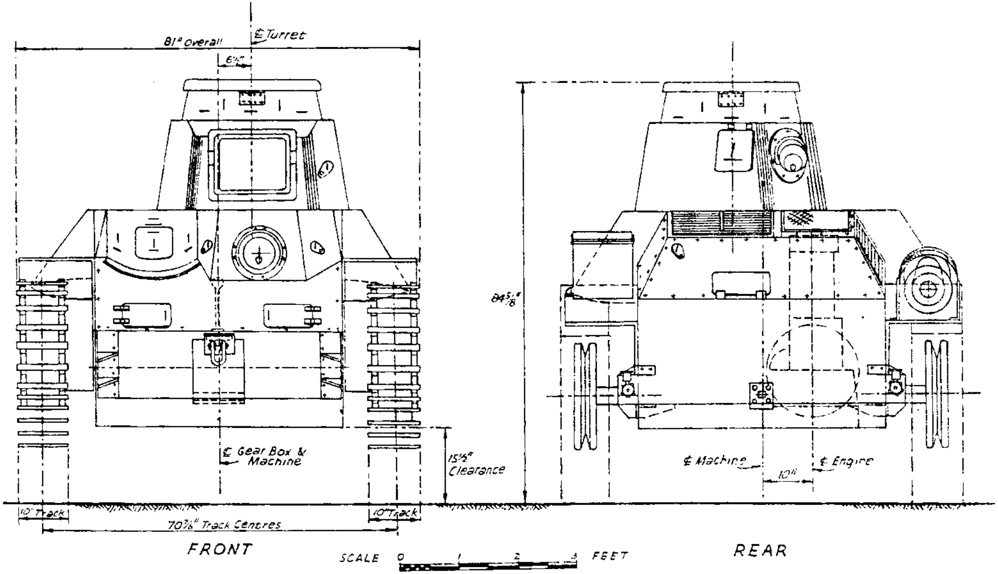


Fig. 4.
Turret Operating Gear.

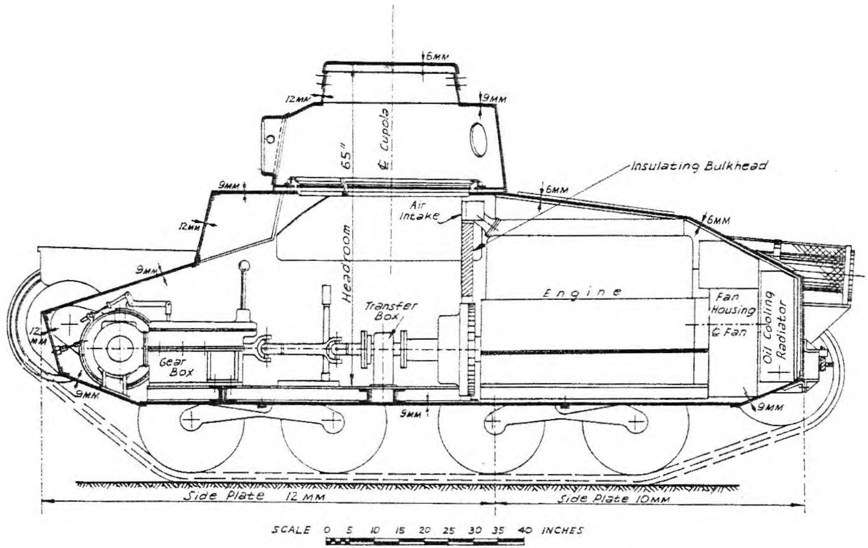


SIDE ELEVATION – HULL

Fig. 5.



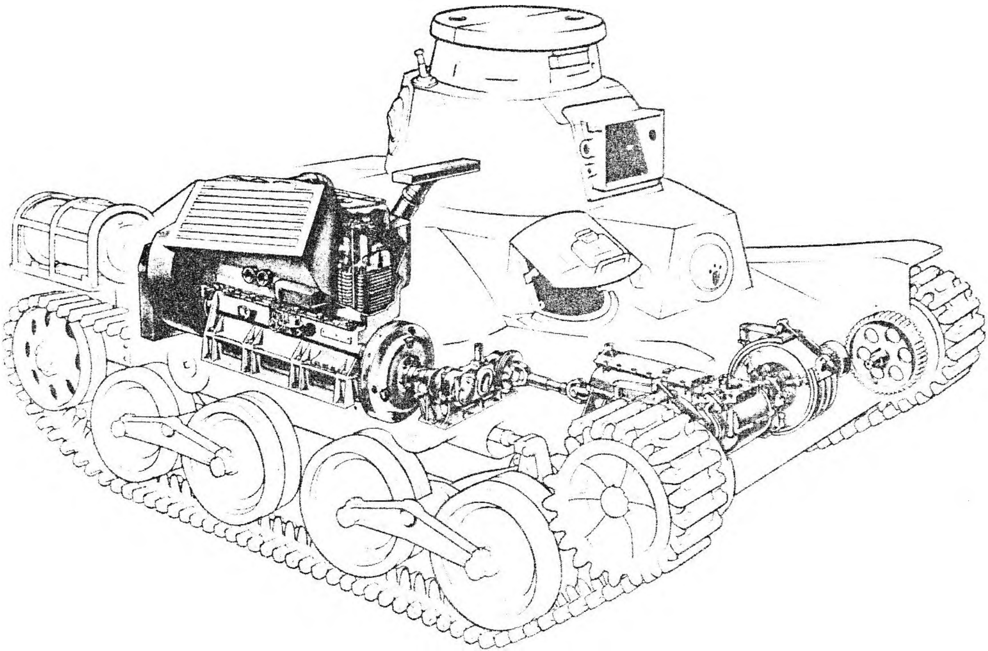
FRONT & REAR ELEVATION _ HULL



LONGITUDINAL SECTION — HULL

Fig. 7.

Fig. 8. - "X-ray" view of tank.



spur reduction. The clutches are built integral with the steering brakes and are operated by the same levers which actuate the brakes. A false floor is provided under the driver's feet to cover the structural members supporting the bottom of the tank. Electric cables, control rods, oil pipes, etc., are contained between the two floors. The forward end of the front compartment houses the driver on the right hand side, and a machine gunner on the left hand side. No exit is provided for the hull gunner, although provision is made for the driver to leave the tank through a large semicircular hinged flap fitted to the right hand front of the hull superstructure. Exits for the gunner in the turret and the hull gunner are provided through the turret cupola or through a door over the engine compartment, access to which is obtained via the door in the engine room bulkhead. The main hull is surmounted by a circular, centrally located superstructure which protrudes over the tracks on either side and which carries the gun turret. The engine compartment is provided with three doors. One permits adjustment of the tappets, and which is provided with louvres to allow escape of cooling air; one which covers the fuel tank filling holes, and a third which provides access to the engine cooling system and the storage batteries. The turret has no rotating floor, nor apparently does it carry seats for either of the gunners. (Gunners must follow their guns by stepping over the cardan shaft tunnel, transfer case, etc.). Considering the smallness of the fighting compartment in relation to the number of crew apparently carried this would prejudice the accurate aiming of guns in action.

No power traverse is provided. Traverse is effected by means of a hand wheel driving a spur gear which engages with the internal gear on the turret, through a single start worm reduction, (Figure 4). The handle is provided with a dog clutch through which it may be disengaged. The Turret can thus be swung rapidly by direct pressure. Two quick-acting thread type clamps enable the turret to be locked while travelling in convoy. One of these is also shown in Figure 4.

Steering is controlled through a direct clutch brake system in which either track may be disengaged from the drive by moving one of the two steering levers provided. Further movement of these levers applies the brake to either track and thus permits sharp turns to be negotiated. The operating levers and linkage are shown in Fig. 9, with the left hand lever in the brake on - clutch disengaged position, and the right hand lever in the brake off - clutch engaged position. The clutches are cam operated and the brakes' actuating mechanism is connected to the clutch levers through slotted links. No hydraulic or vacuum assisting gear is provided. The mechanism is fully described on Page 83.

When the semi-circular panel in front of the driver is closed he obtains his vision through three vertical and three horizontal slits, which taper from 2 mm. wide on the outside to 5 mm. wide on the inside. There are five vertical and five horizontal slits in the turret, and a 55 mm. diameter peep hole, which can be covered by a sliding flap, is provided for the main gunner in the turret. These slits can be seen by reference to Figs. 1 - 7.

Suspension consists of two pairs of double bogie wheels. Each side of the connecting arm is pivoted centrally on a bellcrank, the weight being taken by one helical compression spring for each bogie (a total of four springs for the tank

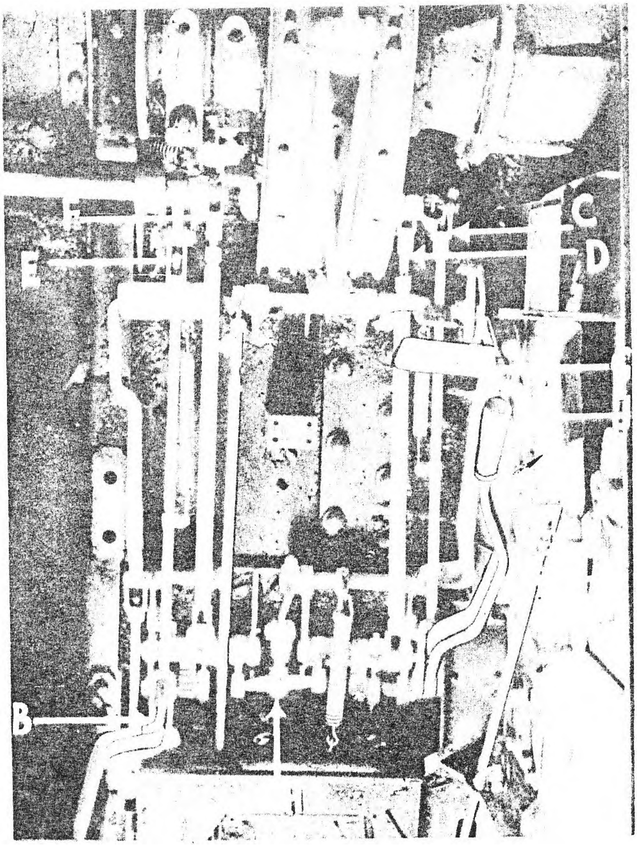


Fig. 9.
Clutch and Brake Operating Linkage.

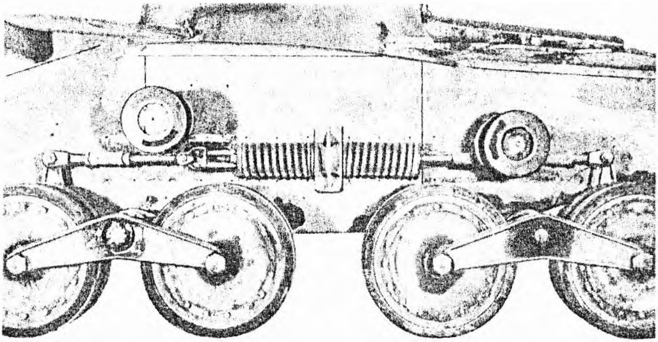


Fig. 10.
Suspension System.

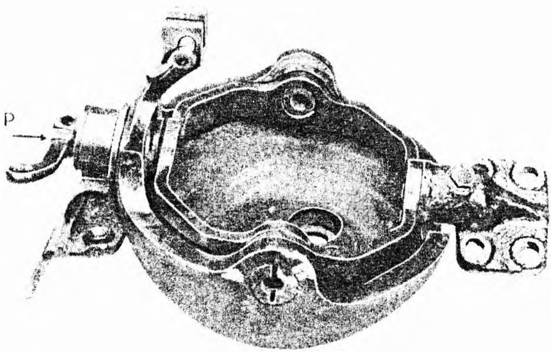


Fig. 11.
Ball Mounting - Machine Gun.

Figure 10. The dimensions of the spring and other components are described under the heading "Suspension" (Page 16) but it is interesting to note here that the springs are protected by semi-circular armour plate guards 4 mm. thick. The inner surfaces of the steering brake drums are provided with vanes which induce a flow of air past the drum, and thus assist in dissipating heat generated when the brake is applied. The tracks are not protected by armour plate, but are covered by a 16 gauge steel fender which runs the length of the tank. On the left hand fender a box is mounted, presumably for the stowage of rations, clothing, etc. for the crew. No appreciable signs of wear or rough useage were observed after dismantling the main units, but it was particularly noted that no provision was made for draining the lubricant from the final drive gear cases.

Owing to the absence of a speedometer, no estimate of the mileage covered by the vehicle could be made, but a drive for the speedometer, consisting of a mild steel gear attached to the right hand output shaft from the bevel reduction, and driving a canvas laminated bakelite pinion, was fitted to the tank. The pinion, in turn, drives a worm reduction to the output shaft, on which is attached a shielded flexible cable. This can be seen in Figure 58. A generator for supplying power to wireless equipment had been fitted to the floor of the fighting compartment. This was driven from the output shaft of the transfer case by means of twin V-belts, the tension of the belts being regulated by an adjustable jockey pulley.

The engine is fitted with decompressing gear for starting purposes. This consists of a circular cam mounted under each exhaust tappet and capable of raising the tappet approximately 30/1000" when it is rotated through 90°. These cams are all linked together and are operated by a small lever on the Driver's right hand through a push rod and clevises.

Two identical mountings for electric motors are provided, one each side of the cylinder block and just behind the fly-wheel ring gear. It is logical to assume therefore, that two motors were used to ensure easy starting. The valve lifting gear and one starting motor mounting are shown in Figure 26 at A & B respectively.

Samples of the lubricating oil from the engine, transfer case, gear box, spiral bevel drive, and final drives were sent together with a sample of the fuel oil, to a leading oil company for analysis and comparison with lubricants in use here. The results of these analyses are quoted in App. 2.

2. ABRIDGED SPECIFICATION

General Data:

Estimated total fighting weight	9 tons
Length	172½"
Width	81 "
Height	84⅝"

Track centres	70$\frac{7}{8}$"
Track width	10"
Length of track ground	92"
Ground clearance	15$\frac{1}{2}$"

Armament:

All armament had been removed from the vehicle prior to delivery to the Directorate of Armoured Fighting Vehicles Production. Mountings for turret and hull machine guns however, were still in place and were found to be capable of 12° elevation, 16° depression and 22$\frac{1}{2}$° traverse on either side of the centre line. (For report on L.M.G. taken from tank, see Tech. Int. Summary No.2, page 30).

Armour Protection:		Hull	Turret
Front plates		12 mm.	12 mm.
Side plates	Front	12 mm.	12 mm.
	Rear	10 mm.	
Rear plates		12 mm.	12 mm.
Top plates	Front	9 mm.	9 mm.
	Rear	6 mm.	(Cupola 6 mm)
Bottom plates		9 mm.	

Turret Ring Diameter: 36"

Crew:

Presumably four persons, i.e., Commander Gunner and Loader Machine Gunner in turret, Driver and Machine Gunner at front.

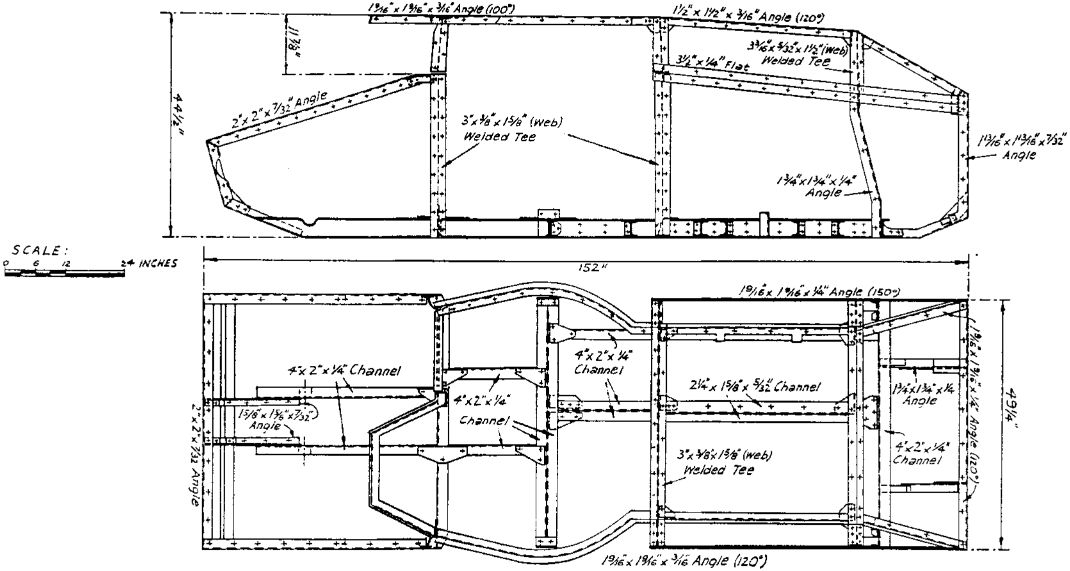
Engine:

Six cylinder in-line type. Air cooled diesel. 200 - 250 B.H.P. at 2000 R.P.M. Capacity 14 litres (855 cu.ins.) Sump lubrication with large capacity oil cooler. Dry weight, less electrical accessories and fuel pump, 1700 lbs appr. Capacity main tank: 23 gallons. Reserve tank: 6 gallons.

Gear Box:

Four forward speeds and one reverse with manual control from orthodox type gear shift rod. Ratios (not including spiral bevel reduction).

1st Gear	2.93 : 1
2nd "	1.79 : 1
3rd "	Direct
4th "	.057 : 1



FRAMEWORK -HULL

Fig. 12.

Reverse	3.55 : 1

Steering:

Clutch brake principle with multi plate clutch working inside external contracting type brake drum.

Final Drive:

Internal Gear reduction		1.82 : 1.
Spur gear bevel	"	3.31 : 1
Spiral bevel	"	1.38 : 1

Permanent overall ratio from gear box including bevel drive 8.3 : 1

Sprocket pitch diameter - 22.7" (19 teeth 9.5 mm pitch.)

Overall Ratios: Engine to Track Sprocket.

1st	24.3 : 1
2nd	14.8 : 1
3rd	8.3 : 1
4th	4.47 : 1
Reverse	29.4 : 1

Suspension:

Two double bogies per side supported through linkages by helical compression springs.

Performance:

28 miles per hour at 2000 R.P.M. (Engine speed in 4th Gear)
Track pressure based on 9 tons laden weight and length by breadth inclusive area of track with 2" sinkage - 9.9 lbs per square inch.

3. Detailed Analysis.

(a) Hull: The general appearance of this unit, which consists of three separate sub-assemblies,
(i) Main hull with central superstructure carrying turret (including hull framing).
(ii) Front cover plates.
(iii) Rear cover plates.
is illustrated in drawing, see Figure 7. The front and rear cover plates, are bolted to the main hull, which is fundamentally of rivetted construction. All rivets and bolts are of mild steel, those exposed to the outside being "Steeple Headed". The various hull plates are rivetted to a channel and angle-iron frame and the central superstructure is both rivetted and welded in place. The frame is detailed in Figure 12.

The floor is supported by a framework of pressed steel channels back to back, the webs being perforated for lightness. The side plates and floor are approximately

12'8" long. The lower hull assembly is divided into two compartments by a bulkhead, manufactured from pressed wood fibre $1\frac{1}{4}$" thick, which is held in a steel frame and protected from damage by heavy gauge wire gauze.

The rear compartment contains the engine, fuel tanks, cooling fan, oil radiator, batteries etc. The walls of this compartment are lagged with wood fibre sheets similar to those in the dividing bulkhead but of 1" thickness. A door in the bulkhead gives access to the engine compartment while the side and top cover plates are all bolted on to permit their easy removal for maintenance on the variou components housed therein. Small access covers and air circulating louvres are provided to enable the fuel tanks to be filled, tappets to be adjusted, etc.

Extending beyond the sides are light running boards or track guards supported from the main side plates by angle-iron stays. The central superstructure, supporting the turret, extends over the tracks to provide inside space for stowage of ammunition. Each track guard therefore, consists of two pieces extending from this superstructure to the back and front of the vehicle respectively. Suspended from the front and rear of these track guards are heavy rubber sheets designed, apparently, to act as scrapers on the track.

A detailed description of the suspension is given under separate heading, but it should be noted here that the anchors holding the stub axles, on which the bellcranks pivot, are rivetted to the side plates and bottom angle-iron of the hull frame, thus forming an integral part of the assembly. (See Figure 3). These anchors are solid steel castings. The gear box, front drive, and steering mechanism are housed in thin sheet metal covers. Apertures are provided, covered by sliding shutters, to facilitate inspection of oil levels and replenishment of oil. The driver's controls are situated on the right hand side of the vehicle. His forward vision is through slits in a small visor plate which can be opened when the tank is not in action. This visor plate is cut in a large semi-circular hinged plate in front of the driver. This can be opened sufficiently to provide entry or exit in an emergency. When not in action, and should climatic conditions warrant it, the vehicle could be driven with this plate open. The three slits immediately in front of the driver have apparently been backed by removable non-shattering glass windows as small frames are in place behind them. The glass, if such existed, had, however, been removed prior to examination of the tank. The hull machine gun is carried in a ball mounting on the left hand side of the vehicle in a compartment extending out in front of the driver's position. Sideways vision for the hull gunner is obtained through slits in both sides of this compartment, as well as through peep holes provided with shutters. No provision has been made for glass blocks behind slits (other than those in front of the driver). The field of fire for the hull gun is given under the heading "Armament" (page 14).

Rivetted to the main side plates at the front end are the final drive gear boxes. The top front plate of the main hull, which is bolted to the angle-iron frame, is provided with two hinged doors giving access to the brake and steering mechanism. (See Figures 1 and 6).

Mounted at the rear of the side plates are the track idler wheels which are adjustable to enable the track to be tensioned. The method of adjustment is dealt with under the heading "Tracks and Suspension". A dummy floor is provided in the driving position approximately 3½" above the bottom plate, to prevent the driver's feet from fouling the rods of the clutch and brake operating mechanism. Two cover plates, situated in the bottom plate under the engine, allow the sump to be drained and the two lubricating oil filtering screens in the sump to be cleaned. A third cover plate under the fuel tank also enables this component to be drained and cleaned. No trapdoors existed in the floor under any other compartments, with the result that the bottom of the tank was fouled with oil, dirt, and other refuse. Drawing, (Figure 7) shows the thickness of the various armour plates in the hull, and these thicknesses are also listed under "General Data" (Page 14). Ballistic properties were discussed in L.H.Q. Tech. Int. Summary Nos 1 & 2.

(b) <u>Ammunition. Stowage & Equipment</u>.

Figures 13 to 17 are photographs showing the general layout of the interior of the fighting compartment. Key letters, tying up with lists for each figure, are provided for further identification of the various items.

Ammunition for the 37 mm. gun totals 130 rounds stowed as follows:

A & B. In 2 banks of clips of six and nine rounds on the turret walls, Figures 13 and 14. (The rack of six clips was missing and Figure 13 shows its location only).

C. In one bank of clips of twelve rounds in the superstructure extension over the left hand track. (Fig. 15).

D. In one rack of six rounds on the left hand side of the hull behind the hull gunner. (Figure 15).

E. Forty-eight rounds in a bin above the transfer case. (Figure 16).

F. Thirty two rounds in a second bin above this. (Figure 16).

G. Eight rounds in a small bin by the engine clutch. (Figure 16).

Ammunition for the machine guns is held in clips, each containing approximately 30 rounds. A rack (H) for 39 clips (1170 rounds) is fixed in front of the hull gunner just below the gun (see Figure 17) and there is apparently a space for another rack (J) holding approximately 60 clips (1,800 rounds) for the turret gun on the left hand side of the hull just behind the hull gunner. (See Fig. 15).

A ball joint for the wireless aerial is provided. Item (m) Figure 15 is a fire extinguisher of the pyrene type.

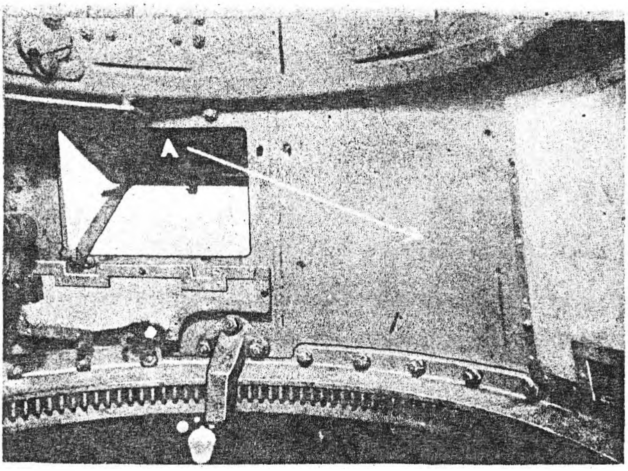


Fig. 13.
37 mm. Ammunition Stowage - Turret.

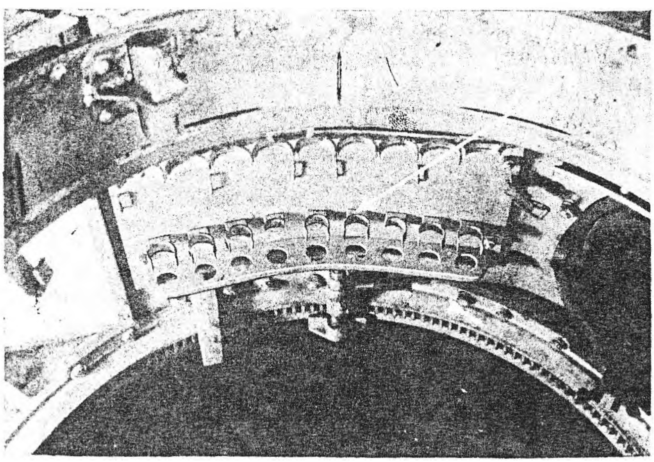


Fig. 14.
37 mm. Ammunition Stowage - Turret.

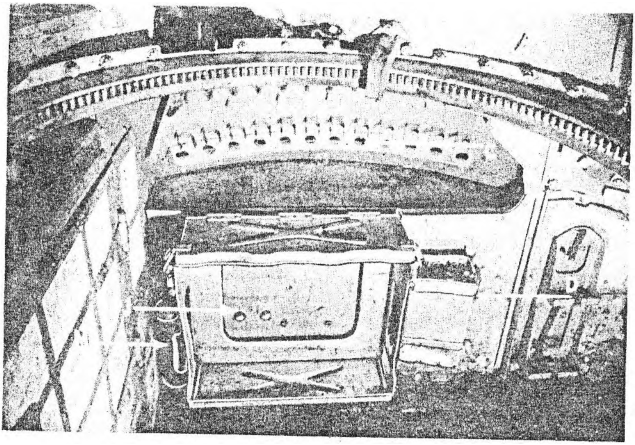


Fig. 15.
Ammunition Stowage in Hull - 37 mm. &
Machine Gun.

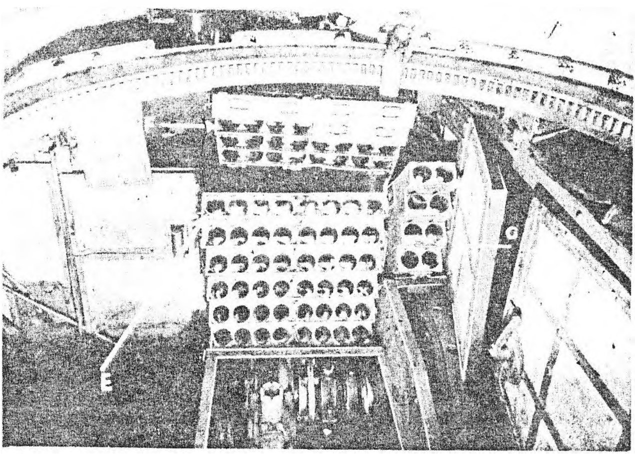


Fig. 16.
Ammunition Stowage in Hull - 37 mm.

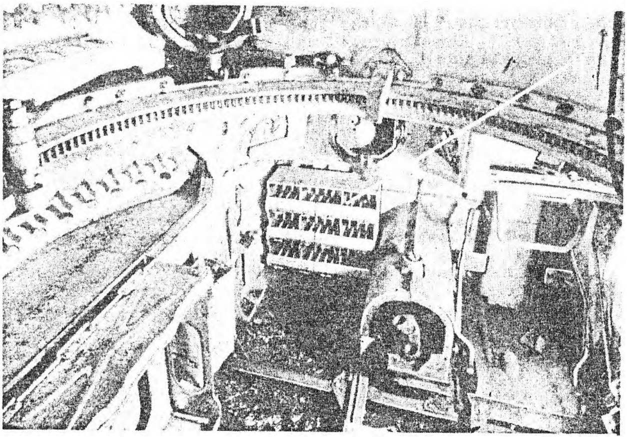


Fig. 17.
Machine Gun Ammunition Stowage - Hull.

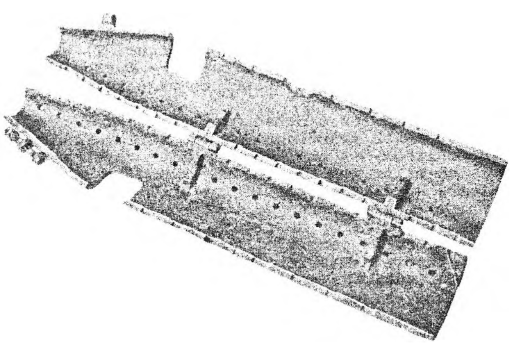


Fig. 18.
Protecting Sheath - Machine Gun.

None of the brackets and clips for holding various items of equipment were marked, nor was any of the equipment left in the tank, so that the use of these can only be surmised. All driving and engine indicating instruments had been removed from the tank prior to delivery to D.A.F.V.P. The controls and gauges fitted, however, were probably as follow :-

Two hand levers to control steering and braking, one for each track.

One foot pedal (left foot) for engine clutch.

One foot pedal (right foot) to apply brake to both tracks.

One hand lever to operate exhaust valve lifters.

One hand lever to operate throttle.

One foot lever to operate throttle.

One hand lever to hold both track brakes for parking.

One electric starter.

Speedometer.

Oil pressure gauge.

Engine temperature gauge.

Ampere meter.

Light switches.

Fuel gauges of the sight glass type are provided on the fuel tanks at the rear of the vehicle. Dipsticks are used for engine sump and all transmission units.

(c) Turret Armament.

The general arrangement of the turret is shown in the longitudinal section drawing (Figure 7) which also gives the plate thicknesses. These are further tabulated under the heading "General Data" on page 14.

The unit is constructed from shaped armour plate bent and welded, with mountings for the various guns, etc., bolted in position. A small cupola with vertical and horizontal vision slits cut all the way round is welded to the top of the turret and provided with lids which open outwards. A peep hole is arranged in each lid and provided with a movable shutter. No rotating platform is used, the gunners being compelled to follow their guns by stepping over the transmission, transfer case, etc., on the floor of the tank. No seats are provided for any of the crew with the exception of the driver.

(d) Armament.

Unfortunately all armament had been removed prior to delivery of the vehicle to D.A.F.V.P., therefore, no detailed information can be given. The following statements are accordingly made from observation only:-

A 37 mm. gun is arranged in the front of the turret, whilst in the rear, almost diametrically opposite, is a ball mounted machine gun (see Figure 7). The machine gun is covered with a perforated pressed steel sheath, Vickers D.P.N. 450. (Figure 18) presumably for protection. A photograph of the ball mounting is shown in Figure 11, whilst the protective sheath for the machine gun is shown in Figure 18. A thumb type screwed clamp ("P" of figure 11) enables the machine gun to be locked into position, presumably for travelling in convoy. The space is so cramped that it would be virtually impossible to load and fire the turret gun and the main armament at the same time. For details of depression and elevation of the armament see "General Data" (Page 14).

(e) Turret Ball Race.

The turret is mounted on a ball race similar in design to the ordinary thrust bearing. This is illustrated in drawing (Figure 23) from which it can be seen that the balls run in 90° V-ways which are ground. The turret is carried on 24 balls 19 mm. in diameter which are separated by a cage consisting of small pressed steel links rivetted together. This would enable the turret ball and cage assembly to be made in extremely long lengths and suitable pieces cut off and formed into rings for various sized turrets in a manner similar to that in use with roller chain. The diameter of the turret ball race is 36 inches and the head room from the floor of the tank to the cupola lid, 65 inches.

(f) Chemical Analysis and Ballistics of Armour.

Pieces of armour plate were gas cut from various parts of the tank for analysis and determination of ballistic properties. These were examined at the Munitions Supply Laboratories, Maribyrnong, and by Major Forrest, Maribyrnong, respectively. The results (shown in pages 75 - 77) indicate that the armour is about 10% better than the equivalent British type.

(g) Engine.

Figures 23 to 47 show the general appearance of this unit, which, being an air cooled diesel engine, is of rather unusual design.

When received the engine was in poor condition because valve gear, fuel pump, and all electrical equipment had been removed. The mechanical condition of the engine was however, excellent. The amount of wear on pistons, cylinder bores, big end and main bearings and crank-shaft journals was very small, i.e., an average of 1/1000" on the cylinder bores, 2/1000" on the pistons, 1/1000" on the big end bearings and 1/1000" on the crankshaft journals.

The cylinder bores were not scored in any way, although certain of the pistons showed signs of slight scuffing. A heavy carbon deposit was noticed in the combustion chambers, but the general condition of the engine indicated that little work had been done prior to capture. The heavy carbon deposit was attributed to the upper cylinder lubrication arrangements, which consist of a rotary valve

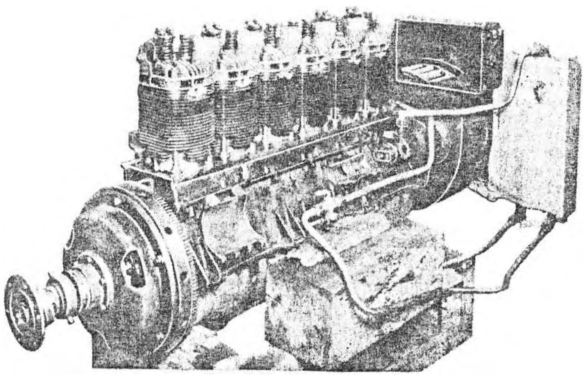


Fig. 19.
Engine Assembly with fan and oil cooler.

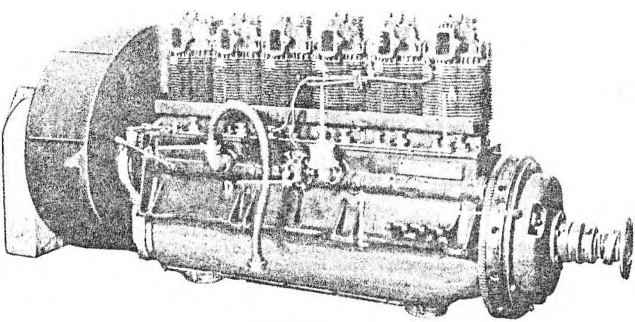
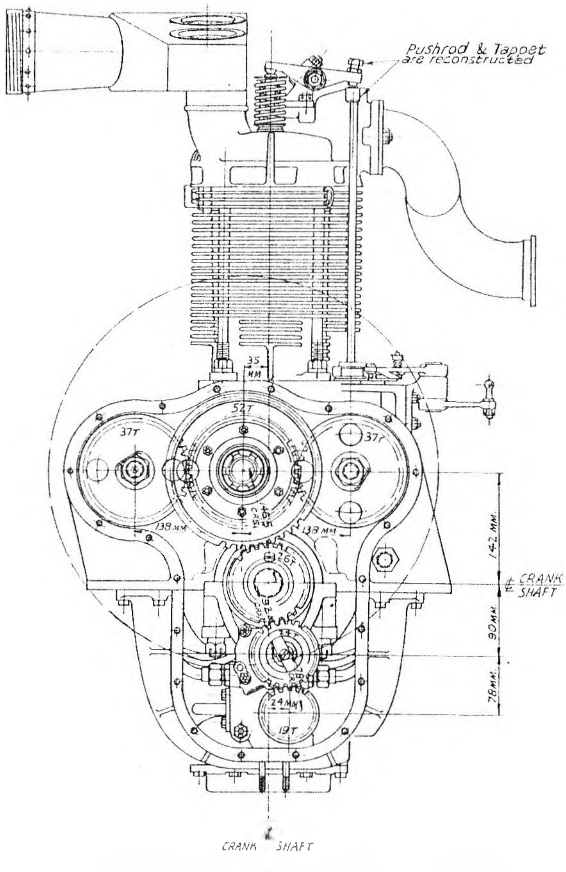


Fig. 20.
Right hand side of engine showing:
(a) Exhaust valve lifters.
(b) Starting motor mount.
(c) Channel for camshaft.
(d) Oil distributor.
(e) Lubrication oil distribution pipes.
(f) Crankcase ventilating inlet.
(g) Crankcase ventilating outlet.



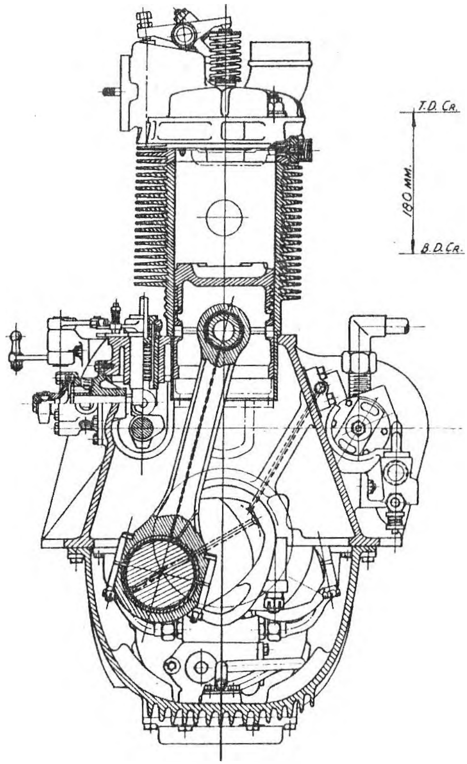
JAPANESE LIGHT TANK _ ENGINE

END ELEVATION.

Impeller, Impeller Drive Gear, and Cover Omitted.

SCALE IN INCHES:

Fig. 21.



JAPANESE LIGHT TANK _ ENGINE

IRREGULAR SECTION THROUGH CYL. NO 4

SCALE IN INCHES:

0 2 4 6 9 12

6 CYL. DIESEL. 4 STROKE. AIR COOLED.
BORE 130 MM. STROKE 180 MM

Fig. 22.

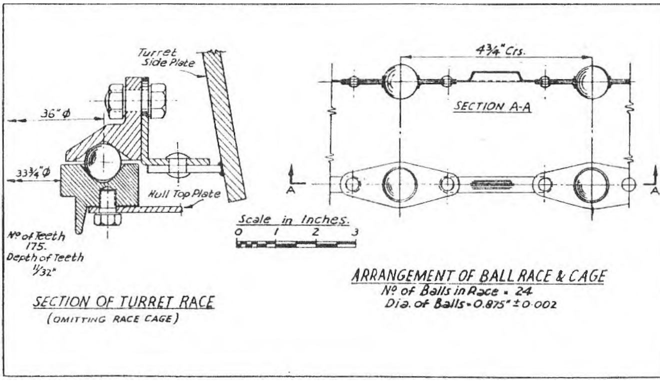


Fig. 23.
Turret Race.

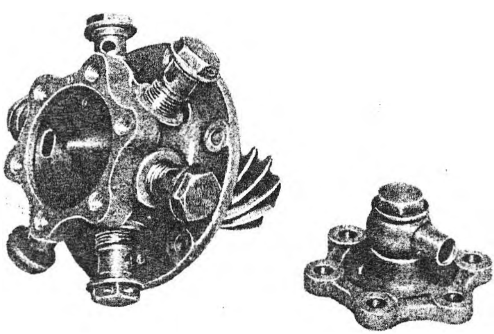


Fig. 24.
Oil Distribution Unit.

with distribution pipes leading to an injector in each cylinder head. (See Figure 20). By this means a drop of lubricating oil is fed to each cylinder during the working stroke, which occurs every two revolutions, the engine operating on the four stroke cycle. This oil distributor is shown in photograph (Figure 24) but it was impossible to estimate the quantity of oil fed to each cylinder because the pump had been removed. The rotary valve is driven through helical gears of 1 : 1 ratio from the cam shaft.

(h) Cylinder.

The cylinders are of cast iron, generously finned, and have a long skirt projecting into the crankcase. The approximate thickness of the cylinder wall is 12 mm. at the top and 6 mm. at the bottom, whilst the cooling fins project 40 mm. (maximum) from the outside of the barrel. Four studs, projecting through the crankcase and provided with nuts at their lower ends, hold the cylinders in position, whilst circlips fitting into recesses in the crankcase prevent the studs from falling through when the cylinders are removed. These studs run the full length of the cylinders, pass through holes drilled in the fins and serve to hold the cylinder heads in position.

(j) Cylinder Heads.

These are cast from a light alloy (for composition see Appendix 3 at end of report), are generously finned and provided with air ducts around the valve seats and cylinder head bolts to give adequate cooling. (See section of head, Figure 25). On the left hand side of the head the injectors are fitted, being held in place by the usual clamp fitting fastened with two studs. The main body of all the injectors was missing but one nozzle had been left. This is illustrated in Figure 26 and consists of a hollow sheath into which is pushed a short jet provided with two small holes, (approx 1¼/1000" (.0015") dia.) through which the fuel is injected. Short air induction manifold pipes sweep upwards on the left hand side of the heads and connect with the sheet metal manifold which couples with the air cleaner. Lubricating oil injection nozzles are screwed into the right hand side of the cylinder heads. One inlet and one exhaust valve are provided per head and each is maintained in the closed position by two helical springs. Cast iron valves guides are pressed into the head (see photograph of section head: Figure 25). The upper end of the guide bush is chamfored and the lower end relieved. A bracket to support the rocker arm shaft is bolted to each cylinder head, one short shaft being provided for each cylinder. These shafts are surface hardened, presumably by Nitriding to V.P.N. 950. Lubrication to the rocker arms is by a grease nipple in the end of each shaft. The rocker arms themselves are steel forgings of a V.D.P. hardness No. 331, and the contact tip which operates the valve is of hardened steel V.D.P. 950.

(k) Valves.

These are of the standard mushroom type. An analysis of the steel in the inlet and exhaust valves is contained in Appendix 3 at the end of the report and a section photograph is given in Figure 28. Two valve springs are provided for each valve, the outer being fabricated from 9 gauge wire wound on a pitch diameter of 35 mm., the free length being 73 mm. with 8 coils including one each end

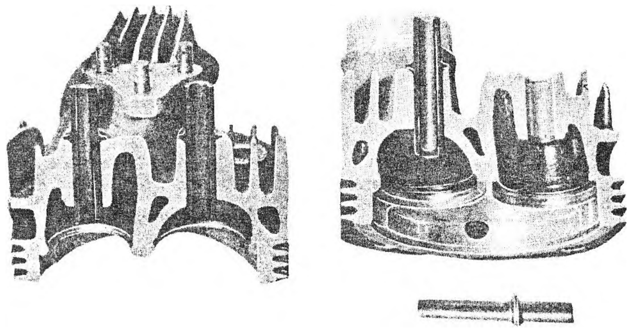


Fig. 25.
Section of Cylinder Head.

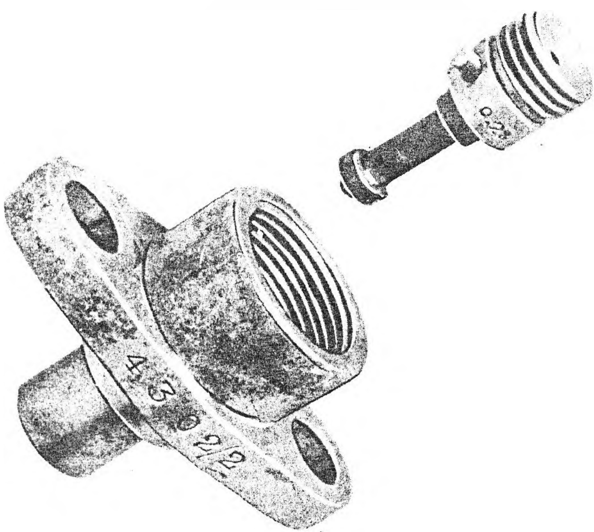


Fig. 26.
Fuel Injection Nozzle.

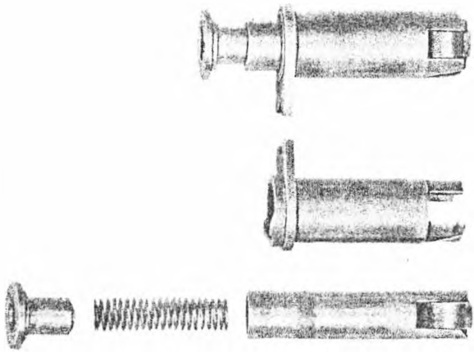


Fig. 27
Tappet Assembly.

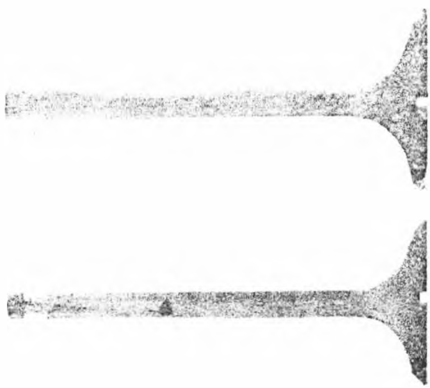


Fig. 28.
Section Through Valves.

ground square. The characteristic of this spring is 44 lbs per inch of deflection. When in position on the engine with the valve closed the length is 60 mm. The inner spring contains ten coils of 10 gauge wire wound on a pitch diameter of 25 mm. The free length being 60 mm. with one coil at each end ground square. The characteristic of this spring is 60 lbs/inch of deflection. The springs are held in place by a recessed washer with split tapered collars fitting into grooves on the valve stem. The valves seal against phosphor bronze seats pressed into the head as seen in the section Figure 25. An analysis of this material is given in Appendix 3 at the end of this report.

The diameter of the exhaust valve head is 68 mm. and that of the inlet 61 mm. The area of the ports and consequent gas velocities are given under the heading "General Data" (Page 50). The tappet assembly seen in Figure 27 consists of the following components: A phosphor bronze sleeve held by a flange on its upper end and guiding the cam follower and roller. The latter is hollow and contains a spring, on top of which rests a recessed cup into which fits the lower end of the pushrod. The recessed cup is a close working fit in the cam follower and clearance in the valve setting allows the spring to hold it away from the top edge of the follower so that the rocker arms, push rods, etc. are always held in firm contact. The cam path which can be seen on the top surface of the guide bush belonging to the exhaust valve forms part of the decompressing gear since the valve will be lifted when the mating piece is caused to move through a portion of a circle and so ride on the high spots of the cam path.

The cam body is 17 mm. radius with a straight sided lobe 10 mm. high giving an outside radius of 27 mm. This outside radius is swept into each of the cams' straight sides by a 5 mm. radius and the included angle between the sides is 44° 20'.

The cycle in degrees of crankshaft revolution, is as follows:

The inlet valve opens 19½° before T.D.C. and reaches its point of maximum opening 75° after T.D.C. It remains fully open at 130° after T.D.C. when it commences to close, which it finally does 212½° after T.D.C. making a total inlet period of 232°. The compression and firing strokes then take place following which the exhaust begins to open 226° before T.D.C. It reaches its maximum open position 140° before T.D.C. and commences to close 80° before T.D.C. being finally closed 12° after T.D.C. The total period for which the valve is open is 238° and the exhaust valve has a similar profile to the inlet except that the included angle between the sides of the lobe is 50° 20'.

(1) Air Induction System.

The short branch pipes sweeping up from each cylinder head fit into a shaped pressed steel manifold (Figure 29) which is connected to the air cleaner by light gauge steel pipe and a flexible bellows type leather union. Provision is made for detaching the latter by a knurled screwed union. The air cleaner itself is connected with a screened air intake in the turret by means of a flexible steel pipe.

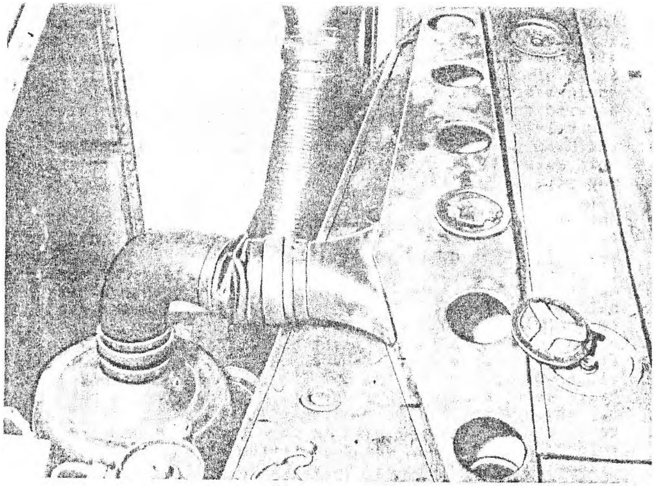


Fig. 29.
Induction System and Air Cleaner.

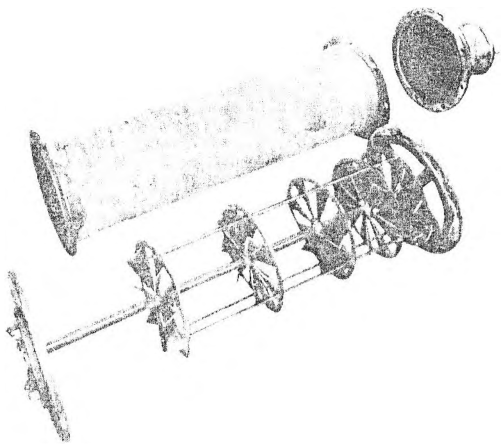


Fig. 30.
Silencer.

Here again provision is made for easy removal of the air cleaner by means of a screw union. There is no way of diverting the induction of air from the turret, other than disconnecting the pipe, so that, irrespective of atmospheric conditions, a draught of air will pass through it whilst the engine is running.

(m) Air Cleaner.

This is a combined centrifugal and oil bath cleaner. It consists of a removable spun sheet shell to which the inlet pipe is welded tangentially. After circulating around this shell the air is deflected downwards through an annular space, and is caused to bubble through oil contained in the bottom of the cleaner proper by means of a circular baffle plate. After passing the baffle plate the air rises to the surface of the oil and then leaves the cleaner through a central vertical outlet after passing through a double cone of bronze gauze packed with steel wool. The bottom of the cleaner is hopper shaped and provided with a deflector plate so that dirt collecting in the bottom is not subsequently remixed with the oil when the latter is agitated.

(n) Exhaust Manifold.

This is of all welded construction and is manufactured in two halves which join on to a single exhaust pipe of three inches diameter through a two port manifold with each port $2\frac{1}{4}$" diameter. The pipes lead out through holes in the right hand side of the tank and are protected by a curved screen of 4 mm. thick armour plate. A silencer (Figure 30) is attached to the end of the exhaust pipe, the latter being very short (18 inches) because the engine is mounted in the rear of the tank. The silencer consists of a sheet metal cylinder, $7\frac{1}{2}$" diameter and $27\frac{1}{2}$" long with five sets of vanes so disposed to give a circular motion to the gas.

(o) Crankcase.

This is one of the most interesting features of the engine, since it is of all welded construction and fabricated from shaped pieces of mild steel plate. It is ribbed where necessary for strength, and the primary function of the design is to combine maximum strength with lightness. The internal webs which support the main bearings, and the front and rear end plates, are steel castings. These are welded to the crankcase. The camshaft (Figure 31) runs along the right hand side of the engine, and in order to accommodate it a semi-circular relief is shaped into that side of the crankcase (Figure 20). A curved plate has been welded on to each side of the engine near the flywheel and machined to take a starting motor. One of these is illustrated in the same Figure, as also are the crankcase ventilating arrangements. These consist of an air intake in the shape of an inverted cup containing a wire gauze filtering element bolted to the crankcase just to the right of the lubricating oil distributor, and a flexible pipe fixed to the crankcase by means of a flanged connection. This pipe is connected to the outlet side of the duct conveying cooling air over the cylinder heads. The connection takes the form of an elbow with the outlet pointing in the direction of cooling air flow thus forming an "ejector" and withdrawing gas from the crankcase. To replace this gas air is inducted into the crankcase through the above mentioned cup and bell.

The rear plate of the crankcase forms part of a housing for the various gears which drive the fan, oil pumps, camshaft, and fuel pump. The cover for this housing is of cast aluminium alloy and is held in place by studs and dowels.

(p) Auxiliary Drives.

The arrangement of the gear train is shown in Figures 33 and 34. Referring to Figure 33, the oil pump driven gears D and E, 19 and 24 teeth, are of steel 286 V.P. No., the main crankshaft timing gear, B, 26 teeth, of alloy steel heat-treated to 430 V.P. No., the idler gear cluster G and F 52 and 37 teeth, of steel 285 V.P. No., the crankshaft fan driving gear, C 50 teeth, of 285 V.P. No., the camshaft and fuel pump gears, A and J, 37 teeth, of steel to 194 V.P. No., and the fan driven gear, H, 28 teeth, of steel to 285 V.P. No.; these gears are single helical 15° helix angle, 3½ module, and work on centres shown in the drawing, Figure 21. Widths of the gears are as follows:-

Timing gear train	24 mm.
Fan drive	28 mm.
Oil pumps	18 mm.

No gaskets are used for joints in the gear case or elsewhere throughout the engine, general oil tightness being obtained by hand scraping or by surface grinding, which method has been used for the top and bottom surfaces of the engine crankcase.

(q) Crankshaft.

This is of exceedingly robust construction, the main journals being 100 mm. diameter and the big end journals 90 mm. (See photograph, Figures 35 and 36). Lubrication is force feed to all bearings by means of ducts drilled through the shaft. No external balancing is provided and the throws are located at 120° to each other with the exception of the two centre ones which are in the same plane. The big end and main journals are not "hollow" and the shaft runs in seven lead bronze, steel backed, shell type, bearings 100 mm. in diameter. The webs are all of the same section being 23 mm. in thickness and 132 mm. width across the face. The rear end of the crankshaft carries a timing gear and finishes in a taper to which is keyed a helical gear driving the fan. The crankshaft is surface hardened, the hardness being 550 - 600 V.P. No., on the journals and 250 V.P. No. on the core. An analysis of the material is given at Appendix 3.

(r) Piston.

These are of cast iron with three compression rings and one oil scraper ring above the gudgeon pin hole. They have an oil collector ring with suitable holes drilled through the skirt to facilitate the return of oil from the cylinder walls to the sump. This oil return groove is turned below the oil scraper ring groove, (see photograph, Figure 32). The head is recessed out to form a turbulence chamber, the recess not being concentric with the outside of the piston. Three slots are cut from the

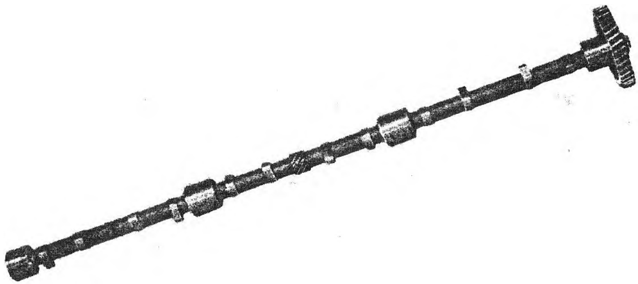


Fig. 31.
Camshaft.

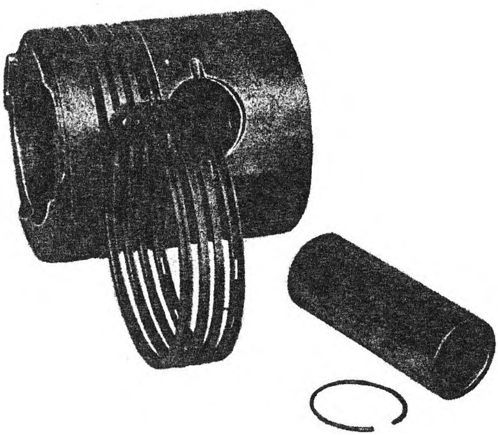


Fig. 32.
Piston Assembly.

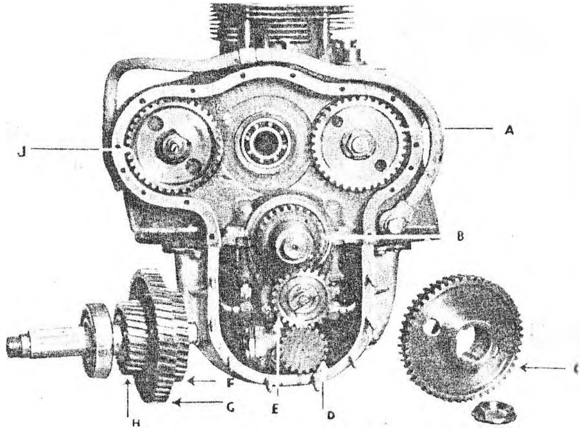


Fig. 33.
Gear Train - Auxiliary Drives (Gears removed).

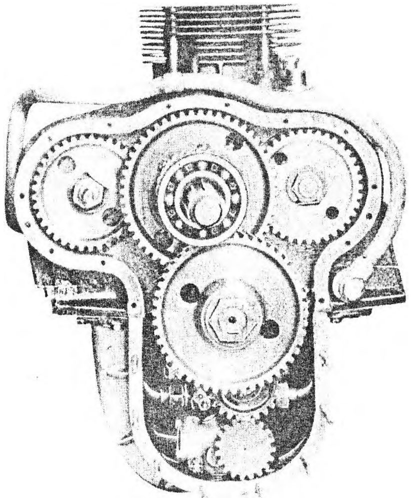


Fig. 34.
Gear Train - Auxiliary Drives (Gears replaced).

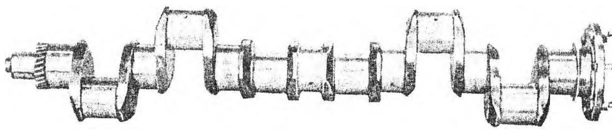


Fig. 35.
Crankshaft.

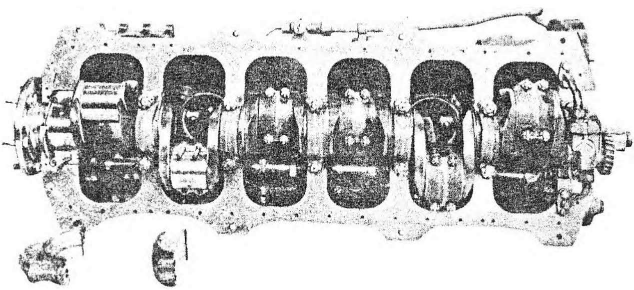


Fig. 36.
Crankcase - Showing Shaft in position.

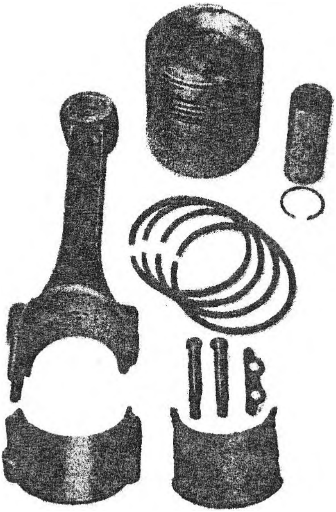


Fig. 37
Connecting Rod Assembly

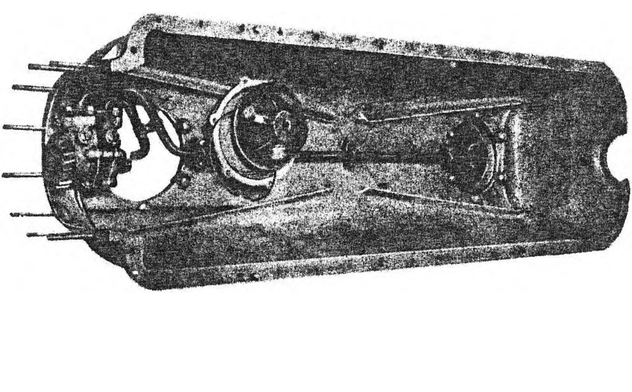


Fig. 38.
Engine Oil Sump.

outside diameter into this recess, two of them accommodate the valve heads and one allows the fuel spray uninterrupted passage into the turbulence chamber. These features are adequately illustrated in Figure 32. A large diameter (44 mm.) full floating hollow gudgeon pin is used and is located by two circlips. The piston and connecting rod assembly is shown in Figure 37. The gudgeon bearing in the piston is unbushed and is drilled and grooved for lubrication purposes. Its bearings in the piston and connecting rod have been stepped to provide a maximum working area under pressure on the explosion stroke. Provision for articulation of the connecting rod is made by leaving a gap between the two machined surfaces. The widths of the piston rings, which are of the concentric cast iron type, are as follows:

Top ring.	5 mm.
2nd & 3rd ring.	4 mm.
Oil ring.	6 mm.

(s) Connecting Rod.

The connecting rod is of "H" section forged steel. The big end is fitted with removable bearing shells of the steel backed lead bronze type. An oilway 6 mm. in diameter is drilled through the centre of the rod to convey oil to the gudgeon pin. It communicates with an annular groove around the outside of the bush and enters the bearing through a hole at the top, drilled right through both rod and bush. This permits a jet of oil to be injected into the underside of the piston to facilitate cooling. A second oilway, smaller in diameter ($3\frac{3}{4}$ mm.), is drilled on an angle from the big end and discharges oil on to the cylinder wall at the top of the stroke, when it comes opposite the hole in the crankshaft. The hardness of the connecting rod is 323 V.P. No., and the halves of the big end bearing are held together by four 12 mm. diameter bolts, 256 V.P. No.

(t) Camshaft.

This is driven from the crankshaft by helical gearing situated at the rear or fan end of the engine. It is carried in four plain bronze bearings which are located in the crankcase by dowels. End play is adjusted from the gear housing cover plate by means of a threaded bronze thrust pad provided with lock nuts. Thrust in the opposite direction is taken between the timing gear boss and a flange on the rear end camshaft bearing. An illustration of the shaft is seen in Figure 31. It is case-hardened all over, the hardness of the cams being 700 V.P. No., and that of the core, 210 V.P. No.

(u) Sump.

A cast aluminium alloy dry type sump of exceptionally light weight is used. The bottom surface is finned along its length to assist in cooling the engine oil. At the front and rear two small cavities are provided and fitted with gauze strainers (see Figure 38). From beneath these strainers oil intake pipes lead to the scavenge pumps bolted to the rear end, (see paragraph "Lubrication

System"). This arrangement of wells obviates any risk of the oil pump starving for oil when the tank is operating at a large angle to the horizontal. For cleaning purposes, each well has an inspection plate held by six studs and located directly above trapdoors in the tank floor. The sump is held to the crankcase by 38 set screws and is located by four dowels. An analysis of the alloy in this component is given in Appendix 3.

(v) Lubrication System.

The main oil pressure pump is shown in Figure 39. This is fed from two scavange pumps built into one housing as shown in Figure 40. The drive is by helical gears from the small crankshaft gear which drives the main oil pump direct, the drive for the scavenge pumps being taken from this gear. These pumps draw their supply from the front and rear sump cavities respectively, the oil being strained through wire gauze (refer Figure 38). These scavenge pumps are bolted to the sump floor while the main oil pump housing is integral with the rear main bearing. The scavenge pumps discharge through an orifice in the sump floor to the inlet side of the radiator via a 20 mm. diameter copper pipe.

The radiator (shown in Figure 41) is of the cross flow type, the oil passing from right to left along the lower section of tubes then up through the left hand header tank and across from left to right into the right hand tank. It is interesting to note that the radiator header tanks and the oil tank are light alloy castings.

A suction pipe carries the oil from the bottom of the oil tank back to the inlet side of the main oil pump via a controlling cock. This cock is, in reality, of two-in-one construction and contains a large valve for controlling the oil (already mentioned) and a small valve for shutting off the fuel. Presumably, therefore, when the engine is shut down, both oil and fuel are turned off. The discharge from the main oil pump is piped to an external distribution manifold running the length of the crankcase. (see Figure 43). A relief valve shown disassembled in Figure 39 is included in the circuit. The valve consists of a phosphor bronze body containing a spring loaded plunger which normally covers up a set of radial holes and thus prevents the discharge of oil. The tension on the spring is controlled by a threaded plug held in place by a square "T", the arms of which engage in slots in the body. The assembly is screwed into a block in the lubrication circuit and held in place by a locknut, the valve being sealed by a screwed cover.

The distribution manifold carries the oil to the main bearing via ways drilled in the supporting webs. An external connecting pipe takes oil to the rotary valve rotated on the opposite side of the engine for distribution to the cylinder bore. Ducts are drilled in the crankshaft to lubricate the big end bearings and each connecting rod has one large oilway drilled through its entire length to carry oil to the gudgeon pin bearing. This oil duct terminates in an annular groove turned around the outside of the gudgeon pin bush, a hole being drilled right through the connecting rod and bush at the uppermost point of the former. Hence not only is oil led to the gudgeon pins but it is also sprayed on to the under

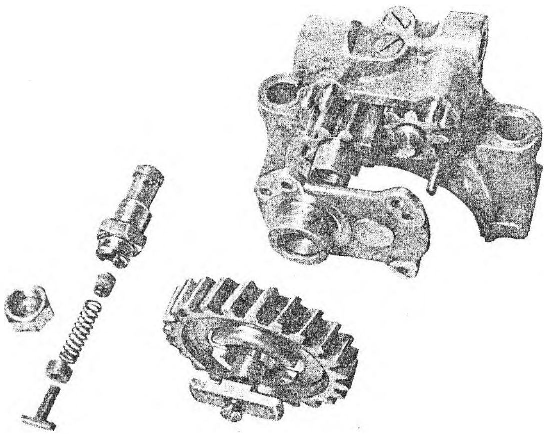


Fig. 39.
Main Oil Pump.

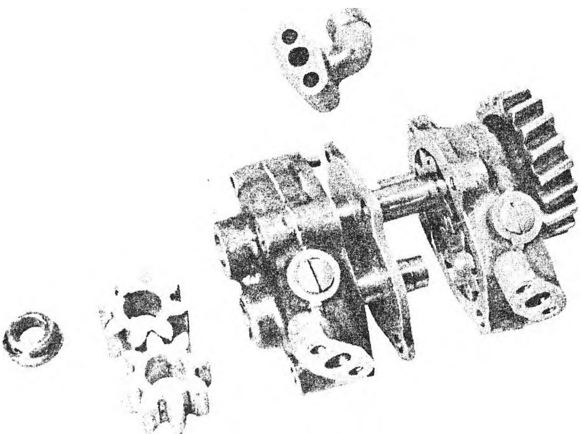


Fig. 40.
Scavenge Pumps.

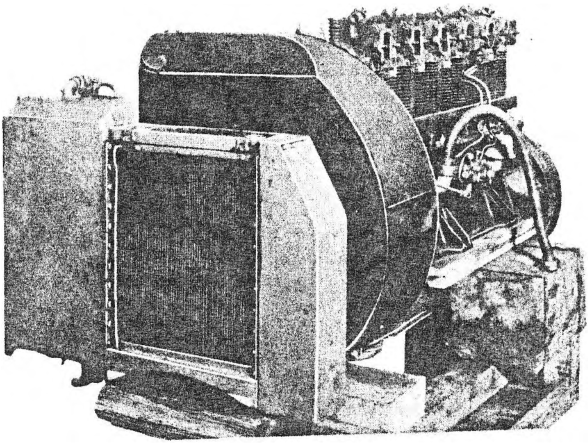


Fig. 41.
Radiator in Position.

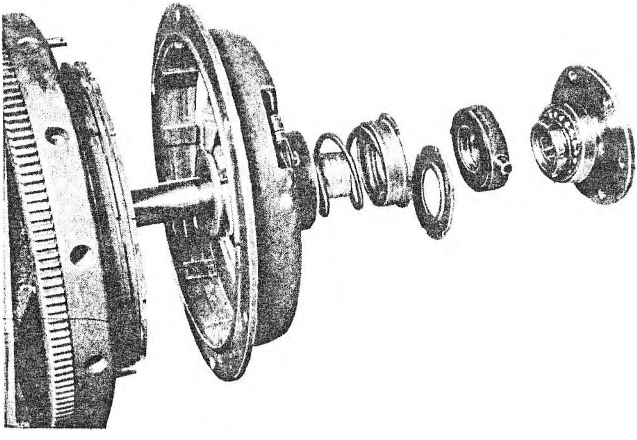


Fig. 42.
Engine Clutch.

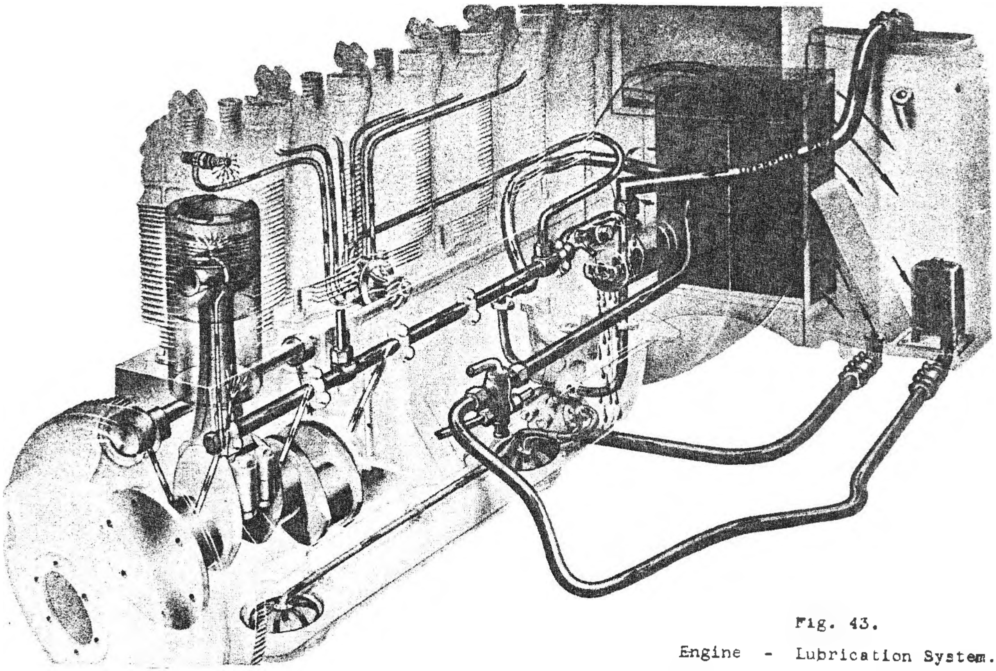


Fig. 43.

Engine - Lubrication System.

surface of the piston. A second oilway drilled at an angle from the big end bearing and pointing upward provides an intermittent spray on to the cylinder bore.

An overflow pipe is taken from the top of the oil supply tank direct to the engine sump, and a non return valve is fitted to the inlet pipe at the bottom of the tank. The oil outlet pipe is protected by a wire mesh filter screen. These features can be seen in Figures 41 and 43.

The main oil pump is driven at 1.08 times and the scavenge pumps at 1.37 times crankshaft speed. In all these pumps the driving gear is mild steel and the driven gear phosphor bronze, whilst all pump gears have 8 teeth and an outside diameter of 42 mm. The pump delivery, calculated at 100% volumetric efficiency, is 475 gallons an hour. The volumetric efficiency of the pump, however, probably being 60%, this would make a total of oil circulated at maximum speed approximately 235 gallons per hour or 12 gallons per hour per brake horse power at maximum B.H.P.

An analysis of the engine oil is contained at Appendix 2 at the end of the report.

Lubrication of the rocker arms is by individual nipples in each rocker arm shaft.

(w) Clutch.

A conventional type of multiple plate clutch is used and is built into a bell-like housing bolted to the flywheel by means of six 12 mm. studs. Twelve slots are formed on the inside of this housing and these slots drive two intermediate steel plates and the pressure plate. Three other steel plates faced on each side by woven asbestos linings form the driven member of the clutch. These plates slide on a small drum provided with eight heavy splines. The unit is shown disassembled in Figure 42.

Pressure for the drive is obtained by a single helical clutch spring having the following dimensions :-

Free length	165 mm. - 6.497 ins.
Wire diameter	8 mm. - 0.315 ins.
Pitch diameter	92 mm. - 3.622 ins.
Length of spring in position	$2\frac{1}{2}$ ins.
Number of coils	6
One coil each end ground square.	

The woven asbestos clutch facings are 343 mm. outside diameter and 273 mm. inside diameter. ($13\frac{1}{2}$" and $10\frac{3}{4}$" respectively). The area of the plates is therefore 52.2 sq. ins. and the mean radius 6.06 ins. The mechanical advantage of the levers is 3.28 to 1 and the reaction of the spring 290 lbs. so that the total thrust on the clutch faces is 995 lbs. and with a coefficient friction of 0.3 and six friction surfaces the horse power transmitted equals 328 at 2000 r.p.m. Therefore, when transmitting 250 H.P. the working coefficient would be 0.23. Pressure between the plate is 19 lbs. per square inch.

(x) Cooling System. - Fan.

This is a turbo impeller type, and the air stream is carried by a duct to the cylinder assemblies. The housing and duct are insulated on their outer surface by thin cork sheeting.

A simple type of centrifugal clutch, which is entirely automatic in action is used to drive the fan. At idling speeds the power available to drive the impeller is cut down considerably, (it varies as the cube of the speed) and this should be of use in warming up the engine quickly. In addition, it enables the engine to accelerate and decelerate rapidly, independent of the fan. This minimizes inertia stresses in the fan driving gears, etc.

The impeller is geared to run at 1.78 times engine speed, and consists of 32 aluminium alloy vanes rivetted to a front and rear plate. (See Figure 44). Incorporated in the rear plate is the clutch housing containing two woven asbestos friction discs attached to the impeller body, (See photograph of assembly, Figure 45) and located between these are two steel plates on the splined drive-shaft. One of these plates has an angular recess cut on its inner face, and eight steel balls are seated in this recess. They are spaced by a grooved plate attached to the inner surface of the second steel plate. As the speed increases, these balls are thrown outwards by centrifugal force, and force the two plates apart and into contact with the fabric friction discs attached to the impeller body, thus progressively taking up the drive. The shape of the casing can be gauged from Figure 46, whilst general data and some dimensions of the unit are listed hereunder :-

Fan.	Diameter of complete unit.		498.5 mm.
	Width		193 mm.
	Radial angle of vanes		15°, Pitch 5°
	Width of vanes	Front	50 mm.
		Rear	90 mm.
	Length of vanes		170 mm.
	Thickness front and rear plates		2 mm.
Drive.	Face width of fabric discs		37 mm.
	Outside diameter of fabric discs		140 mm.
	Inside diameter of fabric discs		66 mm.
	Drive splines		6
	Diameter of drive shaft		44 mm.
	Diameter of steel balls		19 mm.
	Hardness of steel plates		870 V.P. No.

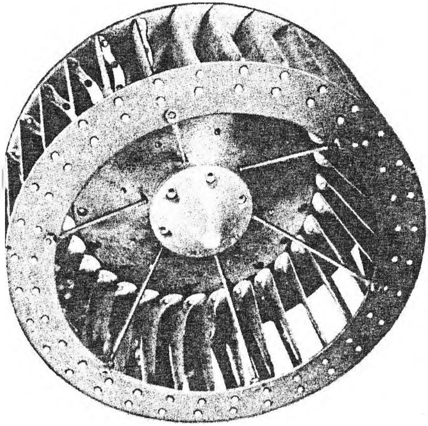


Fig. 44.
Fan Runner.

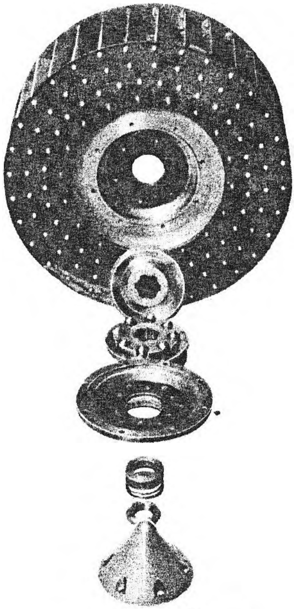


Fig. 45.
Fan Drive Assembly.

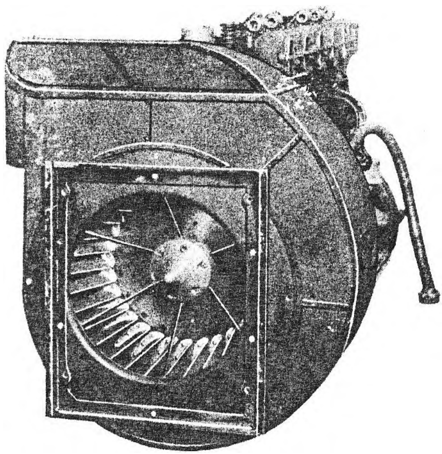


Fig. 46.
Fan Casing.

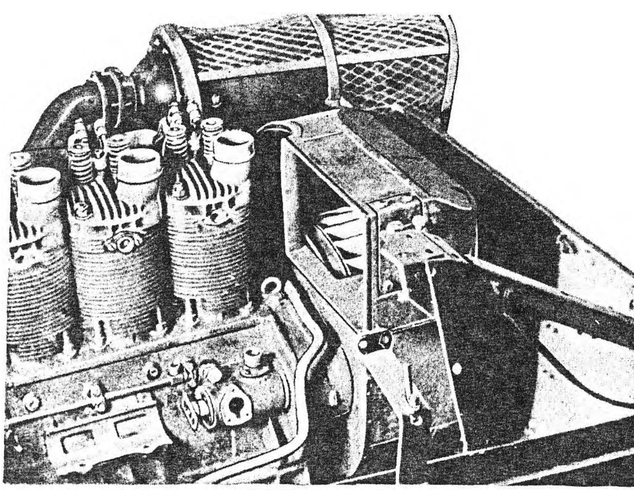


Fig. 47.
Fan Location.

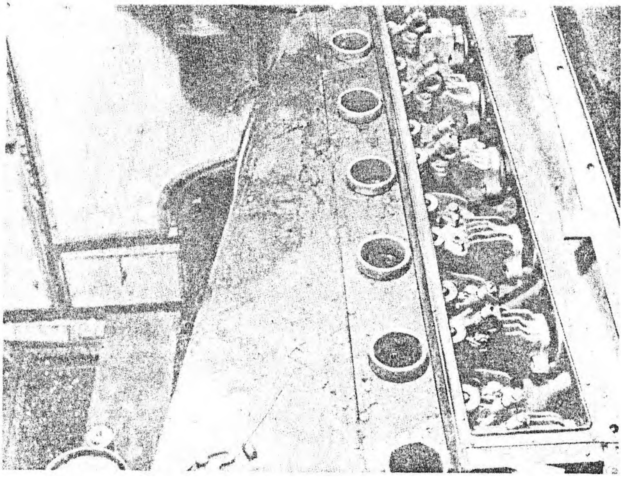


Fig. 48.
Cooling Air Distribution Duct.

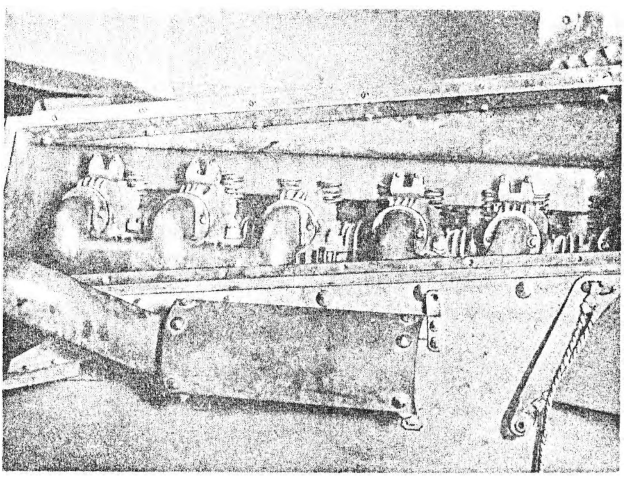


Fig. 49.
Cooling Air Duct Outlet.

Maximum H.P. transmitted at 2000 r.p.m. engine (3560 r.p.m. Fan) and coefficient of friction 0.3   48 H.P.

Following is information on the probable delivery of this fan against various resistances:

Fan speed		3200 r.p.m.	
C.F.M.	H.P.	Outlet velocity	Total Fan Head.
4750	18.5	5200	14.5
7700	24.8	8500	12.4
9800	31.0	10800	11.0
11600	36.0	12780	9.0

(y) Cooling System - Air Ducts

The discharge from the fan, the location of which can be gauged from Figure 47, is conducted to the engine through a tapered manifold, (Figure 48), forming one side of the shrouding completely surrounding the cylinder barrels. The outlet side of the shrouds is bolted direct to the hull (Figure 49), and covered by louvres (Figure 2). The duct work consists of light gauze steel sheet covered on its outside surface with thin cork lagging, and a manually operated butterfly valve, used to control the flow of air over the engine in accordance with climatic conditions, can be seen in Figure 48.

4. GENERAL DATA : ENGINE.

On pages 50 - 57 inclusive physical characteristics of the engine are tabulated. This tabulation can be sub-divided into:-

General

Valves and Gas Velocities

Inertia Forces and Bearing Loads

Cylinders

Piston

Connecting Rod

Crankshaft

Lubrication System

Cooling System

Since it was impossible to run the engine, such characteristics as Brake Horse Power and Brake Mean Effective Pressure have been estimated, as also has the maximum speed of 2,000 r.p.m. In the case of this latter characteristic, it was arrived at by computation back from the maximum reported speed of the vehicle, namely, 28 miles per hour. It does, however, seem to be a very probable figure for an engine of this size, but the fact that it is only an approximation must be borne in mind when considering other data, such as inertia forces etc. which is dependent upon the engine speed.

(a) General.

Type number of engine	4302
Number and arrangement of cylinders	Six vertical
Bore	130 mm. - 5.118 ins.
Stroke	180 mm. - 7.087 ins.
Stroke/Bore ratio	1.382 : 1
Area of one piston	132.8 sq.cm. - 20.55 sq.ins.
Total piston area of engine	796 sq.cm. - 123.3 sq. ins.
Swept volume of one cylinder	2385 cu.cms. - 146 cu.ins.
Total swept volume of engine	14,300 c.c. - 875 cu.ins.
Clearance volume of one cylinder	170 c.c. - 10.35 cu.ins.
Compression ratio	15.05 : 1
Estimated normal B.H.P. and speed	240 B.H.P. at 2000 R.P.M.
Estimated normal B.M.E.P.	110 lbs/sq.in. at 2000 R.P.M.
Piston speed	2360 ft. per min. at 2000 R.P.M.
Cu. in. of swept volume per B.H.P.	3.66 cu. ins.
Sq.in. of piston area per B.H.P.	0.514 sq. ins.
H.P. per cu. in. of swept volume	0.275 B.H.P.
H.P. per sq. in. of piston area	1.95 B.H.P.
Type of valve gear	Overhead valve rockers and push rods.
B.H.P. per litre of swept volume	16.8 B.H.P.

(b) Valve Areas and Gas Velocities.

Diameters

Induction pipes	62 mm. - 2.44 ins. dia.
Inlet port	61 mm. - 2.41 ins. dia.
Exhaust port	53 mm. - 2.087 ins. dia.

Exhaust branch pipes	37 mm. x 70 mm. tapering to 57 mm. (2.244 ins. dia.)

Cross Sectional Areas

Induction pipe	30.2 sq.cm. - 4.68 sq. ins.
Inlet port	29.2 sq.cm. - 4.52 sq. ins.
Inlet valve (dh.)	19.2 sq.cm. - 2.98 sq. ins.
Exhaust valve (dh.)	16.6 sq.cm. - 2.58 sq. ins.
Exhaust port	22.1 sq.cm. - 3.43 sq. ins.
Exhaust branch pipes	25.8 sq.cm. - 4.0 sq. ins.

Gas Velocities.

Induction pipe	172.8 ft. per sec.
Inlet port	179 " " "
Inlet valve	272 " " "
Exhaust valve	315 " " "
Exhaust port	203 " " "

(c) **Inlet Valves (One per cylinder)**

Outside diameter	68 mm. - 2.677 ins.
Port diameter (in cylinder head)	61 mm. - 2.402 ins.
Width of seating	3.5 mm. - 0.137 ins.
Angle of seating	45^{o}
Radius under valve head	20 mm. - 0.787 ins.
Lift of valve	10 mm. - 0.394 ins.
Diameter of stem	11 mm. - 0.433 ins.
Over-all length of valve	154 mm. - 6.063 ins.
Number of springs per valve	Two

Outer

Free length of spring	73 mm. - 2.874 ins.
Length of spring in position (no lift)	60 mm. - 2.362 ins.
Mean diameter of coils	35 mm. - 1.378 ins.
Gauge of wire	9 gauge
Number of coils	8

Inner.

Free length of spring	68 mm. - 2.677 ins.
Length of spring in position (no lift)	60 mm. - 2.362 ins.
Mean diameter of coils	25 mm. - 0.984 ins.
Gauge of wire	10 gauge.
Number of coils	10
Ratio length of spring lift to valve	6 : 1
Weight of valve complete with spring and cottor.	1.092 lbs.
Weight of springs	0.306 lbs.
Inlet valve opens, deg. on crank	$19\frac{1}{2}^{\circ}$ B.T.D.C.
Inlet valve closes, deg. on crank	$212\frac{1}{2}^{\circ}$ A.T.D.C.
Period of induction	232°
Inlet tappet clearance	0.3 mm. - .012 ins.

(d) Exhaust Valves (One per cylinder)

Outside diameter	61.0 mm. - 2.402 ins.
Port diameter (in cylinder head)	53 mm. - 2.087 ins.
Width of seating	3.5 mm. - 0.137 ins.
Angle of seating	45°
Radius under valve head	20 mm. - 0.787 ins.
Lift of valve	10 mm. - 0.393 ins.
Diameter of stem	11 mm. - 0.433 ins.
Length of valve guide	96 mm. - 90 mm. effective
Over-all length of valve	154 mm. - 6.063 ins.
Number of springs per valve	Two

Outer.

Free length of spring	73 mm. - 2.874 ins.
Length of spring in position (no lift)	60 mm. - 2.362 ins.
Mean diameter of coils	35 mm. - 1.378 ins.
Gauge of wire	9 gauge

Number of coils	8

Inner.

Free length of spring	68 mm. - 2.677 ins.
Length of spring in position (no lift)	60 mm. - 2.362 ins.
Mean diameter of coils	25 mm. - 0.984 ins.
Gauge of wire	10 gauge
Number of coils	10
Ratio. Length of spring lift of valve	6 : 1
Weight of valve complete with springs	0.992 lbs.
Weight of springs	0.306 lbs.
Exhaust valve opens, deg. on crank	226° B.T.D.C.
Exhaust valve closes, deg. on crank	12° A.T.D.C.
Period of exhaust	238°
Exhaust tappet clearance	0.3 mm. - .012 ins.

(e) Inertia Forces, Bearing Loads etc.

Weight of piston, complete with rings and gudgeon pin.	10.0651 lbs.
Area of piston	20.6 sq. ins.
Weight per sq. in. of piston area	0.488 lbs.
Weight of connecting rod complete	10.86 lbs.
Weight reciprocating part of connecting rod	2.55 lbs.
Total reciprocating weight per cylinder	12.625 lbs.
Weight per sq. in piston area	0.612 lbs.
Length of connecting rod (centres)	320 mm. - 12.598 ins.
Ratio. Connecting rod/crank throw	3.55 : 1
Inertia, lbs.sq. in piston area top centre (2000 R.P.M.)	6500/20.6 - 314 lbs./sq.in.

Inertia, lbs. sq. in piston area, bottom centre.	3660/20.6 - 177.6 lbs/sq.in.
Weight of rotating mass of connecting rod.	8.321 lbs.
Total centrifugal pressure (2000 r.p.m.)	3550 lbs.
Centrifugal pressure, lbs. sq. in piston area.	163 lbs./sq.in.
Compression pressure ($PV^{1.36}$ - constant)	590 lbs./sq.in.
Probable maximum explosion pressure	900 lbs./sq in. approx.
Diameter of crank pin	90 mm. - 3.543 ins.
Rubbing velocity (mean at 2000 r.p.m.)	30.8 ft./sec.
Effective projected area of big end bearing.	65.8 sq.cm - 10.1 sq.in.
Loading on big end bearing. Top dead centre (lbs./sq. in piston area)	421 lbs./sq.in.
Loading on big end bearing. Bottom dead centre. (lbs./sq in. piston area)	479 lbs./sq.in.
Load factor on big end bearing. Top dead centre (load x Velocity)	13,000 lbs ft.sec.
Load factor on big end bearing Bottom dead centre. (load x Velocity)	14,700 " " "

(f) Cylinders.

Over-all height of bare cylinder from top of base chamber.	220 mm. - 8.661 ins.
Depth of spigot at base of cylinder	70 mm. - 2.756 ins.
Diameter outside fins.	220 mm. - 8.661 ins.
Valve centres (between inlet and exhaust)	72 mm. - 2.835 ins.
Thickness of flange at base of cylinders.	12 mm. - 0.472 ins.
Number of holding down studs per cylinder	Four

Diameter of holding-down studs.	18mm.-reduced to 14mm.(ie. 0.709 ins.red.to 0.557
Thickness of fins.	3½mm.average-0.138 ins.)
Mean thickness of cylinder barrel	5 mm - 0.196 ins.

(g) <u>Piston</u>

Type of piston	Cast iron (recessed crown)
Diameter at top	129 mm. - 5.079 ins.
Diameter at bottom	129.5 mm. - 5.099 ins.
Length	145 mm. - 5.709 ins.
Ratio. Piston length/cylinder bore	1.118 : 1
Number of rings per piston	3 piston rings, 1 scraper ring.
Position of rings	All above gudgeon.
Width of rings	Top 5 mm., Two intermediate 4 mm., oil ring 6mm.
Gap of rings in cylinder	1 mm. - .039 ins.

(h) <u>Connecting Rod</u>.

Length between centres	320 mm. - 12.598 ins.
Ratio. Connecting rod/crank throw.	3.55 : 1
Little end bearing type.	Phosphor bronze bush.
Gudgeon bush, projected area of bearing on gudgeon pin.	24.7 sq.cm. - 3.8489 ins
Ratio. Piston area/projected area of little end bearing	5.4 : 1
Big end bearing, type.	Steel shell, lead bronze lined
Big end bearing. Length (actual)	79 mm.
Big end bearing. Length (effective)	73 mm.
Big end bearing, diameter.	90 mm. - 3.543 ins.
Big end bearing, projected area.	65.8 sq.cm.-10.1 sq.ins.
Ratio. Piston area/projected area of big end bearing.	2.03 : 1
Number of big end bolts.	Four
Full diameter of bolts.	12 mm. - 0.472 ins.

Diameter at bottom of threads.	9.75 mm. - 0.385 ins.
Total cross sectional area, bottom of threads.	0.464 sq. ins.
Pitch of threads.	$1\frac{1}{4}$ mm.
Stress per sq. in. at 2000 r.p.m.	21,600 lbs./sq.in.

(j) Crankshaft.

Number and type of main bearings	Seven steel backed lead bronze.
Cylinder centres	180 mm. - 7.087 ins.
Crankpins: outside diameter.	90 mm. - 3.543 ins.
Length	54 mm. - 2.126 ins.
Journals: Outside diameter.	100 mm. - 3.937 ins.
Length, front end	64 mm. - 2.520 ins.
Length, rear end	64 mm. - 2.520 ins.
Length, intermediate	53 mm. - 2.087 ins.
Crank Webs: Width	132 mm. - 5.197 ins.
Thickness	23 mm. - 0.906 ins.
Radius at ends of journals and crank-pins.	4 mm. - 0.157 ins.

(k) Lubrication System.

Number and type of oil pumps	Three, rotary gear
Specific gravity of oil	0.909
Ratio. Main pump speed/crank-shaft speed.	1.08 : 1
Ratio. Scavenge pump speed/ crankshaft speed.	1.37 : 1
Pump delivery (calculated at 100% volumetric efficiency)	475 galls. 1 hour

(l) Cooling System.

Number and type of cooling fans	One centrifugal
Diameter of inlet	365 mm. - 14.37 ins.
Dimensions of outlet	242 mm. x 345 mm. (9.528 x 13.583 ins.)
Diameter of rotor	498.5 mm. - 19.626 ins

Cooling area of one cylinder	7.35 square feet
Cooling area of cylinder head	2.18 square feet
Total cooling area per cylinder	9.53 " "
Ratio. Fan speed/engine speed	1.78 : 1
Approx. output of fan at 2000 r.p.m. engine speed	10,600 c.ft/per minute at 10" W.G.

(5) Transfer Case.

As the power unit is fixed in relation to the gear box assembly, a transfer box has been used to couple the engine with the propeller shaft. The box, photograph, Figure 50 and Drawing, Figure 51 is made of cast aluminium alloy in two sections. (See metallurgical report Appendix 3 Page 87 Eight 12 mm. studs are used to join the sections, which are located by two dowels, and joint surfaces have been hand scraped and fitted with thin paper gaskets.

Three straight tooth gears running in oil are used. The driving and driven gears have 28 teeth and the idler has 27; the face width is 35 mm. and the pitch 5/4 module stub.

The gears are supported on each side by double row self-aligning ball races, which in turn are located in push-fit steel housings. These are provided with a combined oil-seal and locating ring situated in the middle of their outside diameter. The complete unit is then placed in the lower section of the transfer box and is prevented from turning by a small dowel. The one exception to this is the ball race opposite the power intake side. This race is smaller, has no oil-seal flange or dowel, and is located by an outside plate forming part of the ball housing, and secured to top and bottom sections of the box by six studs. All ball races with exception of one referred to as above, are identical.

Provision for any misalignment of the box is by the use of a toothed coupling consisting of an internal gear flange plate mating with a spur gear having its teeth chamfered to allow universal action. This is fitted between the power unit and transfer box, (see Figure 50) and has 28 teeth, 3½ module pitch, and 20 mm. face width. The output shaft of the box carries a driving plate coupled to the gear box by a short universal shaft having a needle.roller type joint either end. A starter motor dog which was apparently not used is located on the side of the power output gear remote from the universal joint. An oil filler and breather, drain-plug and dipstick are provided. The average hardness of the gears is 570 V.P. No., whilst the internal gear of the coupling is 220 V.P. No., and the gear itself 294 V.P. No.

Composition (and hardness) of all main transmission gears is the same and is given in Appendix 3.

Checking tooth loading of this transfer case against B.S.S. No. 436 we find that at maximum horse power and speed (220 H.P. at 2000 R.P.M.) the strength value is 101% of that given by this specification, whilst the wear value is 78½%.

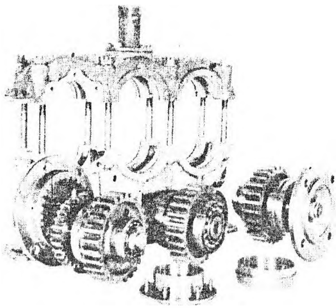
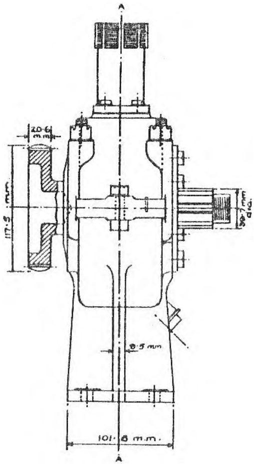
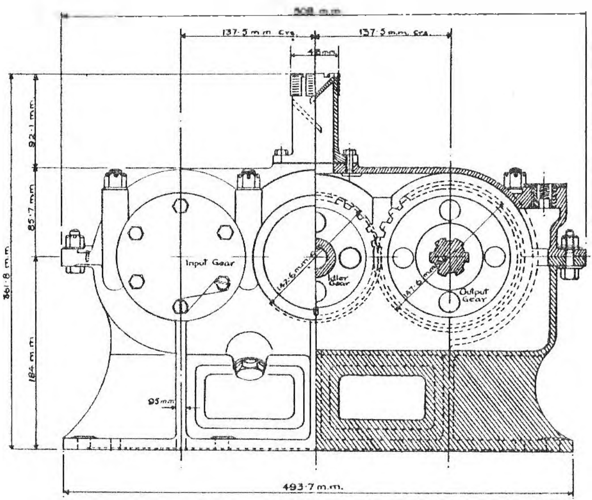


Fig. 50.



JAP. LIGHT TANK TRANSFER CASE.

Fig. 51.



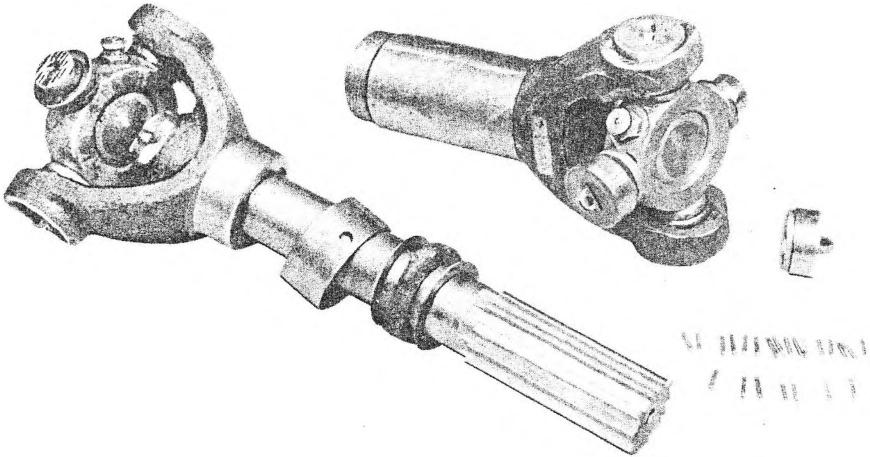


Fig. 52.
Propeller Shaft and Universal Joints

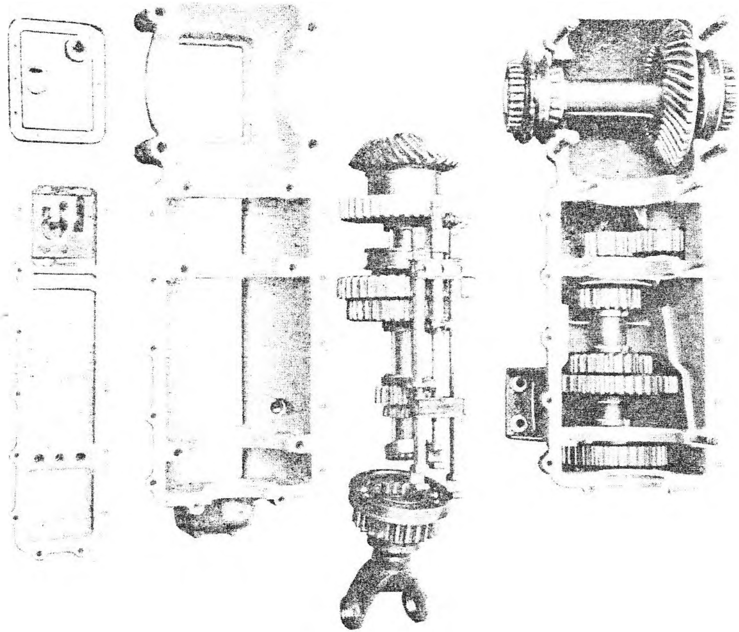


Fig. 53.
Gear Box Assembly.

These computations were made assuming that the box transmitted full load for one hour per day.

6. Propeller Shaft.

The design of the vehicle is such that this shaft is extremely short being only 16½" between centres of the universals.

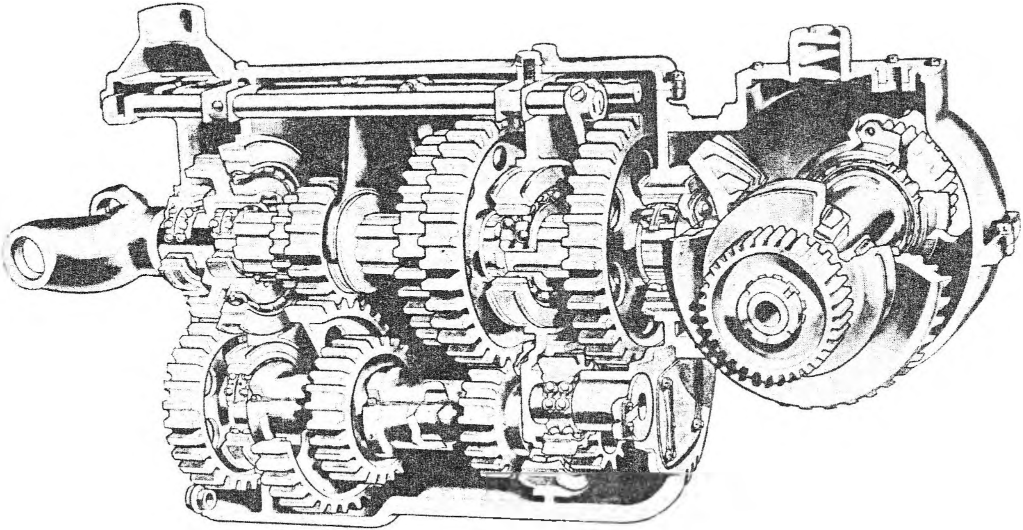
The shaft and universal yokes which are illustrated in Figure 52 are of heat-treated alloy steel 310 V.P. No., whilst the cups holding the rollers and the spider itself are case-hardened to 750 V.P. No. These cups are held in place by circlips provided by an alemite fitting in the spider.

7. Gear Box.

The gear box is a straight forward "clash" type with four forward speeds and one reverse. Straight spur gears are used throughout and these are well finished, the tooth profile being ground. A light metal alloy has been used for the box castings, an analysis of which is given in Appendix 3, page 87. A photograph of the box appears as Figure 53. A drawing is shown in Figure 54. From these it can be seen that the lower portion of the housing containing the spiral bevel reduction is made separate from the light alloy gear case. It is cast in steel for added strength so that the holding down lugs will not break off under the strain of driving in low gears. The lid itself covers both gear box and bevel reduction housing, and is a unit casting in the light alloy. It is provided with two inspection covers, one for the bevel gear housing, and one for the gear box proper. The latter holds the gear selector mechanism. The ball and roller bearings which support the main and lay shafts are mounted back from the end so that one set of gears is overhung at each end. This is obviously done to reduce stresses in, and deflection of, the shaft. The gears on the lay shaft are spaced by split collars held together by set screws. The spiral bevel pinion mounted on the output end of the main shaft, meshes with a crown wheel which forms part of the front axle drive. The bearings of the crown wheel shaft, which are of the tapered roller type with a high angle bearing adjacent to the crown wheel to take the thrust, are supported in the cast steel housing which is spigoted to the end of the gear box. Adjustment for the correct meshing of the crown wheel and pinion is obtained by shims. It was noted that, although one pair of gears are in constant mesh (in addition to the reverse gear idler) in order to drive the lay shaft, all the other gears (with the exception of 3rd gear) are engaged by actually meshing the driving teeth themselves by means of three gear shift forks. Third gear is a direct drive and is obtained by sliding a dog clutch into engagement with teeth cut in a recess formed inside the constant mesh driving gear. Lubrication of the gears and bearings is by splash only, and longitudinal fins are cast on the external surface of the sump to cool the oil.

Dismantling of the gear box is carried out by first removing the top cover plate and then the upper half of the gear box. This allows the main driving shaft and gears to be with-drawn. A removable cover plate is provided in the end of the case directly opposite the layshaft. This shaft can be withdrawn through the bearings after removal of the

Fig. 54. - Engine Clutch.



split spacing collars which hold the gears in position.

Gear Data.

Gear No.	Gear Box Ratio	Face width of teeth	Pitch of teeth
1	35/27 x 43/19 2.95 : 1	35) $1\frac{1}{2}$" (constant 27) " mesh)	5/4 module stub
		43) 1-3/16" (less $\frac{1}{8}$" 19) lead)	5/4 " "
2	35/27 x 36/26 1.80 : 1	36) $1\frac{1}{4}$" (less $\frac{1}{8}$" 26) lead)	5/4 " "
3	Direct 1 : 1		
4	35/27 x 19/43 .572 : 1	19) $1\frac{1}{4}$" (less $\frac{1}{8}$" 43) lead)	5/4 " "
Reverse	35/27 x 41/20 x 20/15 3.55 : 1	41) 1-5/16" (less $\frac{1}{8}$" 20) lead) 15)	5/4 " "

The average hardness of the gears is 550 V.P. No. (uniform throughout the transmission). The composition is given in Appendix 3 page 87.

The loading on the constant mesh gear would be similar to that on the transfer case gears so that, since the face width is less, they would be approximately 75% of the strength required by the British Standard Specification, from the wear angle, when full horse power was being transmitted at 2000 R.P.M., assuming that this condition persists for one hour per day.

8. Steering and Braking.

Power is transmitted from each end of the crown wheel shaft of the bevel reduction which was illustrated in Figure 54, to the right and left hand steering clutches through internal gear type universal joints of similar proportions to that used to couple the engine with the transfer case. This drives to a conventional multiple plate type clutch through a flange and spline shaft, which are illustrated in Figure 55. The clutch has six plates lined on both sides with woven asbestos fabric, and pressure is applied by means of six helical springs through three levers with a mechanical advantage of 3.2 : 1. The outer plates drive the brake drum through twelve large splines, whilst the inner plates are driven from eight splines on the circumference of a phosphor bronze drum mounted on the splined drive shaft. The brake drum has an outside diameter of 403 mm. and a width of 130 mm., the friction area of lining per brake is 210 sq. ins.

The clutch thrust consists of a normal ball type thrust race held in a suitable housing and operated through a fork, supported in a bearing carried from the tank floor. The clutches and brakes are both operated simultaneously

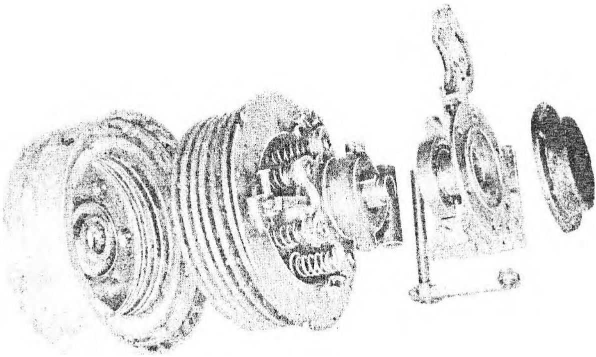


Fig. 55.
Steering Clutch & Brake Assembly.

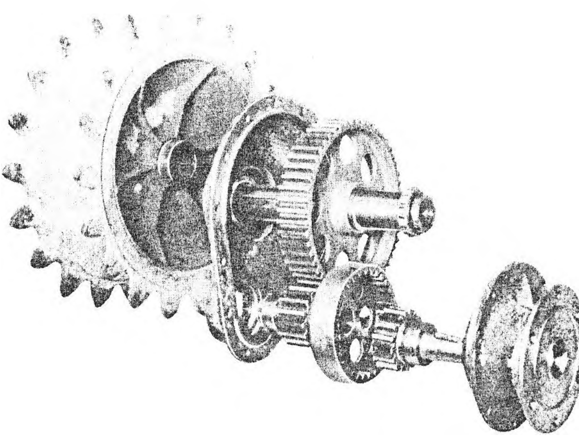
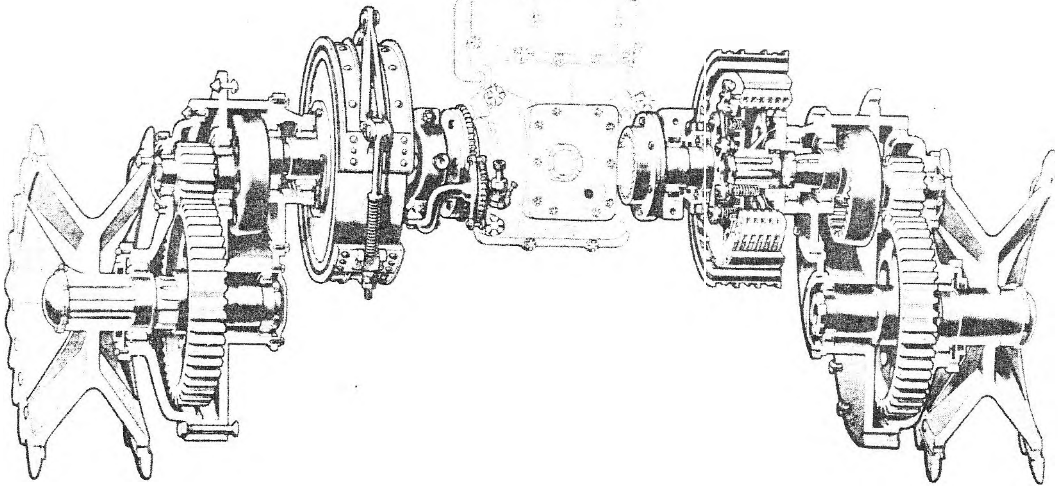


Fig. 56.
Final Drive and Gear Train.

Fig. 57 - Final Drive.



from handles on the right and left hand sides of the Driver respectively, (A and B in Figure 9), the clutch being disengaged and the brake applied by backward motion of the lever. The system of levers is illustrated in Figure 9. By means of lost motion a cam operating the clutch releases this for the first portion of the lever's travel, after which further movement applies the brake. Independent adjustment by means of screwed clevises (C,D, E and F, Figure 9) is provided for both clutch and brake linkages, and the brake is located by adjustable stops screwed to the front of the tank to prevent one half from dragging while the other is free. These can be seen in the longitudinal section drawing, Figure 7.

A foot pedal (c) operates both brakes independently of the clutch mechanism, the brakes being connected together by an equalising arm (h) for this purpose. A small hand lever (j), on the extreme right of Figure 9 enables the foot brake to be locked in the "on" position without parking the tank.

The complete unit is supported by a double row self aligning ball bearing located between the clutch and universal joint and caged in an aluminium alloy housing bolted to the floor of the tank. The other end is connected by a flanged plate to, and in consequence, supported by, the final drive housing.

9. <u>Final Drive.</u>

This consists of a double spur reduction comprising an internal gear 31 teeth 6 module pitch driven by a 17 tooth pinion on the shaft of which the brake drum is mounted. The internal gear is forged integral with a short spline shaft on which is mounted a 16 tooth pinion 6½ module which in turn drives a 53 tooth gear. The gear is splined to the final drive shaft which projects through the housing and carries on its outer end the double ring type driving sprocket. The average hardness of these gears is 550 V.P. No., and the composition is as shown in Appendix 3.

The housing is a steel casting and is rivetted and bolted to the hull side plate. It is provided on the outside with a large cover plate, also of cast steel, which carries the main roller bearing for the sprocket shaft and a smaller roller bearing to support the final drive pinion. An artist's drawing (Figure 57), shows the complete drive in section, while the photographs, (Figure 56), shows an angle view of the components back to the flange which bolts on to the brake drum.

10. <u>Tracks and Suspension.</u>

This is a modified Cardon Lloyde type and consists of two pairs of double bogies each side of the vehicle. Reference to photographs 58 and 59 show that the system consists essentially of a pair of arms carrying double wheels at either end and suspended from a bellcrank by an axle at the centre. This bellcrank is pivoted on a short stub axle of cast steel having a flange suitably shaped to enable it to be rivetted to the hull structure. It is attached by this means to both the hull side and floor. The weight of the vehicle is taken by a compression spring for each bogie and coupled to the bellcrank by means of an adjustable tension member. The compression springs are seated one on each

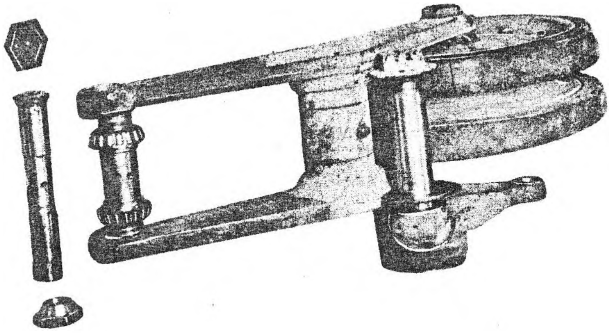


Fig. 58
Bogie Assembly.

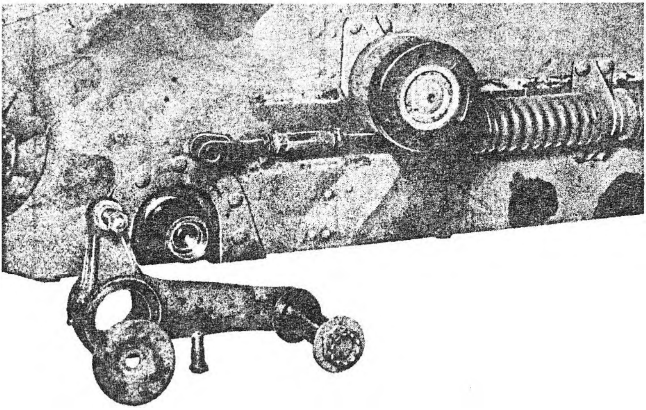
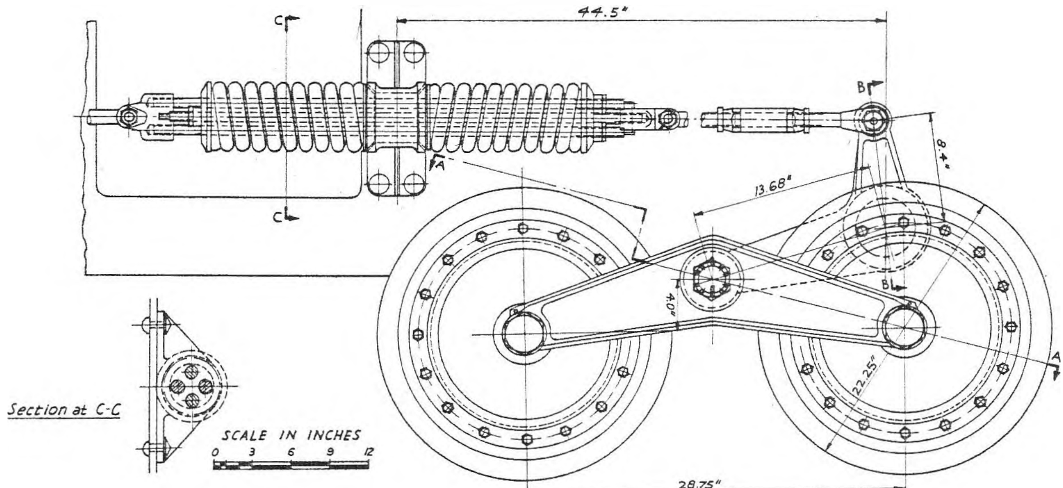


Fig. 59.
Bellcrank - Suspension.

JAPANESE LIGHT TANK



BOGIE ASSEMBLY

Fig. 60.

side of a suitable bracket rivetted to the hull as is seen from Figure 60. The tension rod from one spring passes through the centre of the other and consists actually of two rods attached to a suitable cross piece from which one larger diameter rod extends to the adjusting turn buckle. This arrangement is necessary so that the tension rods for each bogie do not foul each other, (See section CC, drawing Fig. 60.

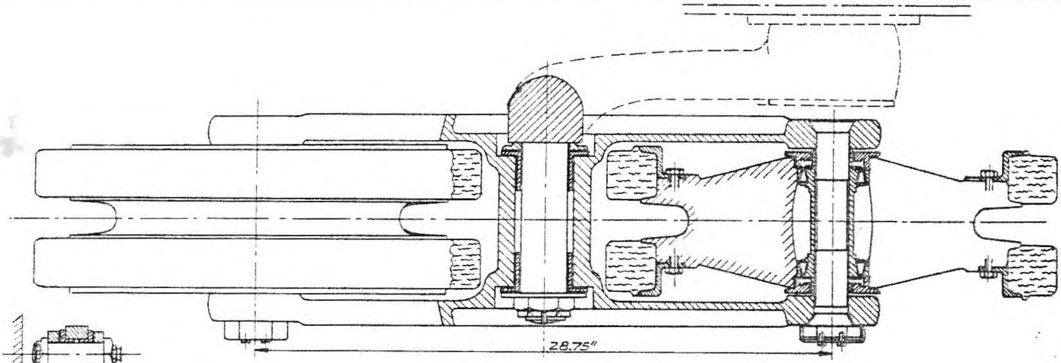
A notable feature of the suspension is that when fully laden the tank has a weight such that the springs ride coil to coil. The markings where the coils have been hammering each other can be seen in Figure 58. In addition, the material is very highly stressed considering its diameter (10500 lbs per sq. inch).

The bogie wheel assembly is shown in drawing, Figure 61, and photograph, Figure 59. The wheels are steel pressings and the boss is welded on. They run on opposed tapered roller bearings, mounted on a collar clamped to the bogie side members by a stationary axle. The tyres are not moulded on to the wheels, but are vulcanised on to a substantial canvas rim and have two flexible steel cables moulded in them to give stiffness and prevent stretch. The wheel periphery is formed so that the tyres fit neatly on to it. They are held in place by a pressed steel rim secured by 16 set screws. A cross section of the tyre is seen in Figure 62 whilst Figure 63 shows the wheel with clamping rim. An analysis of the rubber is given in Appendix 4. Eight indentations around the rim and clamping ring bite into the tyre and prevent it from turning when clamped up.

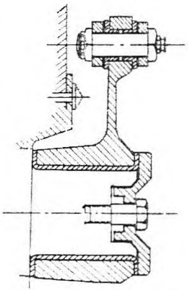
Track Adjuster:

Adjustment of tracks has been simplified by the provision of a suitable slide and slipper gear upon which the stub axle holding the rear track idler is mounted. The arrangement is shown assembled in position in Figure 64, and its components illustrated in Figure 65. The mechanism consists of a cast steel housing (a) fitted with a back plate (b) and machined to take a sliding block (c) which is cast integral with the stub axle. The plate (b) is merely pushed into a recess in (a) and when the latter is bolted to the tank, plate (b) is permanently held in place. Extreme care has been taken to make (c) fit neatly into (a) as all surfaces have been hand scraped to bring this about. A screw (d) provided with a holding ratchet and a squared end to take a key, passes completely through (a) and engages a thread in (c). A cover plate (e) clamped to the stub axle by a set screw and having its edges turned through 90° to engage grooves in (a) (see Figure 64), prevents dust from entering the slot in (a) through which the stub axle projects. A spring loaded plunger (f) engages the ratchet on (d) and prevents the latter from turning. Adjustment of tracks for tension can be carried out immediately, without any preliminary loosening in clamping bolts, etc. by applying a key to (d) and turning it in the requisite direction.

The track had apparently not stretched, since, by measurement over 20 links, its pitch was 3.8" (9.65 c.m.); and the track when wrapped about the sprocket had a diameter to the pin centres of $20\frac{7}{8}$" giving a straight distance between pin centres of 3.8" also. Hence, the pitch of the sprocket and track coincided.



Section AA (from Fig 60)



Section B-B (from Fig 60)

JAPANESE LIGHT TANK
BOGIE ASSEMBLY

SCALE IN INCHES
0 2 4 6

Fig. 61.

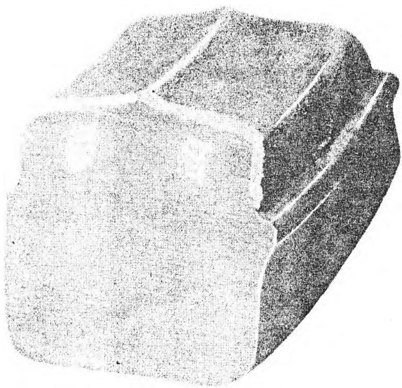


Fig. 62.
Bogie Tyre Section.

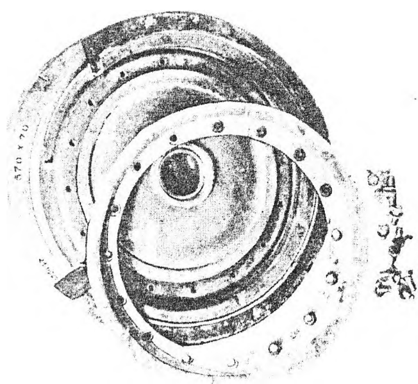


Fig. 63.
Bogie Wheels

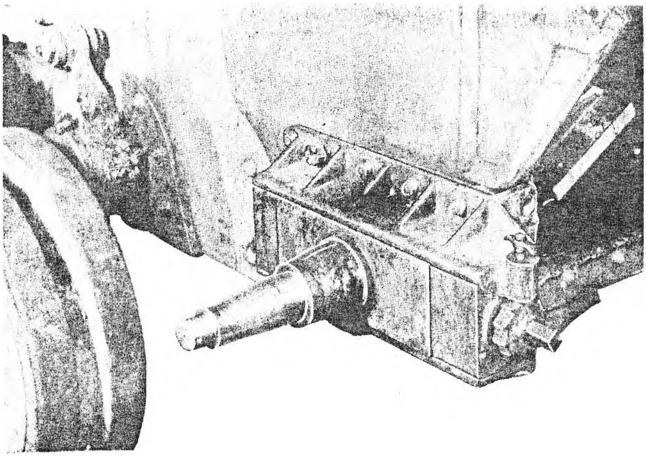


Fig. 64.
Track Adjustor.

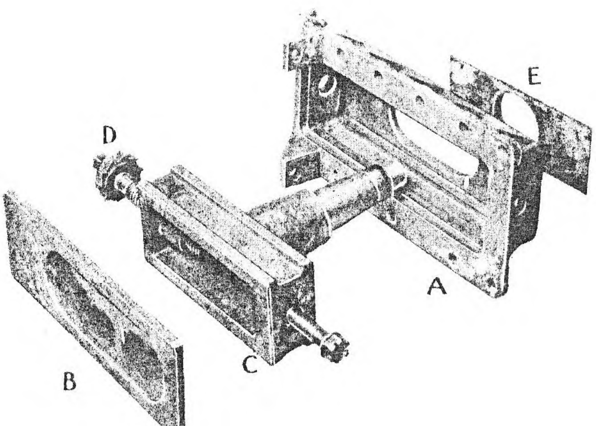


Fig. 65.
Track Adjuster Assembly.

11. Fuel System.

This consists of a main tank, capacity 23 gallons, and a smaller tank, capacity 6 gallons, coupled together with a 1" diameter flexible pipe. They are fabricated from heavy gauge (approx. 18 gauge) galvanised steel plate and shaped to fit the inside contour of the tank. Handles are provided to render them easily removable if damaged by a projectile, and to facilitate this they rest in a leather covered angle-iron bracket and are held in place by easily removable clamps.

The fuel pumps and all pipes were missing, but the fuel was apparently led from the tank through a settling chamber (provided with sight glass) to allow separation of water, and a filter consisting of two gauze screens of approximately 80 and 150 mesh respectively. It was thence led to the priming and injection pumps after passing through a controlling cock mentioned previously in connection with the lubrication system. Sight glass type gauges are fitted to both tanks.

12. Armour Plate.

(a) General considerations with regard to the disposition of armour.

Armour basis of the tank is as follows :-

(i) Front of the hull approximately 12 mm. face hardened armour.

(ii) Side of the hull 12 mm. and 10 mm. face hardened armour.

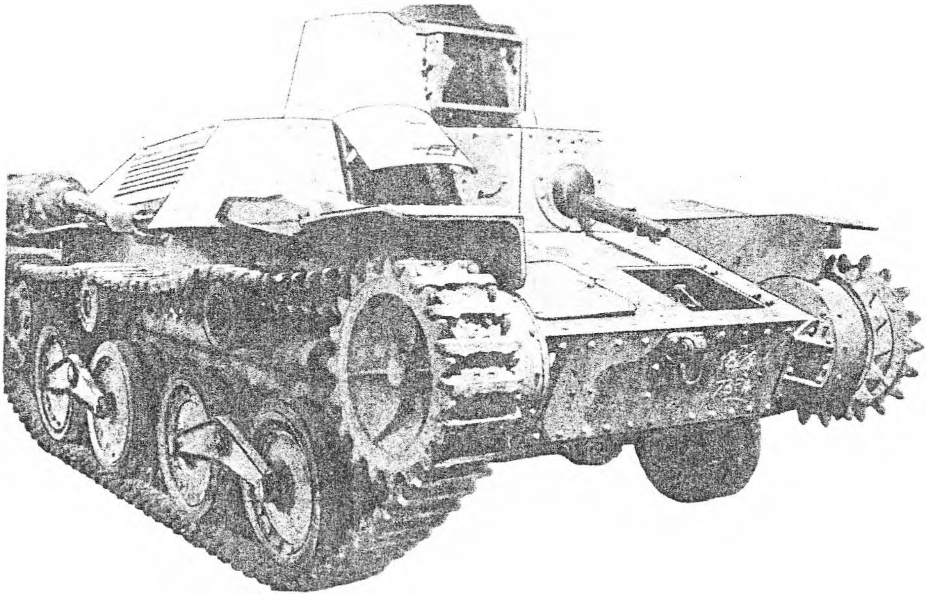
(iii) Rear of the hull 12 mm. face hardened armour.

(iv) Turret 12 mm. face hardened armour.

The disposition of the armour is considered to be rather poor especially at the front where there are a number of profiles with re-entrant angles. It is assumed that the intention was to build a tank with good overall resistance against .303 A.P. at close range and which will withstand .5 A.P. attack at 20° at an approximate range of 150 yards. Surprisingly enough the turret is built on the same armour basis as the hull, the side of which shows the weakness of having circular plates under the turret (see Figure 67). This plate can be attacked at normal from a large arc by changing the position of the gun, also it should be mentioned that these circular plates are designed on an oblique vertical angle, thereby decreasing the probability of obtaining the benefit of the action of compound angles. This feature also applies to the driver's front shield.

(b) Splash Resistance.
No splash tests were carried out on the tank, but from a general examination, it can be said that while the rivetted joints are splash proof, the tank has the weakness of having a large number of long vertical and horizontal vision slits, situated in the front of the hull and the top of the turret. It is considered that a well placed burst of .303 ball ammunition could very easily incapacitate the crew.

Fig. 66. - Showing position of curved plates underneath turret.



(c) <u>Metallurgical Features of the Armour Plate.</u>

The armour plate on this tank was in four thicknesses, i.e., 6 mm., 9 mm., 10 mm. and 12 mm. (For quantative results of Lamination see p. 112 L.H.Q. Tech. Int. Sum. No.2.)

From the point of view of strength and toughness of these plates the composition is good. There is a total alloying content of 4.5% and this, with the high nickel and chromium percentage, brings the steel into the range of the "Vibrac" type extensively used before conservation of alloying elements was enforced.

(i) 6 MM PLATE - The hardness of this plate was 530 D.P.H. It had been hardened and tempered and the resultant structure was fairly finely tempered martensite, containing a fair number of non-metallic inclusions, mainly manganese sulphide (see L.H.Q. Tech. Int. Sum. No 2. p 114).

(ii) 9 MM PLATE - The hardness of this plate was 445 D.P.H. and was, from the point of view of inclusion content, rather dirty, there being a fairly large number of manganese sulphide inclusions as well as some other smaller sonims. The structure of the plate was tempered martensite. There was evidence of laminations which would indicate a tendency towards flaking when overmatched (see L.H.Q. Tech. Int. Sum. No.2. p. 115).

(iii) 12 MM PLATE - This plate proved to be cemented type, being carburised to a depth of 0.045 inches with a face hardness of 715 D.P.H. The base metal of the plate had a hardness of 450 D.P.H. and from the point of view of inclusion content, it was very similar to the 6 mm plate and definitely cleaner than the 9 mm. (See L.H.Q. Tech Int Sum. No 2. p. 116). The carbon content of this plate was much lower than the other two thinner plates, this being necessary in the heat treatment procedure. This procedure was, most probably, oil quenching from approximately 850°C. and tempering between 250 and 300. A higher carbon content would cause too great a hardness in the base metal. It is also of interest to note that a lower carbon content is used for the 6 mm than for the 9 mm plate.

The chemistry of these armour plates suggests that no consideration was given to the economy in the use of alloying elements and it is thought very doubtful whether the present armour being produced in Japan would be of similar composition. Before the war, and even in the early stages of the present war, chromium nickel armours were looked upon in Britain and other countries, as the orthodox proved type of plate. However, large requirements and a general shortage of alloying elements have caused drastic changes to be introduced, especially in the curtailment of the use of nickel.

It is rather remarkable to find armour of 12 mm thickness face hardened. This was standard practice in Czechoslovakia and, to a lesser extent, in U.S.A. and Great Britain. It has, however, been largely curtailed on account of production difficulties, and it can be assumed that the more recent Japanese tanks will not carry such a large proportion of face hardened armour but will have an increased armour basis to compensate for the decreased immunity.

(d) Cast Armour.

There was a casting covering the gun mounting in the turret, the analysis of which was as follows:-

Carbon	0.45%
Silicon	0.63%
Manganese	1.00%
Sulphur	0.02%
Phosphorus	0.03%

The D.P.H. of this metal is 185 and it is evident from this and from the micro examination that it was in the annealed condition (see L.H.Q. Tech. Int. Sum. No 2. p. 118). This part could not be termed cast steel armour, as its hardness is far too low. It is rather difficult to understand why a pearlitic manganese steel should be used in the annealed condition. It is possible that a mistake was made in the production and the steel which had been fully annealed for machining was not heat treated. Firing trials against this casting were not carried out but it can be safely assumed that its ballistic properties are from 30 - 35% inferior to British Specification I.T. 90.

(e) Firing Trials.

(See pp 113 - 119 L.H.Q. Tech. Int. Sum. No 1., p. 111 L.H.Q Tech. Int. Sum. No 2.).

(f) Discussion.

It is realised that the firing trials were not as complete as was hoped, but there is sufficient evidence to reach the following conclusions :-

1. The Japanese light armour used in this tank compares favourably with similar British armour.

2. In addition to this, it has the unusual feature of possessing a high degree of hardness with non-flaking properties. This is a feature previously only found in German armour and it is thought to be dependent upon particular features in the steel-making.

3. Judging by the examination results of the armour of this tank, it is suggested that when assessing the vulnerability of Japanese light armour, it is advisable to assume that it is superior to the equivalent British type by approximately 10%. Owing to insufficient firing data, it was not possible to draw up danger area diagrams with any reliable degree of accuracy.

(g) Welding and Rivetting.

The constructional joints of the tank were a combination of welding and rivetting. All welding was done from the outside, except in the case of Double Vee butt-welds and corner welds which had had a closing weld deposited on the opposite side. All butt-welds in the face hardened 12 mm. plates were of the Double Vee type (see p. 117 L.H.Q. Tech. Int. Sum. No 2).

An unusual feature was the method of welding face hardened armour, pre-heating being used so as to avoid cracking of the carbonised face, the width of pre-heating being approximately 1" from the centre of the weld.

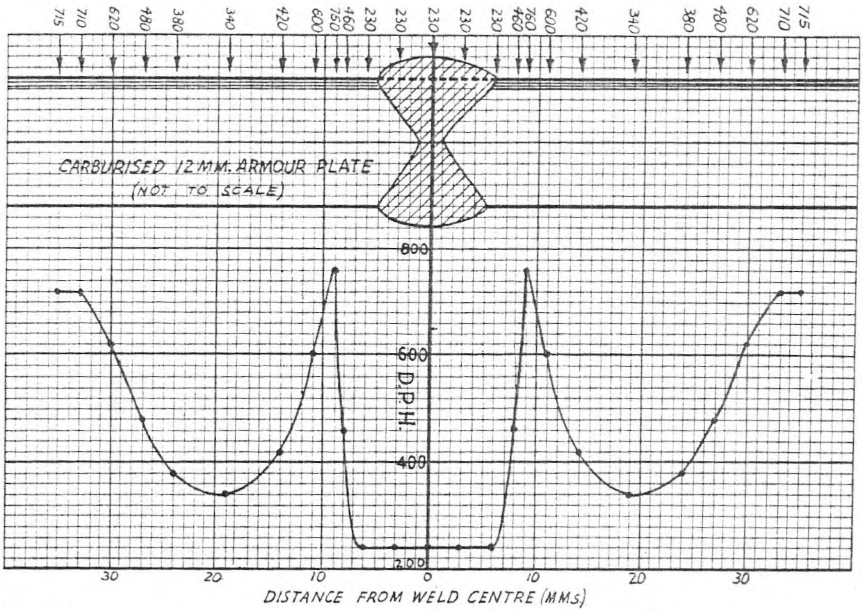


Fig. 67. - Hardness traverse across the top of a butt weld.

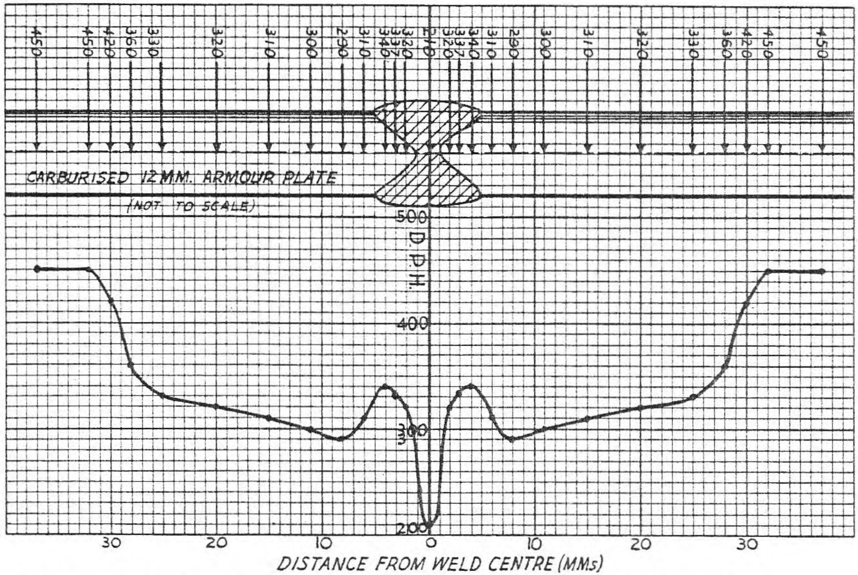


Fig. 68. - Hardness traverse across centre sections of a butt weld.

This caused this face, and the base plate to soften considerably and also decreased the cooling velocity of the adjacent zone during welding. By using this method, cracking was advoided. Figure 67 shows the hardness figures across the outside surface of a butt-weld.

While this method of welding face hardened armour overcomes the cracking difficulties, it has a disadvantage of producing softened zones, adjacent to the welds, thus causing a considerable reduction in the ballistic properties in these places. The weld being soft in comparison with the face hardened armour has ballistic properties which are approximately 20 to 25% inferior to the armour but this was compensated for by reinforcing the weld approximately 15% on each side of the plate. All welds were of the austenitic chromium nickel type which have proved satisfactory for the welding of armour. Two specimens were cut out for examination, a Double Vee butt-weld and a corner joint. The chemistry of these welds was as follows :-

	Butt.	Angle.
Carbon	0.18 %	0.33 %
Silicon	0.45 "	0.38 "
Manganese	0.75 "	2.50 "
Nickel	9.50 "	7.90 "
Chromium	16.1 "	15.2 "
Sulphur	0.01 "	0.01 "
Phosphorus	0.01 "	0.03 "

The rivet heads which were exposed to A.P. fire had a hardness of 220 D.P.H. The rivet holes in the armour were drilled before hardening with only small tolerances and the displacement of these holes due to distortion of the plate on heat-treatment was not critical as all armour plate members were attached to a mild steel frame work and thus secondary holes could be drilled at the required points during assembly.

13. Track Links and Track Pins.

(a) Track Link.

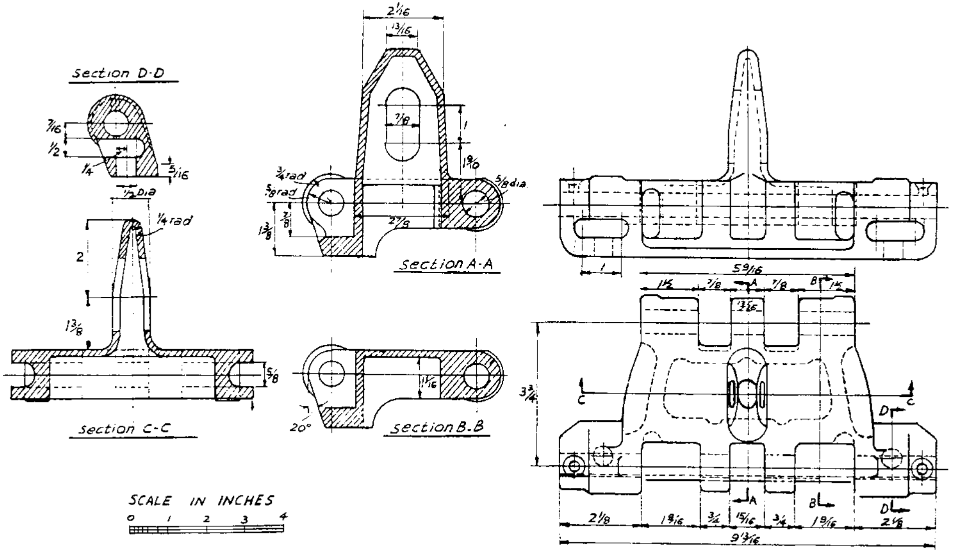
The track link was an austenitic manganese steel of the following composition :-

Carbon	0.95 %
Silicon	0.65 "
Manganese	13.24 "
Nickel	Trace
Sulphur	0.02 "
Phosphorus	0.05 "

Note that there are no stiffening alloys such as Chromium in this steel. The D.P.H. was 195 and this and the micro-examination showed it had been fully softened by water quenching from about 1000°C.

X-ray examination on a number of links showed that all were sound castings.

The links are of the single horn type with a pitch of 3.8" having 6 shear points in each of the 3 and 4 boss ends. For details of construction see Figure 69. The pins are fully floating, being prevented from sliding out by split



JAPANESE LIGHT TANK - TRACK LINK

Fig. 69.

pins in both ends of the link. Pin holes are cored and are of ⅜" dia. The weight of each link is 8 lbs. and the calculated ground pressure of the tank when fully loaded is 9.8 lbs. per square inch.

(b) Track Pins.

The track pin was 19/32" dia. and 8¼" long. It was of good quality case hardened steel of the following composition:-

Carbon	0.12 %
Silicon	0.20 %
Manganese	0.53 %
Nickel	2.14 %
Chromium	0.21 %
Sulphur	0.01 %
Phosphorus	0.03 %

It had been case hardened to a depth of approximately 0.060" with a case hardness of 920 D.P.H., while the core was 225. There were free carbides present in the case which would make it rather brittle but highly wear resistant.

14. Analysis of Design.

The vehicle must be considered as having been designed to be proof only against 303 A.P. attack at close ranges, and from this angle the design generally is good. However, the front surface contains three re-entrant angles which tend to decrease the immunity of the vehicle to ammunition larger than 303 A.P., although it will withstand .5" A.P. attack at 20°, at an approximate range of 150 yards. On the other hand, general vulnerability is greatly increased by the large number of vision slits, which are unprotected by glass visor blocks. These are such that a well placed burst of 303 ball ammunition would create splash sufficient to incapacitate the crew.

All rivets and bolts are mild steel and, although steeple headed, would be easily broken and forced into the hull by direct hits.

It would be difficult, with small arms fire, to damage the suspension, track, or track sprockets, sufficiently to put the vehicle out of action, since the springs are protected by a curved 4 mm. armour plate shield, and even in the event of their being broken the springing would not be materially affected since they are in compression.

The bolted and rivetted design for the hull using a mild steel angle - and channel - iron frame lends itself to easy production, since the secondary holes in the frame are drilled using the hardened armour plates as a template. However, the finished product, using this method of construction, could only be regarded as inferior to either a welded or a cast hull.

The armour plate itself is of exceedingly good quality and may be considered, for purposes of assessing vulnerability, as approximately 10% superior to plates of the same thickness made to the equivalent British specification.

The fighting compartment apparently houses three men. This would make aiming of the guns in action very difficult.

In addition, no rotating floor is provided thus increasing the gunner's difficulty in action.

The workmanship and material used throughout, and the design of components generally, are excellent, as the following summary indicates:-

The engine (page 50) rests on cast aluminium bearers provided with hardened steel inserts to prevent attrition at the points of support. It has a welded steel crankcase for lightness and strength, which at the same time indicates however, that either large production was not contemplated, or the engine was designed initially for an-other purpose and subsequently adapted to the tank.

The crankshaft is face hardened, and along with all other engine components is of robust design.

The gas velocities through inlet and exhaust valves are moderate (page 51).

The piston speed and rubbing velocity of the big end and main bearings (page 50) are commensurate with the materials selected and the facilities provided for lubrication.

The design of the fan (page 45) is good, as it provides ample cooling air and also is driven through an automatic clutch which relieves the driving gears of excessive inertia loads. That it has ample capacity to cool the engine is indicated by the following figures, which admittedly, are based on some hypotheses :-

Hypotheses:-

1. That 42% of the total heat energy released by burning fuel must be dissipated leaving 30% for useful work, and 28% for the exhaust. i.e., $\frac{42}{30} \times 240$ or 336 H.P. in this case at maximum H.P.

2. That the fan delivers 10,000 cubic feet of air per minute at 10" water gauge at maximum horse power. 336 H.P. requires that $\frac{336 \times 2543}{60}$ or 14,300 B.T.U. must be dissipated per minute.

Assuming air is inducted at 70° F, at which temperature 13.5 cubic feet weighs one pound:-

Fan delivers $\frac{10,000}{13.5}$ or 740 lbs./min.

Therefore, taking the specific heat of air over the temperature range encountered at an average of 0.24, rise in temperature of air is found from:-

$$740 \times t \times .24 = 14,300$$

Where "t" = temperature rise.

$$\text{Thus } "t" = \frac{14,300}{740 \times .24} = 80^\circ \text{ F rise.}$$

This is moderate, and should allow the engine to operate satisfactorily in ambient temperatures up to 110° F.

The tappet design is such as to eliminate slackness in the push rods.

The capacity of the oil pumps and oil cooler is liberal for the engine (page 40), but apparently no oil filter, other than a gauze screen fitted to the oil cooler, has been provided.

The clutch is exceedingly robust and can transmit the maximum torque developed by the engine with a coefficient of friction of less than .28 and a pressure on the linings of 19 lbs. per sq. inch. (page 44).

The transfer case gears (page 57) have apparently been designed according to British Standard Specification, they are manufactured from nickel-chrome steel heat-treated to 550 V.P. No., the teeth profiles being ground. The steel is excellent for the service and the workmanship of the highest quality. The case itself is made from a heat-treated copper-aluminium alloy and mating surfaces are finished by hand scraping. Self-aligning ball bearings are used throughout. This unit along with all others in the tank shows evidence of ample machining facilities and labour.

The universal joints (page 61) are needle roller type, rollers running on hardened surfaces, probably nitrided, and they are joined by a short propeller shaft thus eliminating any possibility of trouble from excessive vibration since the critical speed would be extremely high.

The construction of the gear box (page 61) exhibits the same high quality of workmanship and material as the transfer case. The gears are proportioned along similar lines. It is, however, a very simple design, containing no synchromesh clutches, all speeds with the exception of 3rd gear being engaged by actual engaging of the teeth in complementary gears. Drive from this box to the steering clutch and brake shafts is through a spiral bevel gear train built integral with the box. Ball and roller bearings are used throughout.

The steering (page 16) is by clutch and brake system. At maximum engine revs. (2000) this shaft does 2550 R.P.M. at which speed each clutch can transmit 350% of the engine horse power with a coefficient of friction of .3. In low gear this is reduced to 75% of the engine's power per clutch with the same coefficient. The pressure on the linings is 19½ lbs. per square inch.

Final drive (page 66) is by internal and external spur reductions, the gears again being profile ground and manufactured from the same nickel-chrome alloy steel, heat-treated to 550 V.P. No. They are adequately supported in ball and roller bearings held in the cast steel gear cases which are well designed and generously finned for strength, and protected by a 12 mm. armour plate shield.

The track sprocket is of peculiar construction in that the two sprocket rings are alloy steel heat-treated to 460 V.P. No., and rivetted to a mild steel centre with 19 rivets. This would render the replacement of the sprocket rings very difficult and the reason for the adoption of this method cannot determined.

The tracks and track pins being of austenitic-manganese steel and case hardened medium nickel-steel respectively, with the pins fully floating, should give exceedingly good service. The pin holes are cored and the links themselves sound castings.

The ground pressure of approximately 9.8 lbs. per sq. inch is low.

The suspension is adapted from the Carden Lloyd principle, using double bogies and compression springs arranged horizontally by the use of bell-cranks. When fully laden the springs ride coil to coil, in which position the stress in the wire (15/16"diameter) is high, (105,000 lbs./sq in.). This is apparently a bad feature and its adoption cannot be understood.

The fuel oil and engine sump oil are of medium quality, but all the transmission oils are of very low grade. The fact that these low grade oils are used with gear boxes, where no effort or expense has been spared, is significant.

The selection of materials throughout the tank is in accordance with the best orthodox practice. Proportioning of components is quite uniform, in so far as the engine and transmission units are concerned, it being impossible to select one item which could be regarded as weak, defective, or un-economic.

Report by: D.A.F.V.P., M.S.L. Maribyrnong, P and E Officer Maribyrnong, C.S.I.R. Melbourne, D.Richardson and Sons Footscray, Vacuum Oil Co. Pty. Ltd. Melbourne.

APPENDIX 1.

Results of Examination.

Heat Insulating Material from Engine Compartment.

This is a brown porous material which is effectively fire proofed to render it both non-inflammable and non-smouldering.

The material is approximately 1.2 inch in thickness and consists of compressed vegetable fibres. It is not possible to determine the exact nature of these fibres, but their appearance suggests that they are of palm origin.

The fire proofing material used is ammonium dihydrogen phosphate ($NH_4H_2PO_4$) one of the most effective fire-proofing agents, and one that is specified for a number of our own service requirements.

A locally obtainable material having a similar structure to the Japanese material is Canite. This material is non-fire-proofed, at present, but could be impregnated satisfactorily with the ammonium dihydrogen phosphate.

APPENDIX 2.

Examination of Samples of Fuel and Lubricating Oils.

Samples were taken from the fuel tank, engine sump, transfer case, gear box, and final drive, and their physical characteristics determined.

The results of this work are as shown hereunder :-

Fuel Oil

S.G.	.863
Color	Dark brown
Cetane No.	46.
Diesel Index	47.5
Flash point	190°C
Initial boiling point	214°C
Final " "	336°C
Pour point	- 7°C
Setting point	-10°C

This is a medium quality distillate fuel oil similar to products used in this country for the same work. Its characteristics indicate that it originated from California or the Dutch East Indies.

Engine Sump Oil

Viscosity at 100°F.	A.S.T.M.	260 Secs.
Viscosity at 130°F.	A.S.T.M.	128 Secs.
Viscosity at 210°F.	A.S.T.M.	49 Secs.
Viscosity Index		71
Gravity		0.909
Open Flash		345°F
Pour point		20°F
Fire point		380°F
Test for saponifiable matter		Negative.

This is a light S.A.E. 20 naphthenic base oil similar to that used in automotive diesel engines in this country up to approximately 18 months ago, but now displaced by the so called inhibited type of paraffin base oils. It would be regarded as a "second grade" oil.

Transmission

Item.	Transfer Case.	Gear Box.	Final Drive.
Viscosity at 100°F. A.S.T.M.	6717 Secs	2102 Secs	1562 Secs
" " 210°F. A.S.T.M.	160 "	123 "	78.5 "
" index	-	83	2
Gravity	.952	.93 appr	.967
Open flash point	435°F	365°F	410°F
Open fire point	530°F	405°F	470°F
Cold test	35°F	70°F	20°F
Test for saponifiable matter	Positive	Positive	Positive
Colour	Black	Dk.Brown	Yellow

The large quantity of water present in the three samples made examination difficult. Also, the oils have undergone considerable use and therefore it is not possible to state whether the saponifiable material present was caused by the oxidation of the oil or added as a compounding material before use.

These oils are uniformly of exceedingly poor quality for the service. That taken from the transfer case is similar to oils used in this country for the lubrication of tramway tracks, wire ropes etc. It has a negative viscosity index, is refined from a crude of high bitumenous content, and probably contains a high percentage of tar as indicated by its low viscosity index.

The oil from the gear box is of slightly better quality, but apparently contains a high percentage of paraffin wax which would account for its high viscosity index and high cold tests. An oil similar to this would be used for the lubrication of cart-wheels and agricultural machinery.

The oil from the final drive has apparently been refined from a crude of high bitumenous content, and along with that from the transfer case and the gear box is of very poor quality. Its normal use would be for the lubrication of shafts and axles where cheapness of lubricant was the main consideration.

APPENDIX 3.

Metallurgical Examination was carried out on the following components:

1. Sump Case.
2. Gear Box.
3. Cylinder Head.
4. Crankshaft.
5. Exhaust Valve &
6. Inlet Valve.
7. Exhaust Valve Insert.
8. Final Drive Pinion.
9. Bearing Metal.

Results obtained were:-

Sump Case.

The analysis of this was as follows :-

Cu. 1.07, Si. 11.4, Zn. 0.17 remainder Al.

This casting had not been heat-treated but was in the "as cast" condition, and had a Brinell hardness varying between 69 & 73. It is a typical Al. Si. casting alloy.

Gear Box.

Analysis of this was :-

Cu.4.27, Zn. 0.57, Ni. 2.02, Mg. 1.39 Remainder Al.

Brinell hardness number was 91 to 96.

The casting had been heat-treated by quenching from a solution temperature of approximately 600°C. The nickel content of this alloy is rather high. The usual nickel content of an alloy containing 4% Cu. is about .5%, but the presence of this additional nickel would have a tendency to raise the U.T.S. and lower the elongation. However, as this casting had not been age-hardened to any extent, the elongation would be high in any case. The U.T.S. of this casting would be of the order of 35,000 pounds per square inch with an elongation of approximately 1 to 1.5%.

Cylinder Head.

Composition of this casting was :-

4.06 Cu. 2.04 Ni. 1.36 Mg. 0.60 Zn. remainder Al.

This is very similar to the gear box casting and is quite possibly the same alloy. The casting had been heat treated and the B.H.N. was 117 to 137 which shows that solution treatment and the high temperature ageing had been used. This B.H.N. is high for this type of alloy which usually runs on the limits 100 to 125. Elongation impact would be very low and the U.T.S. would be approximately 45,000 P.S.I.

Crankshaft.

The analysis of this component was :-

Carbon	.36.%
Silicon	.27 %
Manganese	.54 %
Nickel	3.0 %
Chromium	.57 %
Molybdenum	Trace
Sulphur	.02 %
Phosphorus	.02.%

This is a good quality high strength medium nickel-chromium steel. The low phosphorus and sulphur contents indicate basic electric steel making. The physical properties of this steel after the normal heat treatment of oil hardening of 825°C. and tempering at 600°C. would be :-

Y.P.	45 T.S.I.
U.T.S.	60 "
Elongation	20% Minimum
R. of A.	50% "
Izod	40 ft. lbs.

It may be noted that this steel is prone to temper brittleness which would involve either oil or water quenching from the tempering temperature. A specimen was not taken for metallographical examination and hence it cannot be said whether any form of surface hardening had been used on the bearing surfaces which showed a hardness of 550 - 600 D.P.H. Specification of the steel corresponds very closely to V.N.C.A. as produced by Commonwealth Steel Company of Australia.

Exhaust Valve & Inlet Valve.

Both these valves have been made by upset forging of the head, the stems being solid. Examination showed that no hard facing had been employed on the seating faces. Ferritic high chromium high silicon steel of the orthodox Silchrome type had been used for both valves. The composition and hardness values are substantially in line with requirements STA 5 schedule, steel En 52-V54. The compositions of the two valves are as set out under :-

		Inlet Valve	Exhaust Valve.
Carbon	%	.39	.28
Silicon	"	3.1	2.74
Chromium	"	10.64	11.33
Manganese	"	.46	.62
Nickel	"	Trace	Trace
Sulphur	"	.01	.01
Phosphorus	"	.03	.04
B.H.N.	-	250 - 350	250 - 355

The steel used in both valves was of good quality being free from any excess of non-metallic inclusions.

Temperatures up to 950°C. did not even scale the surface, possibly because the formation of a hard fine protective film of $Al._2O_3$. They have the strength and ductility of mild steel with a higher resistance to corrosion and good retention of hardness at elevated temperatures. A sample was not taken for metallographical examination to determine if the alloy had been heat treated, but aluminium bronzes are very seldom heat treated, unless their aluminium content is above 10%. The addition of the small percentage of nickel which would go completely into solution in the "a" phase would tend to increase the corrosion resistance and tensile strength of the alloy while the iron would raise its yield point. The wearing qualities of this alloy when bearing against steel are very good. Aluminium bronzes have been used in America for valve inserts but it is not known whether they have been satisfactory over a period of time.

Final Drive Pinion.

This component had a surface hardness on the teeth of between 500 and 550 D.P.H. Metallographical examination showed that there were no forms of surface hardening employed and the structure of the steel was tempered martensite.
The analysis of this part was :-

Manganese	0.33 %		
Silicon	0.40		
Nickel	3.5	-	4.0
Chromium	1.8		
Molybdenum	Trace		

The carbon was not determined but from metallographical examination it was approximately .3%. This steel is a high quality air hardening nickel chromium steel. The heat treatment was probably air hardening from approximately 820°C. and then tempering at 250 to 300°C. Properties which would be obtainable after this treatment would be:

U.T.S.	90 to 100 T.S.I.
Elongation	12 to 15%
R. of A.	25 to 30%
Izod	15 to 20ft. lbs.

The steel would be quite satisfactory for this service.

Crankshaft Bearing.

The analysis of this material was :-

Copper	58.8 %
Lead	38.5
Iron	1.1
Nickel	0.65

This totals 99% and it is thought probable that the odd per cent occurs as additional lead.

The bonding of this alloy on to the steel backing was good, there being no signs of any oxide or blowholes.

Comments:

This composition is notable for the high lead content. Bearings containing this percentage of lead have proved successful for use as heavy duty bearings for railroad and rolling mill service in America where loads and temperature are too excessive for white metal bearings. Nickel improves the liquid solubility of the alloy and also its density. It is considered that the main reason for its use in this alloy is that it prevents segregation which being caused by the high lead content is one of the disadvantages of this type of bearing requiring very adequate stirring of the melt and rapid cooling. The iron content is high as it is usually about 0.25 max. It can occur in two forms in the bearing either in the free state or in solution. In either case, it is detrimental as in the free state it will cause hard spots and in solution it increases internal shrinkage leading to casting defects.

This bearing is considered to be suitable for this service, in that it has good strength, high thermal conductivity and very good frictional characteristics. A point worth noting is that it is susceptible to corrosion from organic acids in oils after the operational conditions exceed a certain temperature.

Report by: Munitions Supply Laboratories Maribyrnong, Division of Aeronautics Council of Scientific and Industrial Research, Proof and Experimental Officer Army Inspection Maribyrnong.

APPENDIX 4.

Results of Examination

Rubber Tread from Bogie Wheels.

Physical Tests:

	Japanese Light Tank.	German Mk.111 Tank.	M.C. Carrier
Shore Durameter Hardness	69 - 70	60 - 65	65 Min
Elastometer	60 - 69	55 - 60	
Specific Gravity	1.53	1.51	
Modulus at failure (lbs. per sq. inch)	1900, 1270	2400	
Modulus at 100% extension. (lbs per sq. inch)	814,759	-	
Modulus at 200% extension. (lbs per sq.inch)	1440, -	-	
Modulus at 400% extension (lbs per sq. inch.	-	2170	
Elongation at tread, %	270,180	450	
Adhesion to hard base.	-	8 - 10 lbs/in.	

Chemical Tests

Acetone Extract %	3.2	2.8
Alcoholic Potash Extract, %	0.5	0.4
Total Sulphur, %	2.2	1.25
Free Sulphur in rubber, %	Nil	0.3
Zinc Oxide, %	26.2	34.7
Whiting, %	6.8	1.8
Magnesium, calculated as Magnesium Carbonate, %	5.0	
Carbon Black, %	22.6	15.4

Physical Tests: (Continued)

	Japanese Light Tank	German Mk.111 Tank	M.C.Carrier
Rubber Hydro-carbons, %	Approx. 33	46.65	
Accelerator		Guanidine type	

In accordance with specification "Tanks 3A - Solid Rubber Tyres - General Use.

The canvas used around the base of the tread was approximately equivalent to Australian 18 oz. cotton duck. Each of the two beads contained 60 steel wires (23 S.W.G) arranged in four layers of 15 wires each; each bead was wrapped with a cotton thread and encased in hard rubber or ebonite.

The rubber compound is well vulcanised and appears to be particularly tough. It is noted that the percentage of carbon black in relation to the percentage of rubber hydrocarbons is higher in the Japanese material than in the German material or in normal tyre treads. This corresponds with the lower modulus of elasticity and the increased hardness and toughness.

JAPANESE 37 MM TANK GUN.

1. GENERAL DESCRIPTION.

This gun is part of the armament of Japanese Light Tank reported in this Summary and is carried on trunnions incorporated in the mounting. (Fig 1.). The inner trunnions allow traverse, and the outer trunnions, which are incorporated in the hull of the tank, permit the gun to be elevated or depressed.

Traverse and elevation are both manually applied with the aid of an adjustable shoulder rest attached to the left side of the cradle. (Fig 2.).

Breech mechanism is semi-automatic in operation.

An attachment on the left side of the cradle carries the sighting telescope, and a pistol grip and firing trigger. (Fig 2.). A sliding block with a glass window is used to blank off the sighting aperture in the gun mounting.

2. ORDNANCE.

(a) General.

The barrel, apparently of auto frettaged construction, is machined parallel for 15½" forward from the breech ring, and then tapers down to the muzzle with a pronounced short muzzle swell. (Fig 3.).

The parallel portion of the barrel is carried in a bronze bush in the cradle and acts as a guide during recoil and run out. Rifling is right handed and has 16 grooves.

(b) Breech Ring and Block.

The breech ring is box shaped, and the breech block is of the vertical sliding type.

Mounted on the right hand side of the breech ring is a spring-loaded rack which engages a pinion on the end of the breech actuating-shaft. This spring is compressed when the breech is opened.

The L.B.M. is also mounted on the right side of the breech ring and engages the spring loaded rack through a pawl and cam. The pawl can be moved to enable the breech to be closed manually should a weak or broken actuating spring prevent this from occurring automatically.

There are three positions in which the L.B.M. can be locked by a spring loaded plunger. The first, or top position, allows the S/A gear to function without fouling. The second position locates the breech block in the normal open position, the third position locks the breech block in the open position so that the extracting levers cannot be tripped.

The breech-actuating shaft carries the breech-actuating crank and at its outer end there is a roller arm. On run out this arm engages a cam face mounted on the cradle, and so opens the breech. The breech block, on opening, drops down and, at the end of its travel, engages projections on the extractor levers, forces them outwards and ejects the shell case. As the extractor levers are forced outwards they engage landings on the breech block in the open position and are held there by spring loaded fingers. The insertion of the next shell forces the extractors forward and releases the breech block which closes automatically by the action of the spring loaded actuating shaft.

Mounted on the rear face of the breech block is a safety lock which, in the safe position, engages with the breech ring and locks the breech in the closed position. At the same time it prevents the firing gear from functioning. (See Firing Gear).

On the forward face of the breech ring, projections are formed to which the recuperator rod is attached. This rod prevents the gun from rotating in the bronze guide bush. (Fig 4.).

To Dismantle Breech Mechanism.

(1) Close breech and unscrew actuating spring cap.

(2) Remove screws holding pinion on actuating shaft and withdraw shaft and pinion.

(3) Withdraw breech block, extracting levers, and actuating crank.

Assemble in reverse order being careful to make sure that marks on pinion line up with marks on actuating shaft.

(c) Firing Gear.

A spring loaded firing pin is incorporated in the breech block which is automatically cocked when the breech is opened. The cocking lever, being forced back by the actuating crank, is held in the cocked position by a spring loaded sear. The sear is tripped by means of a cam mounted on a cranked shaft and passing transversely through the breech block. A firing trigger, mounted on the left hand side of the cradle, actuates a plunger also mounted on the cradle. In the run out position pulling of the trigger moves the plunger rear-wards. There it bears against the cranked arm so rotating the shaft and tripping the sear by means of the cam.

A projection on the cranked arm prevents the arm from rotating unless the breech is fully closed.

With the safety lock in the safe position, it engages with cranked arm preventing turning and thus locks the sear and firing pin.

With the breech in the open position, the firing pin can be manually double cocked by means of the cocking handle which is part of the pin itself. When the pin is double cocked the cocking handle depresses a spring loaded pawl which in turn locks against a projection on the breech ring and prevents the breech block from closing should the extractors be tripped.

To Dismantle Firing Gear.

(1) Remove Breech Block (See To Dismantle Breech Mechanism).

(2) Remove sear spring cap and spring.

(3) Withdraw cranked shaft and sear.

(4) Remove safety lock.

(5) Turn firing spring cap through 90° and remove cap and spring.

(6) Close spring catch on cocking lever pivot pin and withdraw pin and cocking lever.

(7) Withdraw firing pin.

(8) Remove double cock safety pawl.

Assemble in reverse order.

3. RECOIL SYSTEM.

The recoil system (Fig 5) which is of the oil buffer and spring recuperator type, is housed underneath the gun in a cylinder machined in the cradle, with an internal shoulder at the rear end.

Recoil is resisted by both buffer pressure and recoil spring. Run out is obtained by the recovery of the spring, and is controlled finally by a control valve with a tapered lead on the buffer rod.

A cap is screwed into the front end of the recuperator cylinder, to which is bolted the buffer rod. The solid brass buffer piston is secured to the buffer rod. The rear end of the rod is tapered to form the final control plunger.

At the front end the buffer cylinder carries a gland which works on the buffer rod. At this end, also, there is an external shoulder against which the recoil spring is located. The rear end of the buffer cylinder has an internal thread and seating into which is screwed a sleeve. The forward end of this sleeve houses the final control cylinder into which the tapered lead on the buffer rod works. The rear end of the sleeve has an internal square thread into which screws the forward end of the recuperator rod. A hardened steel bush is retained in the front end of the final control cylinder, and the cylinder is blind at the rear end. Longitudinal tapered slots are machined inside the buffer cylinder. These have the effect of increasing resistance to recoil as the gun moves backwards.

Two recoil springs are provided end to end, one wound right hand and the other left hand. The front end of the combined spring bears against the external shoulder on the buffer cylinder. The rear end seats against the internal shoulder in the recuperator cylinder.

A bronze bush, situated in the rearmost position of the recuperator cylinder, acts as a guide for the recuperator rod. The rear end of the recuperator rod is palmed and drilled, and is attached to projections on the breech ring by means of a pin.

Requisite initial tension is applied to the recoil springs by screwing up recuperator rod.

To Dismantle Recoil System.

(1) Remove top cover plate on front end of cradle.

(2) Screw up recuperator rod.

(3) Unscrew nut retaining buffer rod, and unscrew front cap.

(4) Unscrew recuperator rod, and withdraw buffer cylinder assembly and recoil springs.

(5) Unscrew parking gland.

(6) Remove set screw locking internal sleeve in buffer cylinder and unscrew internal sleeve.

(7) Withdraw buffer rod and piston through rear end of buffer cylinder.

(8) Remove set screw locking final control cylinder in sleeve and unscrew cylinder.

(9) Unscrew set screw locking retaining nut for control bush, remove nut and hardened control bush.

Assemble in reverse order.

4. MOUNTING. (See Fig. 6.)

A steel cradle casting carries the guide bush in which the gun band works, and immediately under this bush is machined a cylinder which houses the recoil mechanism. To the rear of this casting is bolted a steel framework which carries the shoulder rest, firing trigger and plunger, sighting telescope mounting, spring loaded S/A cam, and a recoil gauge. The steel cradle casting itself is housed in another steel casting which embodies the sighting aperture and sliding block with glass window. This casting is allowed to swivel horizontally on trunnions mounted in an outer steel casting. The outer steel casting can in turn be swivelled vertically on trunnions which are incorporated in the hull of the tank.

5. SIGHTING.

All sighting equipment had been removed from the gun prior to examination and consequently no report can at present be submitted.

(REPORT BY DESIGN DIVISION M.G.O. L.H.Q.)

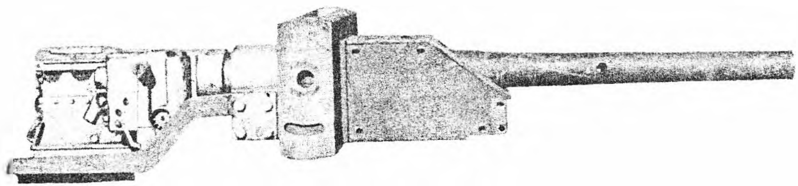


Fig. 1.
Japanese 37 mm. Tank Gun.

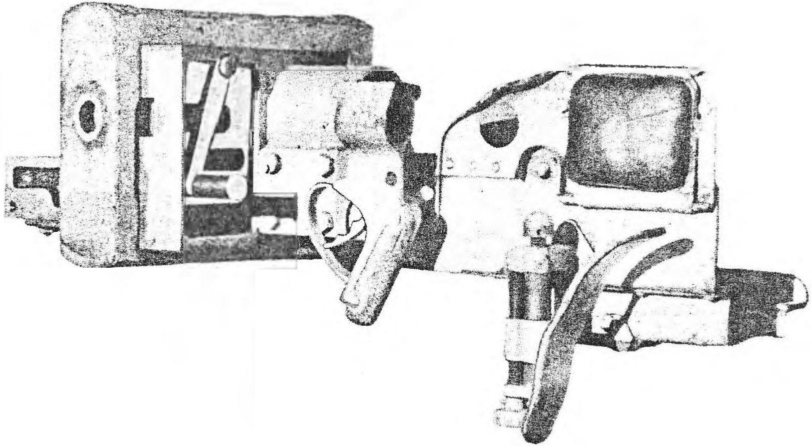


Fig. 2.
Japanese 37 mm. Tank Gun.

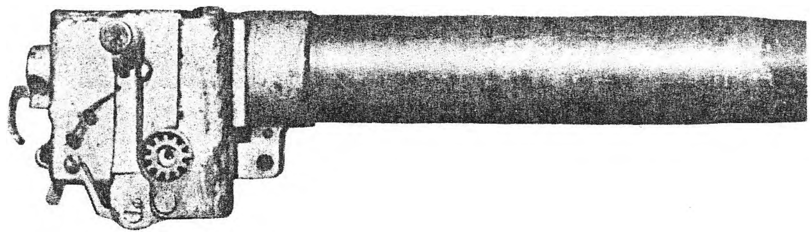


Fig. 3.
Japanese 37 mm. Tank Gun. (Showing machining of Barrel)

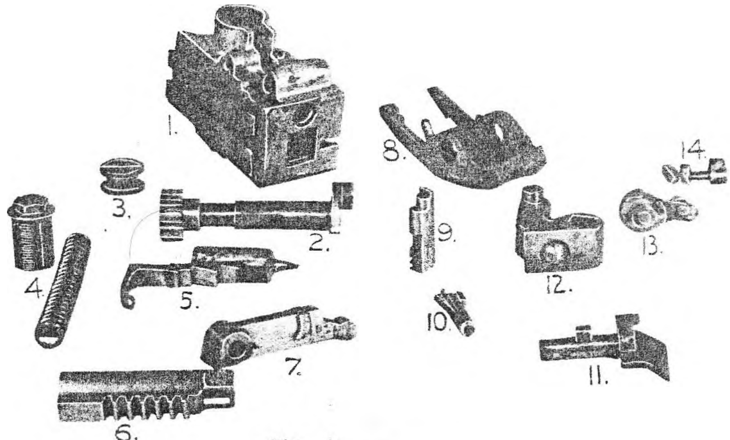


Fig. 4.
Japanese 37 mm. Gun.

(1)	Breech Block.	(8)	Extractor Levers.
(2)	Actuating Shaft.	(9)	Sear.
(3)	Cap.	(10)	Pivot Pin (cocking lever).
(4)	Rack spring & cap.	(11)	Cranked Shaft.
(5)	Firing Pin.	(12)	Actuating Crank.
(6)	Rack	(13)	Safety Lock.
(7)	Cocking Lever.	(14)	Double Cock Safety Pawl.

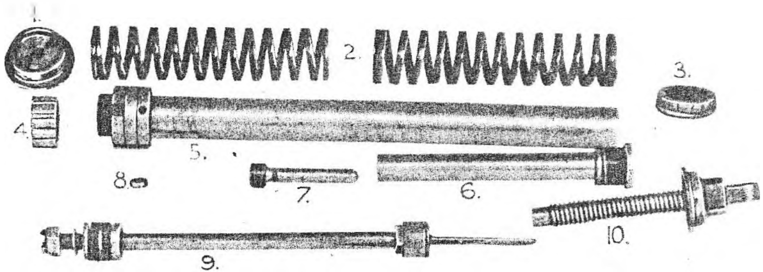


Fig. 5.
Japanese 37mm. Gun.

(1) Cap.
(2) Recoil Springs.
(3) Guide Bush.
(4) Gland Nut.
(5) Buffer Cylinder.
(6) Sleeve.
(7) Control Cylinder.
(8) Hardened Bush.
(9) Buffer Rod & Piston.
(10) Recuperator Rod.

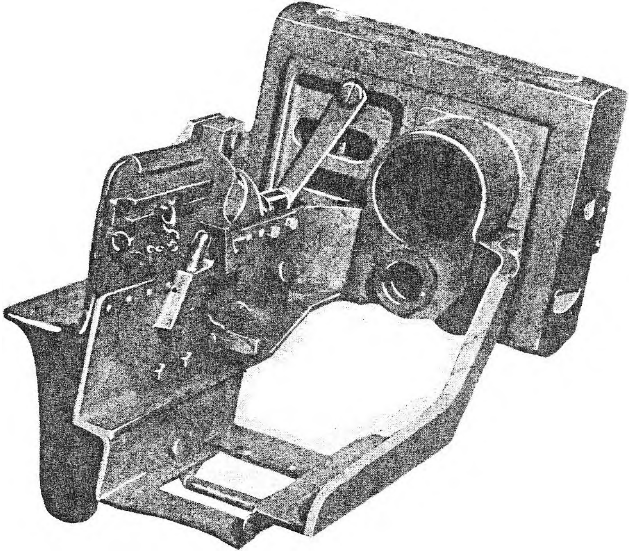


Fig. 6.
Japanese 37 mm. Tank Gun.
(mounting & Cradle)

JAPANESE 13 MM. A/A - TK/A DUAL MOUNTED MACHINE GUN.

On page 2 of L.H.Q. Tech. Int. Summ. No.2, this weapon was described as the Japanese 13 mm. Heavy Machine Gun Type 92. A later report states the reference should be amended to read Type 93.

JAPANESE HEXACHLORETHANE SMOKE CANDLE (UNKNOWN TYPE)

1. GENERAL.

This Japanese smoke candle of an unknown type when received for examination was without a top cover and appeared to have had a paper label attached to its side at one time. The candle was constructed of a shellacked tin plate body. It is ignited by a match head situated in the top of the candle.

2. WEIGHT AND FILLING.

The candle as received weighs 870 gms. and is a cylinder 205 mm. long and 55 mm. in diameter. The main filling is 754 gms. of an HC smoke mixture. The composition of the main filling and that of the ignitor mixture is given below in Tables I and II.

TABLE I

SMOKE MIXTURE, JAPANESE HC SMOKE CANDLE

Hexachlorethane	46.1%
Metallic Zinc	27.8%
Zinc Oxide	24.9%
Binder (by difference)	1.2%
	100.0%

TABLE II

IGNITOR MIXTURE, JAPANESE HC SMOKE CANDLE

Barium Nitrate	45.0%
Aluminium Powder	48.5%
Antimony Trisulphide	5.9%
Organic Binder	0.6%
	100.0%

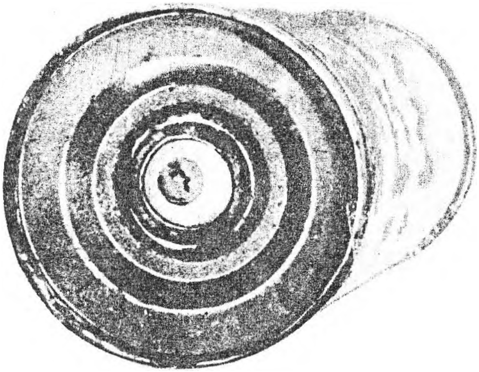
3. ACTION.

The candle is ignited by a match head which extends into the ignitor mixture. The composition of the ignitor mixture is given in Table II.

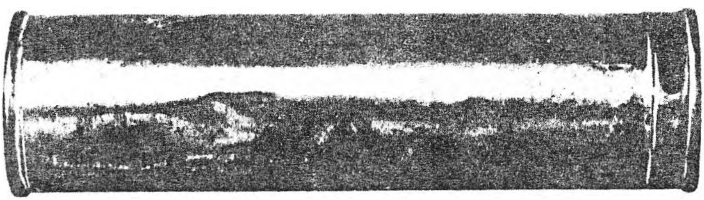
4. ILLUSTRATIONS

Figs. 1 and 2, show top and side views of the candle. Drawing, fig. 3, gives the construction and details of the candle.

(REPORT BY 42ND CHEM. LAB. COY.)
USAFFE



JAPANESE HC SMOKE CANDLE, (U/I) TYPE - FIG. 1

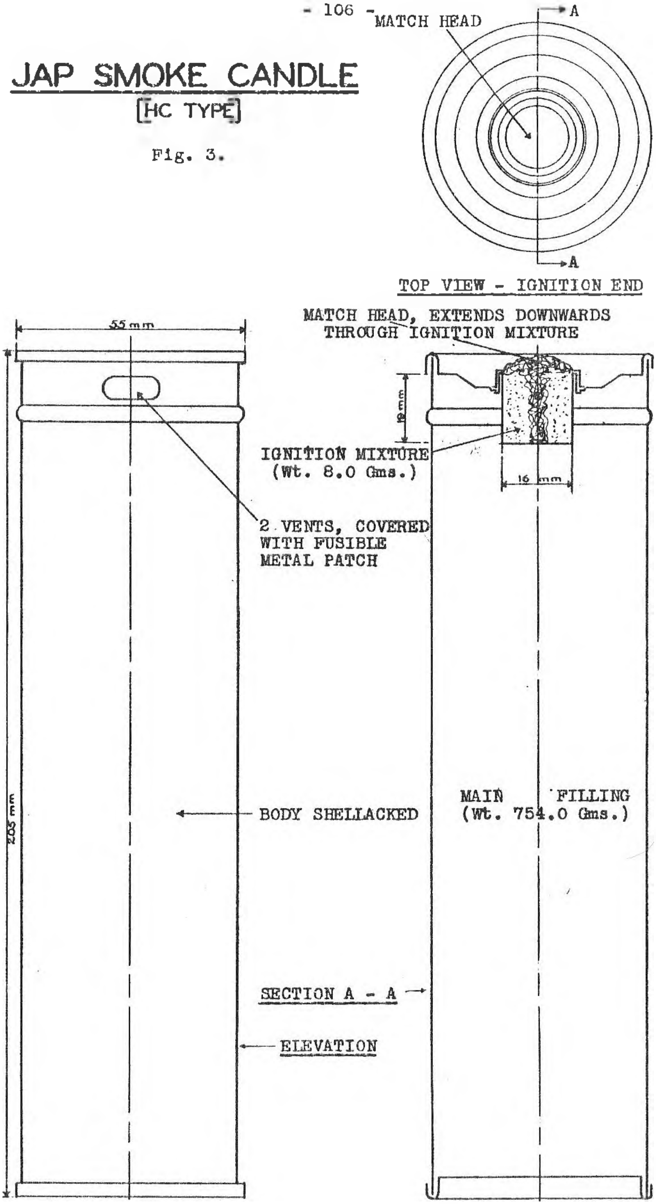


JAPANESE HC SMOKE CANDLE, (U/I) TYPE - FIG. 2

JAP SMOKE CANDLE

[HC TYPE]

Fig. 3.



JAPANESE BODY ARMOUR.

A captured Japanese bullet-proof vest is illustrated in the accompanying photographs. (Figs 1 & 2.)

The outer covering is a good quality drill, olive green in colour, with a lining of similar material throughout.

Two adjusting straps are provided under each arm-hole.

A laced opening in the lining on either side allows of access to a series of calico pockets, each of which holds one armour plate in position.

The armour consists of six plates, moulded to the shape of the body, and arranged in fish-scale fashion on either side of the chest. The vest provides no protection for the back.

Further details are as follows:-

Weight of vest complete	-	9 lbs.
Thickness of plates	-	0.08 inches
Amount of overlap of plates	-	0.5 inches

Analysis of armour plate:-

Carbon	-	0.21
Manganese	-	0.57
Nickel	-	2.54
Chrome	-	0.57
Molybdenum	-	0.34

Brinell hardness - 311

A translation of the tag on the back of the collar reads:-

"Passed by the Inspectors of the Imperial University."

It is considered that the weight of this vest would preclude its use by ordinary infantry, and would confine it to M.T. drivers, special troops and possibly air pilots.

Tests have been conducted against the armour, utilising .303 and 9 mm. ammunition at 100 yards and 20 yards respectively. The accompanying photographs (Figs 3,4, 5 & 6) illustrate results on both inside and outside of the armour at two angles (i) horizontal (ii) 30° from horizontal.

(REPORT BY M.G.O. L.H.Q.)

Fig. 1.

Japanese Body Armour.

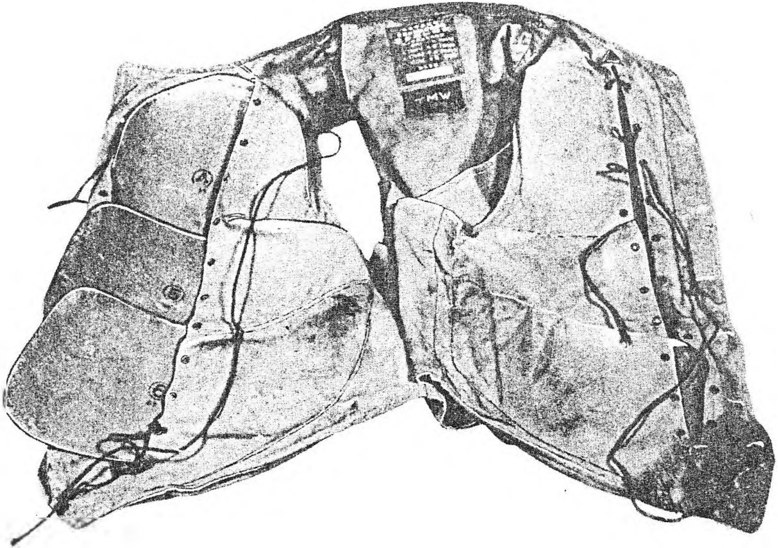


Fig. 2.
Japanese Body Armour.
(inside of vest)

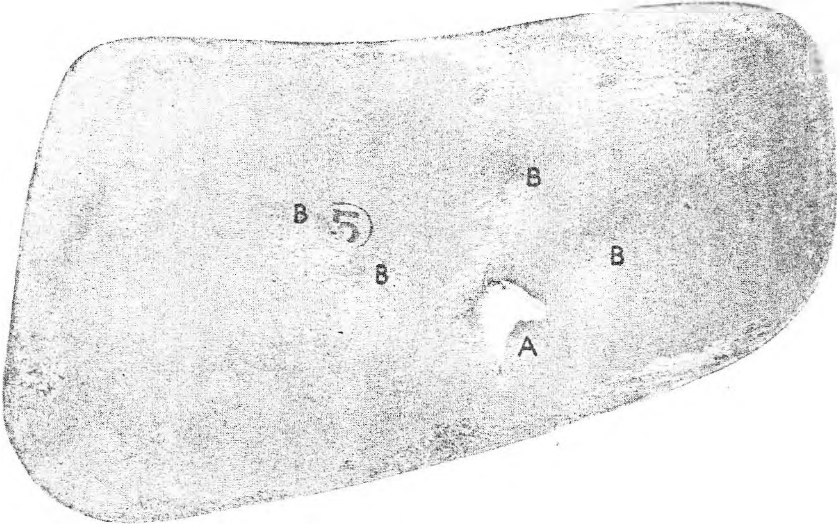


Fig. 3.
Japanese Body Armour.
Penetration Test - Horizontal fire.
(INSIDE. A = .303. B = 9mm.)

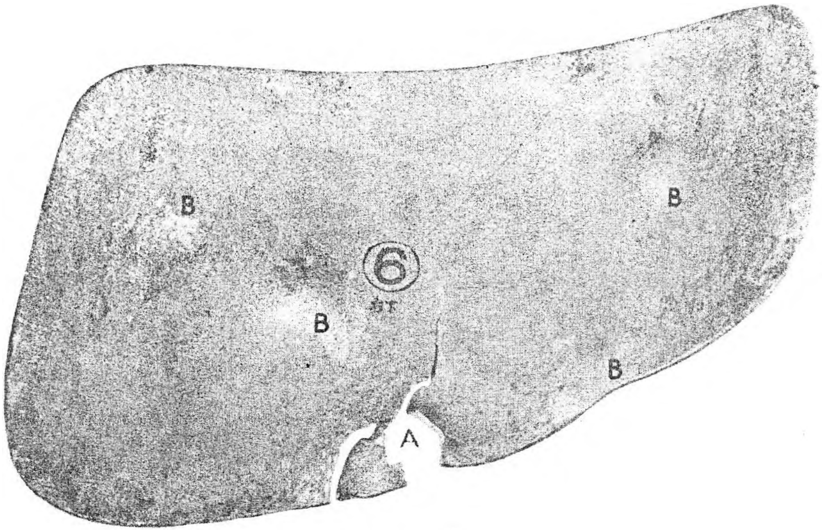


Fig. 4.
Japanese Body Armour.
Penetration Test - Fire 30° from horizontal.
(INSIDE. A = .303. B = 9mm.)

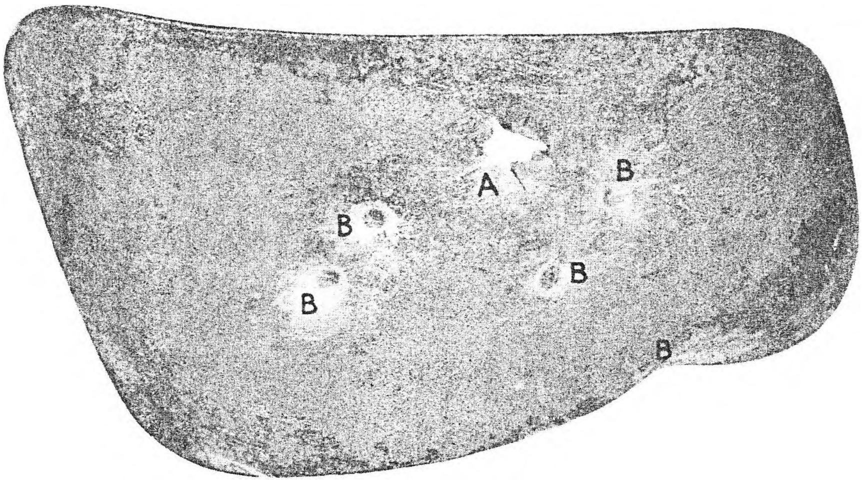


Fig. 5.
Japanese Body Armour.
Penetration Test - Horizontal Fire.
(OUTSIDE. A = .303 B = 9mm.)

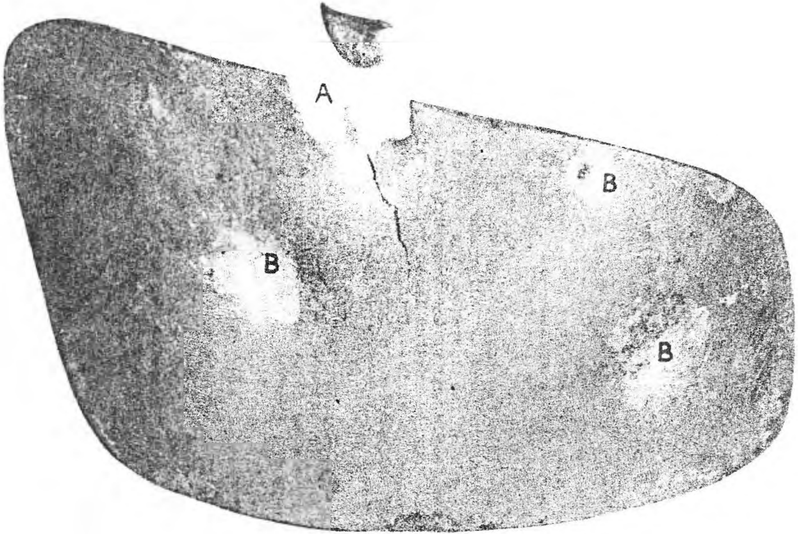


Fig. 6.
Japanese Body Armour.
Penetration Test - Fire 30° from horizontal.
(OUTSIDE. A = .303 B = 9 mm.)

JAPANESE "BANGALORE TORPEDO"
(Improved Type)

1. General.

This report covers a Japanese "Bangalore Torpedo" captured at Guadalcanal by the U.S. Navy B.D. Unit. In the past, the Japanese have used a "Bangalore Torpedo" which consisted of a split bamboo pole held together by a number of bands of twine. Depending on its length, any number of charges could be inserted in the pole. The explosive charge was detonated by a short length of fuse, attached to the detonator cap. (See L.H.Q. Tech. Int. Sum. No 1. pp. 33 - 35).

In contrast to the bamboo type, the new steel tube "Bangalore Torpedo" is self-contained with fuse and explosive charge.

2. Construction.

The torpedo proper (Fig 1) consists of a steel tube with shoulders welded to both ends. When shipped, the tube has a cap screwed over one end and a male plug threaded into the other. The fuse and locking collar are constructed of a light aluminium alloy. The fuse assembly (Fig 2) is in three parts: namely, (a) the fuse body, housing twin friction igniter-detonator systems with lanyard, (b) locking collar, and (c) the pointed cover.

Assembly: To assemble the torpedo for use, the pointed cover unscrews from the locking collar and replaces the cap on the male end of the torpedo. The plug is then removed from the female end of the tube and the locking collar with fuse body is screwed in to replace it. In addition, to connect a series of torpedoes together, the male end of one torpedo can be screwed into the female end of another torpedo.

To explode the torpedo, the safety pin (d) is removed from the fuse head and the lanyard (e) is pulled. There is an eight (8) second powder delay train between the twin friction igniters (f) and the detonators (g).

3. Torpedo Data.

Nationality	:	Japanese.
Size	:	10 lbs.
Target	:	Barbed wire entanglements.
Type	:	Bangalore Torpedo.
Fuse	:	Twin pull igniter.

Data.

(a) Overall length:
- (i) With nose cap and plug in position .. .. .. 46 15/16 inches.
- (ii) With fuse and pointed cover in position .. 51.0 inches.

(b) Length of Body .. .. .. 46 21/32 inches.

(c) Diameter of body .. .. .. 1 13/32 inches.

(d) Thickness of Wall .. .. .. 7/64 inches.

(e)	Material of Wall	Steel.
(f)	Construction of Body	Sheet steel rolled into a tube and internally welded. An internally threaded sleeve is welded to one end of the tube and an externally threaded sleeve to the other end. The former receives the fuse and locking collar while the other receives the pointed cover.
(g)	Color and Markings	Tube-brown with a circumferential red stripe just inboard of the externally threaded sleeve. White triangle near the mid-point of the tube. Eleven inches inboard of the externally threaded end appears a mark (see Fig. 1.)
(h)	Type of Filler	TNT: 36.4% Cyclonite: 63.6%.
(i)	Weight of Filling	3.0 lbs.
(j)	Total weight of Torpedo ..	10.0 "
(k)	Charge/Weight Ratio.. ..	30.0 %
(l)	Wt. of fuse and pointed, cover	353.0 grams.
(m)	Weight of tube empty less plug and cap	6.25 lbs.
(n)	Weight of plug and cap ..	416.0 grams.
(o)	Length of pointed cover ..	4 3/16 inches.
(p)	Diameter of pointed " ..	1 5/8 "
(q)	Length of aluminium locking collar	2 13/32 "
(r)	Maximum diameter of locking collar	1 21/32 inches.
(s)	Length of aluminium fuse body	2 1/4 "
(t)	Diameter of fuse body ..	31/32 "
(u)	Length of brass friction igniter-detonator assembly	4.25 "
(v)	Delay powder train	8.0 seconds.

Remarks:

The "Bangalore Torpedo" is used primarily for destroying barbed wire entanglements. However, with the pointed end attached to the torpedo, it could be used in manifold ways; such as, throwing, jamming between tank treads, blowing up railway tracks, destroying artillery pieces (closing breech and placing a torpedo down the barrel), etc. These torpedoes give a large shrapnel effect as well as that of blast.

Analysis of the main charge by the 42nd Chemical Laboratory Company, USA, APO 923, shows that the main charge is composed as follows:

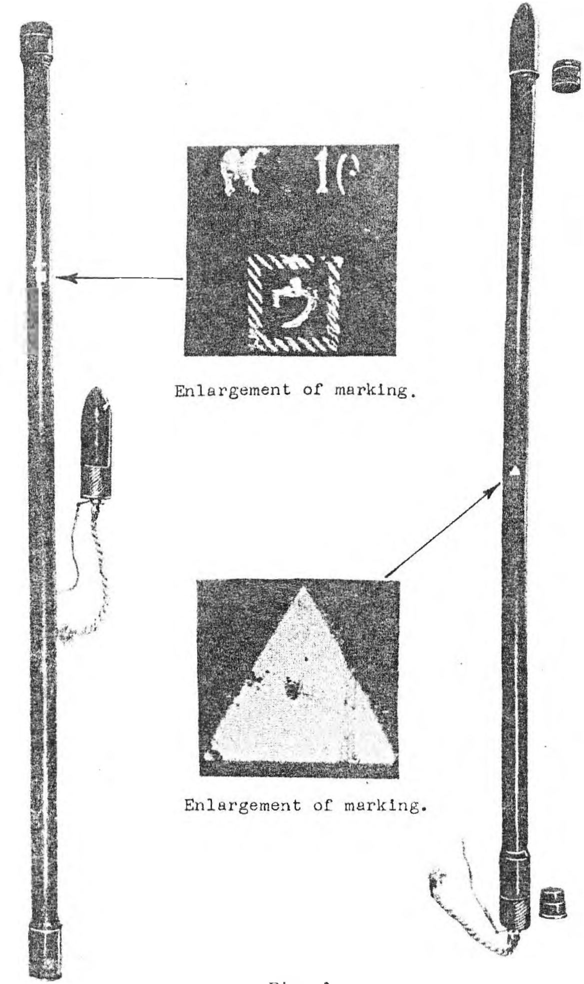
Filling from fused end of tube (booster):

TNT	:	27.2 %
Cyclonite	:	72.8 %

Filling from male-threaded end (main charge):

TNT	:	36.4 %
Cyclonite	:	63.6 %

(REPORT BY M.E.I.U. USAFFE.)



Unarmed

Armed.

Fig. 1.

Japanese Bangalore Torpedo.

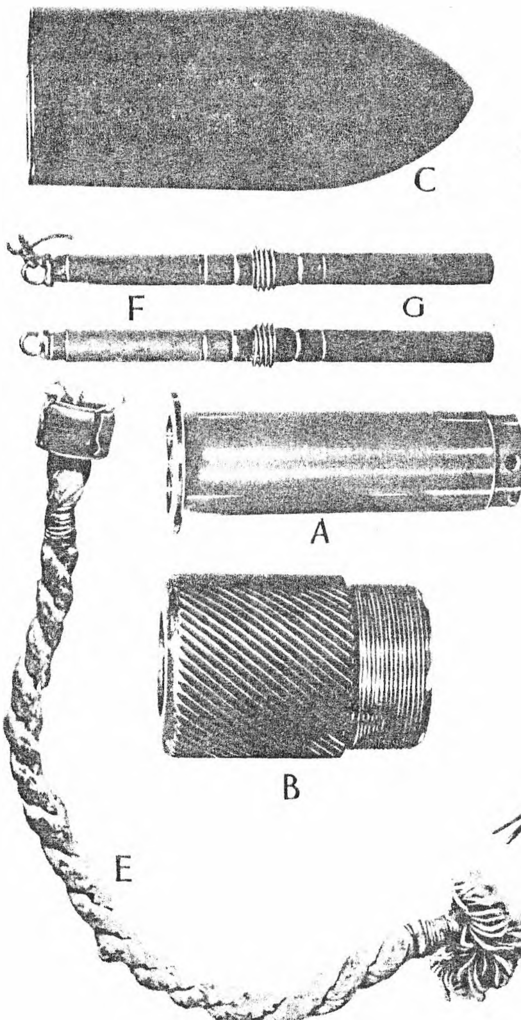


Fig. 25.
Japanese Bungalore Torpedo.

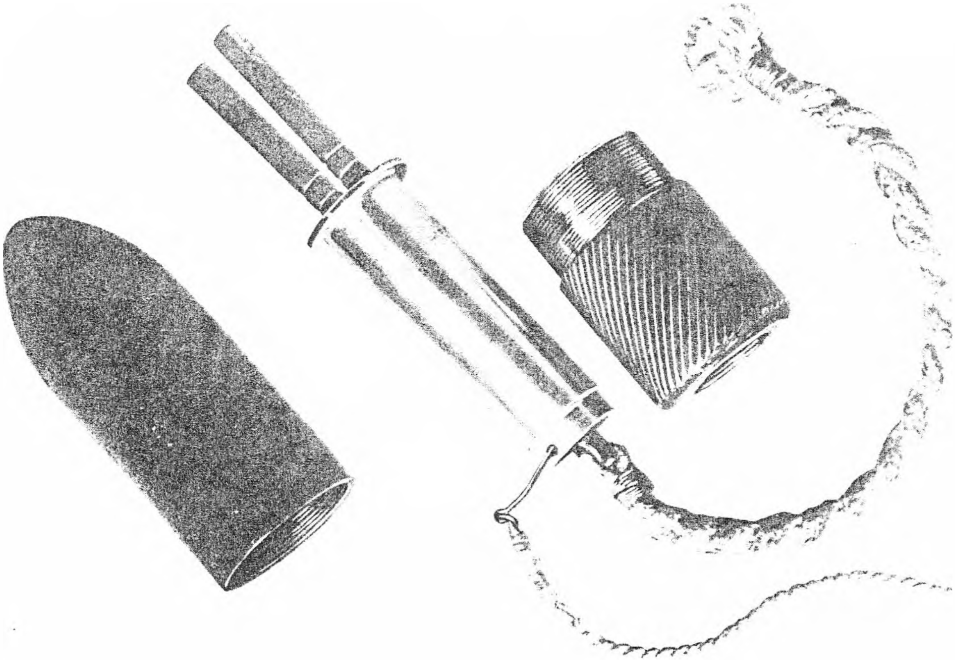
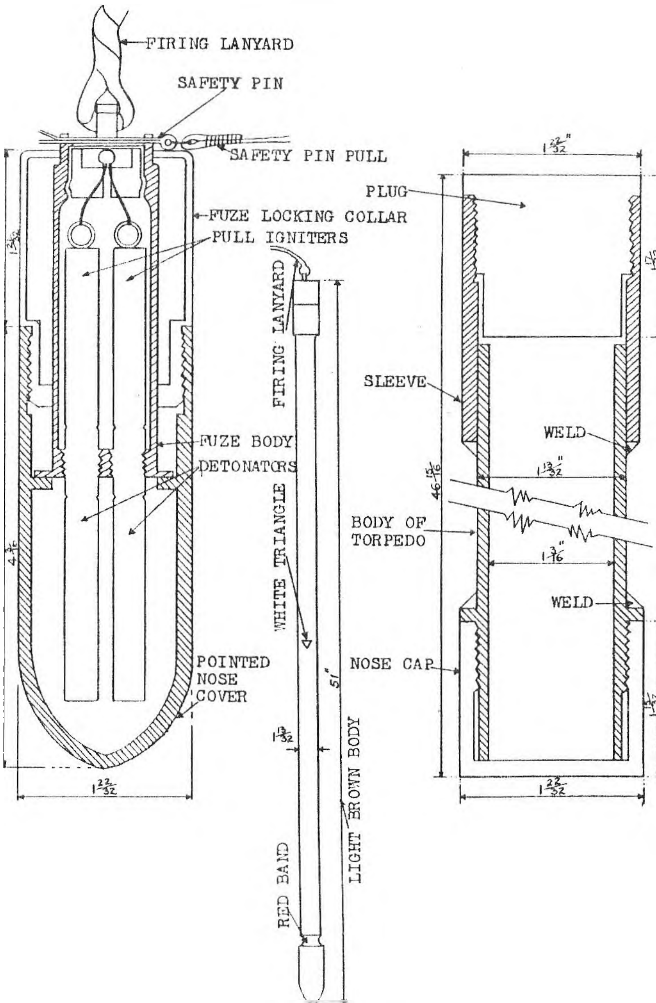


Fig. 3.
Japanese Bungalore Torpedo.
Fuse - Showing method of assembly.

IMPROVED JAPANESE "BANGALORE TORPEDO"

Fig. 4.



JAPANESE SHORT DELAY CLOCKWORK TAIL FUSE FOR AIR BURST.

1. Introduction.

(a) Advance information of a "Japanese 250 kg. Incendiary Shrapnel Bomb" was mentioned in L.H.Q. Tech. Int. Sum. No 3. The following data on the fuse for this bomb was obtained from the R.A.E. ⅃.D.U. at Port Moresby.

(b) Advance information concerning the bomb referred to intermediate or subsidiary fins located between the regular tail fins. These subsidiary fins supposedly give to the bomb a rotary motion which aids in arming the fuse, and in enabling the small burster charge to scatter the incendiary material over a wide area.

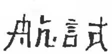
2. Fuse Data.

Nationality : Japanese

Designation : - - - -

Markings and Subsidiary Markings: 
Found on base of clock container.

Information date : May 1943.

Principal Markings:  232

Found on Setting Piece.

Classification: Clockwork tail fuse for air burst.

Type of Missile: Incendiary Shrapnel.

Bombs used in : 250 kg. Incendiary Shrapnel.

Data.

(1) Color .. .. Unpainted brass.

(2) Overall Length .. .. 5¾" (less booster).

(3) Overall Width .. .. 2 7/16".

(4) Material of Construction. Brass throughout except for steel studs in the fuse body and small steel springs, studs, striker, etc. contained within the clock-work mechanism.

(5) Description .. .. The fuse consists of six main parts - flash-transit container (Q), clock base (P), clock setting piece (H) with retaining collar (L), setting spindle (J) with spindle sleeve (J-I), and arming vane assembly (C). The clockwork mechanism is

attached to the clock base (P) by three screws which extend through the clock into the base and are secured by castellated nuts. To the bottom side of the clock base is fitted the flash-transit container (Q) which is positioned by a locating stud and secured by two screw studs. The primer cap and powder train are located within the flash-transit container, and the gaine (type not reported) is screwed into the bottom of the container. The setting piece (H), which bears a scale graduated in half-second intervals from 0-50 seconds, fits over the clock mechanism and is held in position by the retaining collar (L). This retaining collar screws into the clock base (P) and is secured and positioned by a grub screw (M). A friction spring (N) is inserted between the retaining collar and setting piece to prevent their binding. The spindle sleeve (J-I) fits over the setting spindle (J) and is secured by a grub screw in the setting piece. The setting spindle (J) with creep-spring (F) fits inside the sleeve and is positioned by a stud located inside the setting piece. A cap (B) is screwed on top of the setting spindle to prevent the arming vanes from unscrewing and falling clear. The arming vanes (C) and vane boss (D) screw on to the externally threaded spindle sleeve (J-I). A cover (A) is fitted over the sleeve and attached to the vane boss by three set screws.

The rotor arm (3) on the clock is fastened to the arbor shaft (13) by a friction washer which is compressed by another flat washer. This friction drive allows the rotor arm to be turned for setting purposes, but causes it to revolve when driven by the clockwork mechanism. The clockwork mechanism is set up on two brass plates (8) and (11) with a center plate which acts as a bearing plate for the gears and shafts. The clockwork mechanism is prevented from operating by:

(a) The clock stop and release bar (6) which is held in position by the safety wire (14) and the lower circular ring of the setting spindle; and,

(b) the striker safety catch cam (12) which is moved away from the striker (7) by centrifugal motion, caused by the rotation of the bomb in flight.

The striker is held in safe position by a knife-edged striker release bar (5) and is released only when the striker release bar fits into the recess in the rotor arm (4). This is accomplished by the rotation of rotor arm under the power furnished by the clock mechanism. The time delay setting is obtained by revolving the time setting piece to the given number of seconds required and securing it with the grub screw (M). To set this fuse to explode the bomb above the ground, it is necessary to know the altitude of the plane above the ground.

(6) Position and method of fixing in Bomb	With a spanner wrench, the fuse is screwed into an adapter ring located at the apex of the tail cone. No locking device is noted.

(7) Fuses likely to be found with it .. .. .. A-2(a) nose fuse, or suspected modification.

(8) Components of explosive train .. .. Not known.

(9) Arming time .. .. .. After eleven revolutions of the arming vanes, the clock mechanism is set in motion and the fuse is then armed.

(10) Operation .. .. On release from the bomb rack, a safety wire (E) is removed from the arming vanes and at the same time a safety wire (14) is removed from the clock stop and release bar (6). After eleven revolutions, the arming vane boss (D) raises the setting spindle (J) $\frac{1}{8}$" and thus disengages the setting spindle stud (K) from the rotor. At the same instant, the spring-loaded clock stop and release bar (6) moves upward until the recesses in it are opposite the spring-loaded pawl (9) and the striker release bar (5). When the spring-loaded pawl (9) engages the clock stop and release bar (6), it prevents the setting piece from moving down and stopping the clock if the spindle cap (B) is sheared by the vanes. It also allows full movement of the striker release bar (5). The centrifugal safety catch cam (12) is moved outward by the rotary motion of the bomb, and thereby leaves the striker held only by the knife edge on the striker release bar (5). Since the striker (7) is spring loaded, it will tend to force the striker release bar (5) into the rotor arm (3). When the striker release bar falls into the recess in rotor arm (4), which has been brought into position by the movement of the rotor, the striker is released. The striker then fires a primer cap in the flash transit container (Q) which sets off the explosive train.

Remarks:

The clock is wound by removing the cover stud (G) and inserting a key into the winding recess (1). An inspection hole located in the setting piece (H) directly above the graduated scales and covered by a screw, makes it possible to determine the position of the rotor and the stud on the setting spindle.

Rendering Safe:

If it is necessary to remove the fuse from the bomb, the following are two suggested methods:

(a) Take great care to avoid vibration.

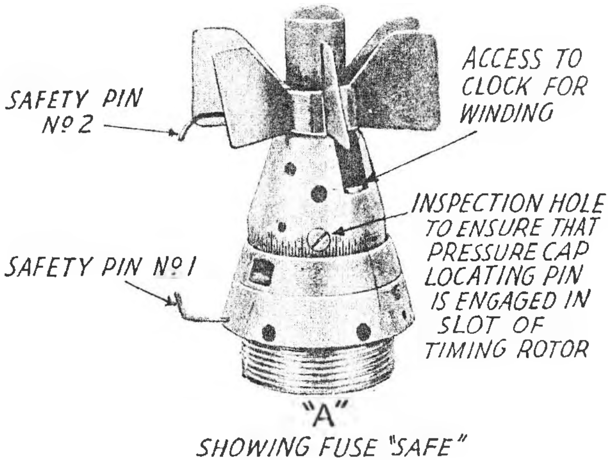
(b) Remove the cover screw from the inspection hole and then determine the relative positions of the stud on the setting spindle and of the rotor. If the stud is engaged in the rotor, the fuse is reasonably safe. If the rotor cannot be seen, the fuse is in a highly dangerous condition.

(c) Inject some quick solidfying substance such as heated candle wax in the inspection hole until the clock is filled, and then allow to set. This will solidify and prevent the rotor from turning.

Or, if the fuse is in suitable position, inject oil through the inspection hole until the clock is filled. The oil will clog the balance wheel and stop the clock.

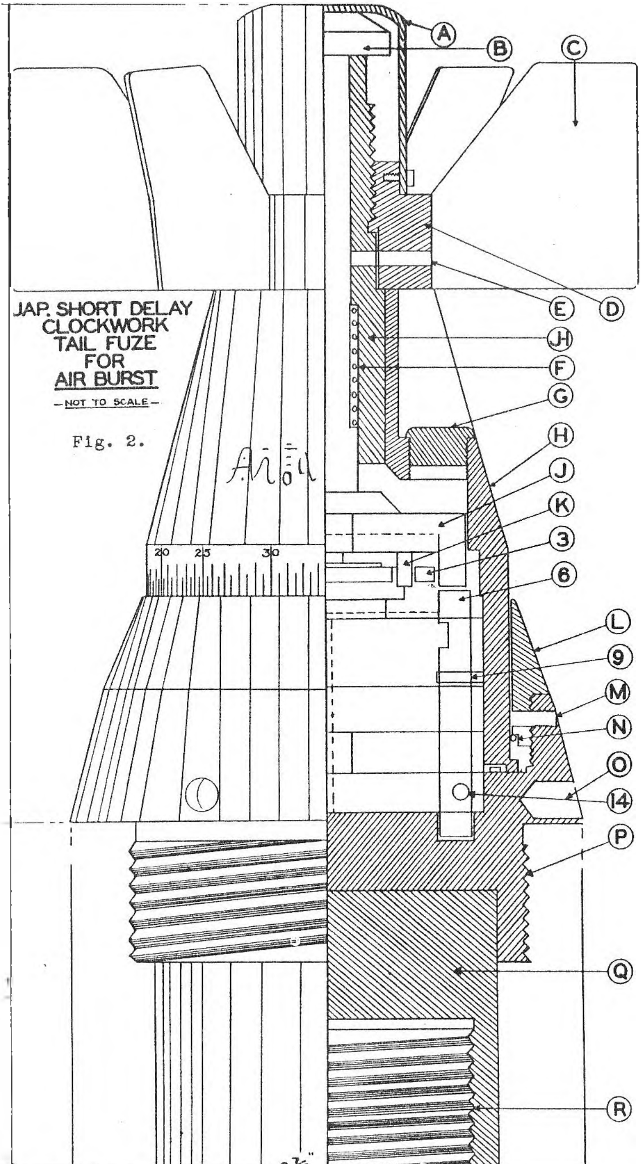
(d) Remove the fuse by remote control.

(REPORT BY M.E.I.U. USAFFE)



JAPANESE SHORT DELAY CLOCKWORK TAIL FUSE
FOR AIR BURST.

Fig. 1.

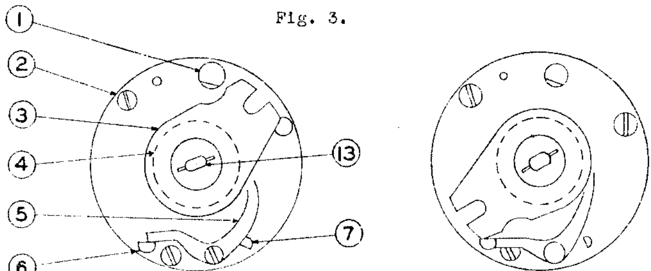


JAP. SHORT DELAY CLOCKWORK TAIL FUZE FOR AIR BURST

— NOT TO SCALE —

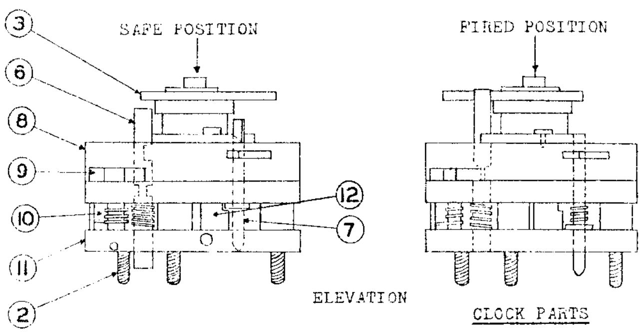
Fig. 2.

Fig. 3.



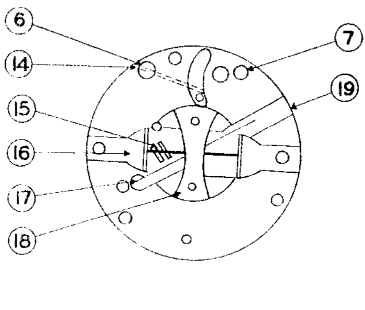
TOP PLATE

JAPANESE SHORT DELAY CLOCKWORK TAIL FUSE FOR AIR BURST



ELEVATION

BOTTOM PLATE



CLOCK PARTS

1. Winding Recess
2. Screw (3)
3. Rotor Arm
4. Recess in rotor arm
5. Striker release Bar
6. Clock Stop and Release Bar.
7. Striker
8. Top Plate
9. Pawl (Engages Clock Stop & Release Bar.)
10. Pawl Spring
11. Bottom Plate
12. Striker Safety Cam (Centrifugal Force Action)
13. Arbor Shaft
14. Safety Wire
15. Pallet
16. Pallet Stops
17. Pallet Spring
18. Pallet Cock
19. Regulator.

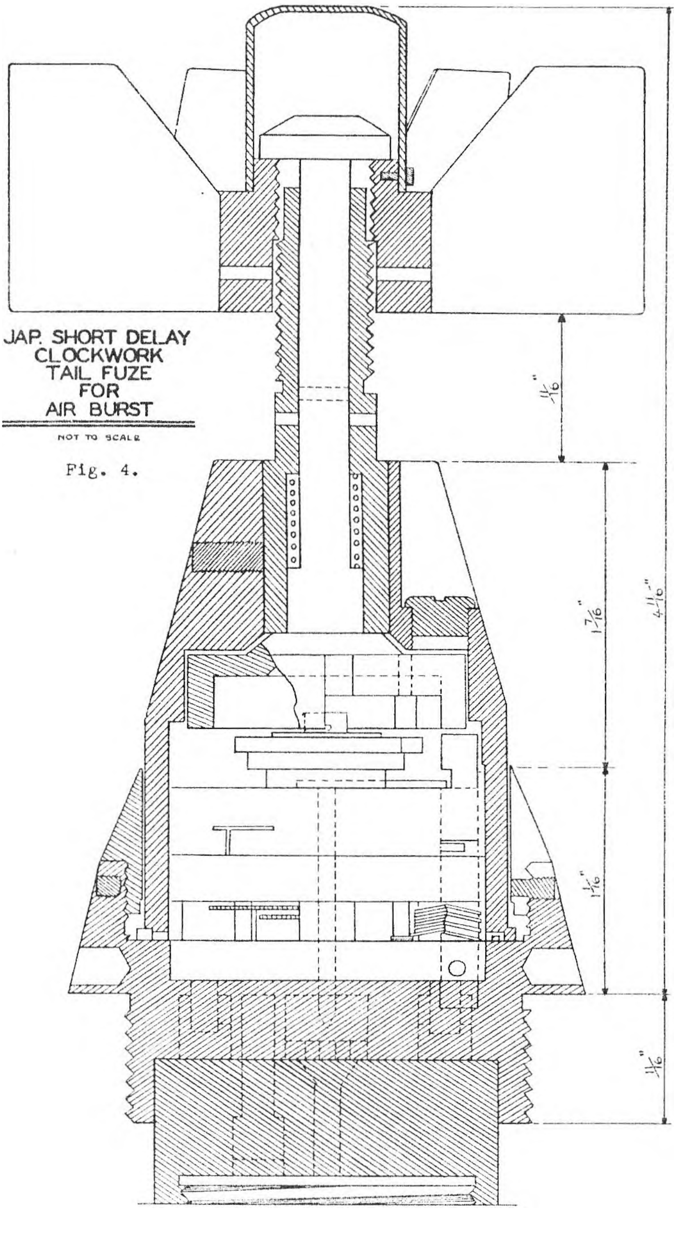

JAP. SHORT DELAY
CLOCKWORK
TAIL FUZE
FOR
AIR BURST
NOT TO SCALE
11/16"
1 7/16"
4 11/16"
1 1/16"
11/16"

Fig. 4.

JAPANESE MOSQUITO REPELLENT.

1. GENERAL.

A sample of repellent submitted for examination consisted of a light green solid of cylindrical shape, about 3" long and $\frac{7}{8}$" diameter. The odour was that of Java Citronella Oil, together with that of a trace of Phenol Carbolic Acid.

2. ANALYSIS.

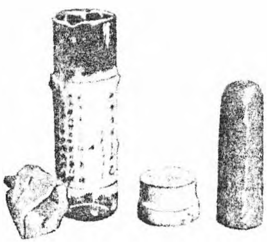
Analysis provided the following results:-

Melting point	42°C. (108°F.)
pH	9
pH in aqueous solution	10
Java Citronella Oil	17%
Phenol	Trace (about 0.3%)
Soda soap of fatty acids (palmitic and stearic)	23%
Water	60%

The repellent consists of a soap containing Java Citronella Oil, together with a trace of Phenol and Water. Melting point is a little above blood heat - 37°C., and the gel is easily spread on the skin in a thin film. The soap acts as a "fixative" for the essential oil, and it is apparent that the enemy considers a fixative necessary to hold the active repellent (a volatile oil) on the skin to maintain the repellent action.

Allowing for errors in the examination of such a small quantity as 3 gms, the true oil content would be about 20% by volume, suspended in a hard soap solution.

(REPORT BY 42ND CHEM. LAB. COY.)
USAFFE



JAPANESE MOSQUITO OINTMENT AND CONTENTS.

Left to right: Small piece of paper previously wrapped around one end of stick of ointment, glass vial with paper label on front, cork stopper and stick of green ointment.