Chapter 1

DESCRIPTION

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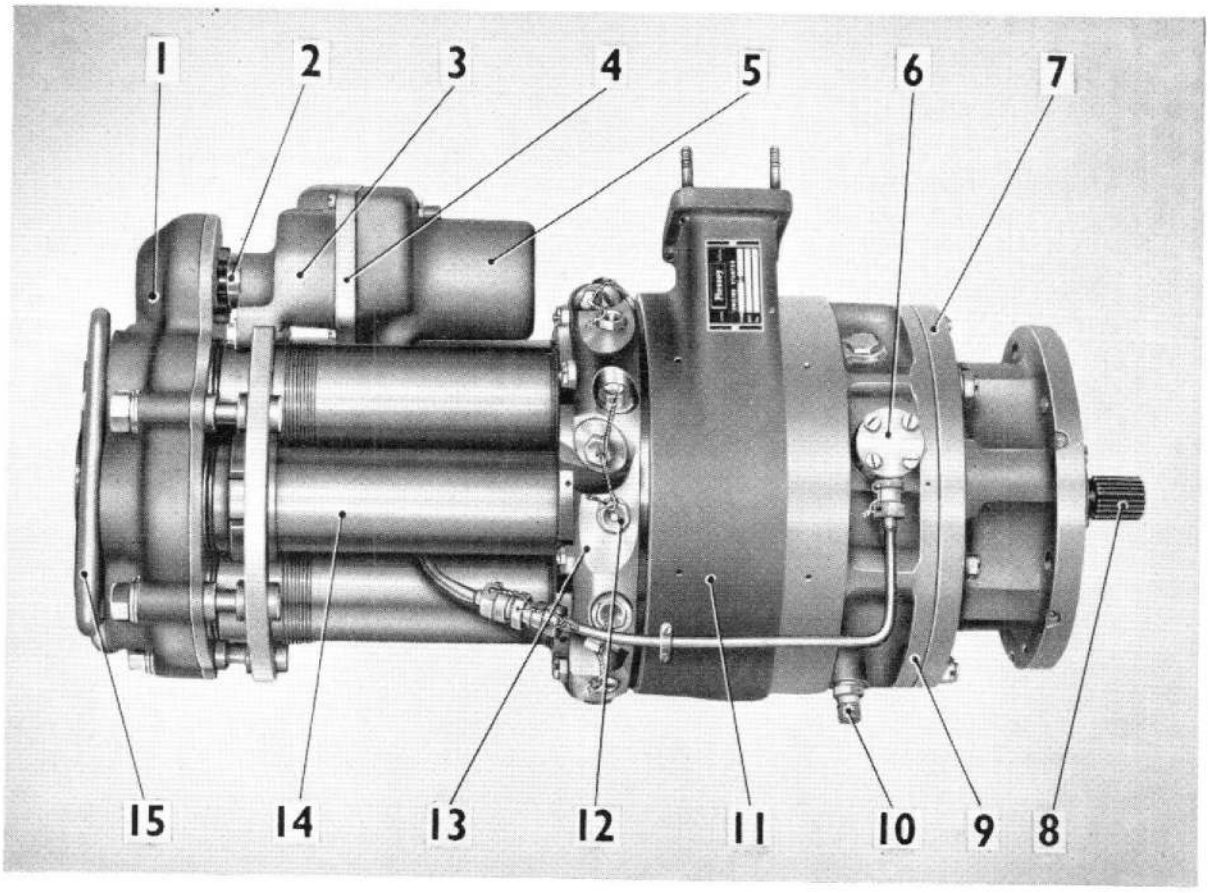
LIST OF ILLUSTRATIONS

INTRODUCTION

1. The type TSC.50 turbo-starter, illustrated in fig. 1, generates its power from a two-stage impulse turbine rotated by high pressure gases liberated by the simultaneous combustion of two cordite cartridges. The gases are fed direct through inlet nozzles to the blades of two contra-rotating rotors, after which the gases are collected in a volute of the rotor housing and exhausted to atmosphere.

2. The torque output of the high speed turbine rotors is transmitted to the starter drive shaft through a double reducing and combining gear train, and a torque limiting clutch.

3. The starter consists of two principal assemblies, a breech with which is incorporated the indexing and firing mechanism, and the starter body comprising the turbine rotors driving the output drive



1 FIRING HEAD
2 INDEX PIN WHEEL
3 REDUCTION GEARBOX
4 MOTOR PLATE
5 MOTOR COVER
6 OIL PUMP
7 MOUNTING FLANGE AND CLUTCH HOUSING
8 FINAL DRIVE SHAFT
9 INTERMEDIATE BEARING HOUSING
10 OIL DRAIN
11 ROTOR HOUSING
12 SAFETY DISC ASSEMBLY
13 NOZZLE BODY
14 BARREL ASSEMBLY
15 HANDLE ASSEMBLY

Fig. 1. Plessey turbo-starter, type TSC.50, Mk. 3

shaft through the reducing and combining gear train. Both assemblies are bolted together to form a complete unit, and the whole is mounted to the engine on the elbow of a Bendix engagement mechanism located on the engine wheelcase. Details of the installation of the starter on any particular engine are to be found in Volume 1 of the relevant aero-engine Air Publication.

BREECH ASSEMBLY

4. The breech assembly (*fig.* 1) comprises four separate sub-assemblies; the firing head assembly (1), barrel assembly (14), indexing gearbox assembly (5) and nozzle body assembly (13).

Firing head

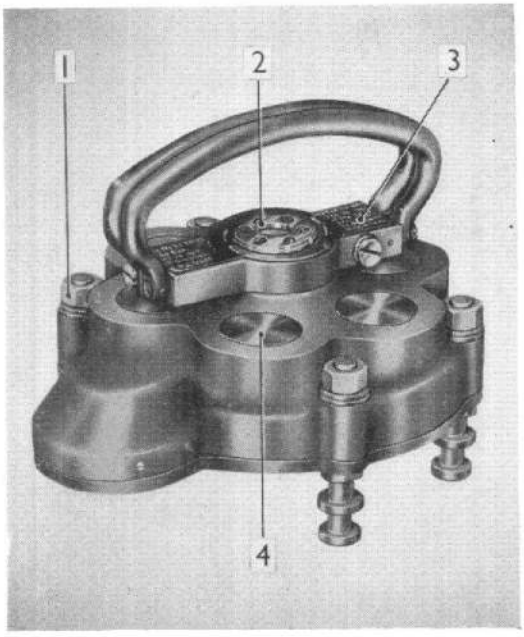
5. The firing head (*fig.* 2) is located on the barrel plate by five studs which have their shanks positioned in locking slots on the barrel plate. A spigot spring, in compression against the spigot on the firing head front plate, causes the heads of the studs to bear against small recesses on the underside of the barrel plate, locking the head in its position for firing, and preventing any tendency for engine vibration to rotate, and thus unlock the head.

6. Contained in the firing head is the firing mechanism and the advancing and retracting mechanism for the sealing pads. The former is actuated by an electrically-driven geneva movement; the latter is manually-operated by the firing head handle when the head is fitted or removed.

Sealing pad retracting mechanism

7. The purpose of this mechanism is to lift the sealing pads (*fig.* 3) and firing pins clear of the cartridge caps so that the firing head may be rotated and removed from the barrel assembly. The same mechanism also brings the sealing pads forward again when the firing head is replaced.

8. The operating handle assembly (*fig.* 2) is attached to the top of a centre gear and stop assembly located in the centre of the firing head. The centre gear meshes simultaneously with six sealing gears (*fig.* 4) each of which, by means of a torsion spring, is able to drive its respective thrust nut which is free to rotate in its housing in the firing head. The thrust nut housings are machined right through the firing head, and are blanked on the top side by sealing plugs.



1 STUD NUT
2 LOCKING DISC
3 HANDLE ASSEMBLY
4 SEALING PLUG

Fig. 2. Firing head

Centre gear and stop assembly

9. This assembly (*fig.* 6 *and* 7) is attached to the firing head by the stop sleeve. The handle sleeve and centre gear are capable of such rotary motion as the stop pin, moving in the pin tracks, will allow (approximately 140°). In addition to this rotary action, the handle sleeve is capable of an axial motion determined by the depth of the slots at each end of the pin track. This axial motion enables the handle sleeve, when depressed, to engage the dogs of the indexing gear. The deeper of the two slots (*fig.* 6) corresponds to the extended position, and the shallow slot (*fig.* 7) to the retracted position of the sealing pads. The pin, at the conclusion of its motion, is retained in one or the other of these two slots by a compressed spring which bears against the collar of the handle sleeve.

Index gear

10. The index gear (*fig.* 10) the function of which is described in para. 18, is located at one end by the centre gear, and at the other end by the front plate. This gear operates upon No. 1 firing gear through an idler gear.

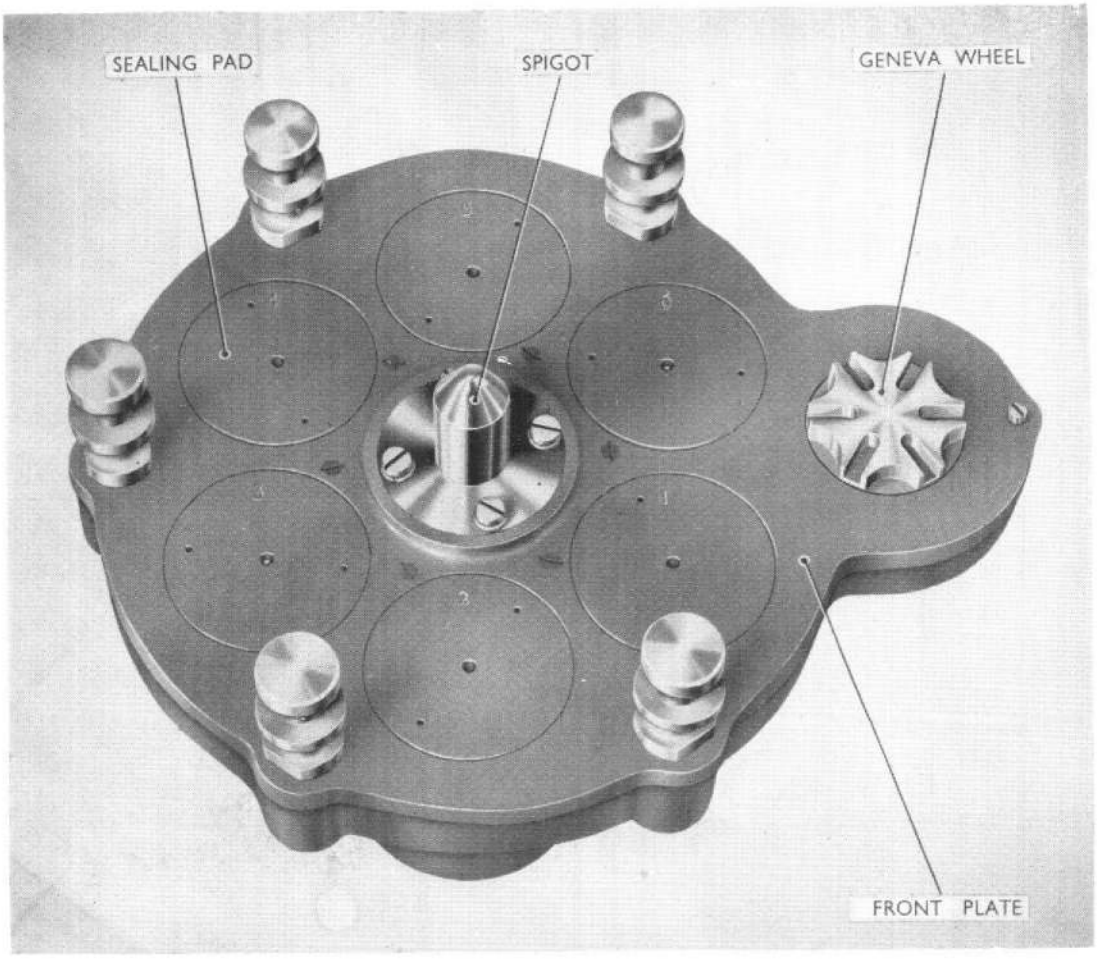


Fig. 3. View of firing head on locking plate

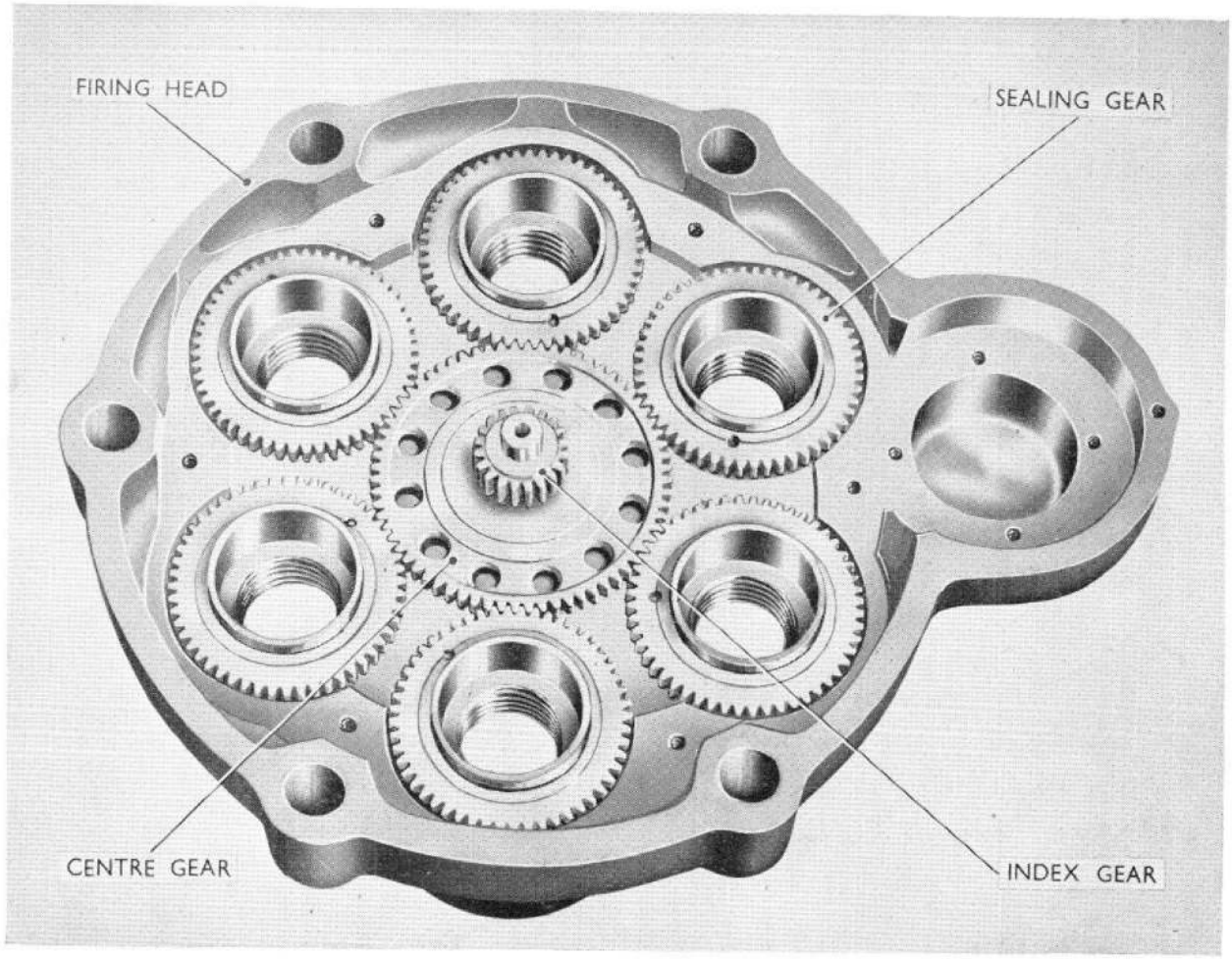


Fig. 4. Firing head showing sealing gears

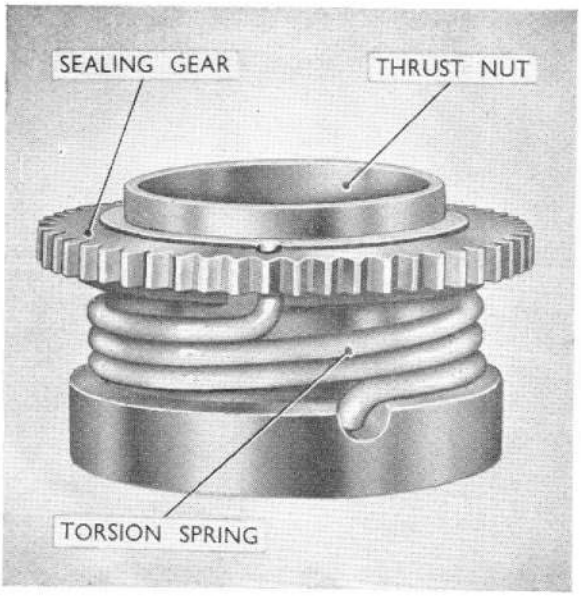


Fig. 5. Sealing gear assembly

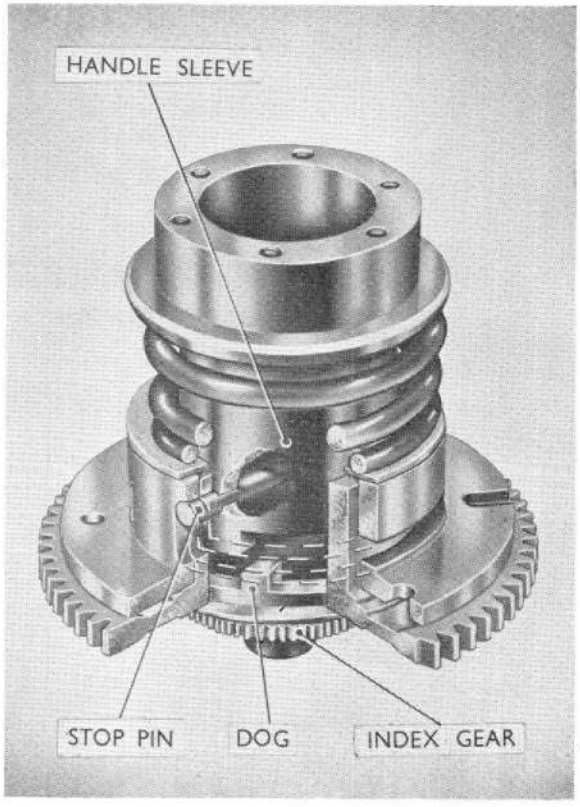


Fig. 6. Centre gear and stop assembly shown partly sectioned

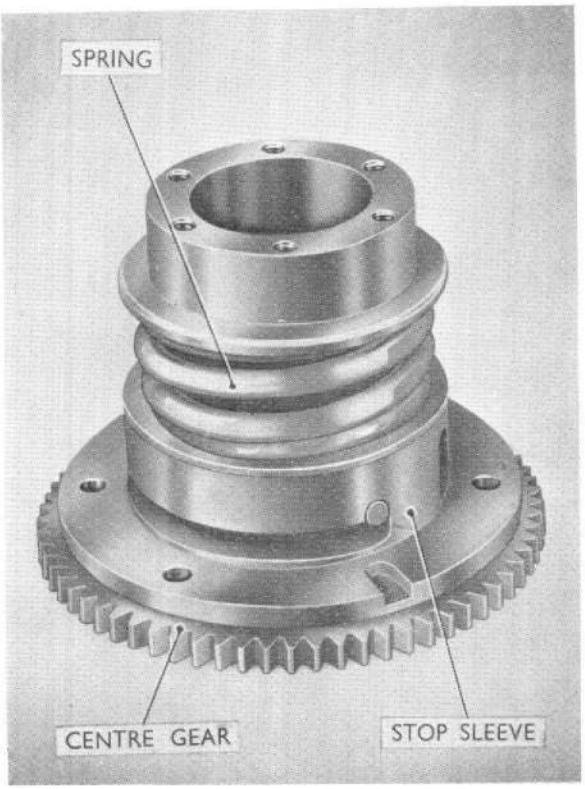


Fig. 7. Centre gear and stop assembly

Indexing and firing mechanism

11. Into each thrust nut is screwed a firing pin assembly (*fig.* 8), the sealing pad of which is prevented from rotating by a key in the front plate (*fig.* 9), which locates in the key-way of the sealing pad. The six sealing gears are in mesh with each other, No. 6 gear also meshing with the geneva gear (*fig.* 10).

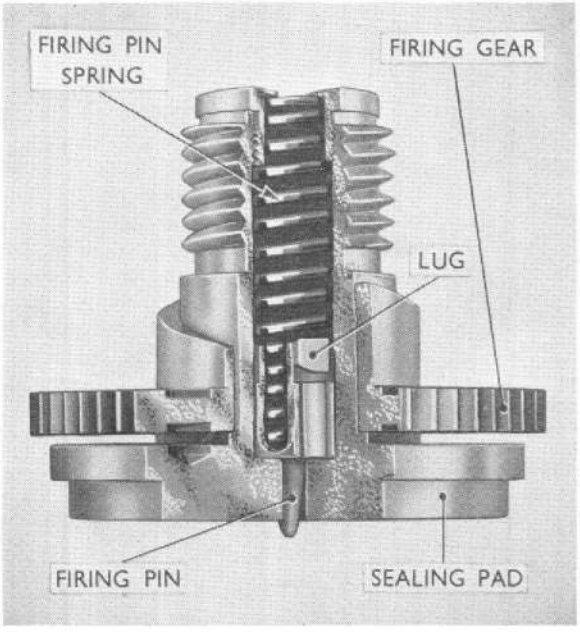


Fig. 8. Firing mechanism shown partly sectioned

Geneva assembly

12. This assembly (*fig.* 10) is attached to the firing head by a flanged bush. The geneva wheel locates in the geneva gear to which it is attached by a pin (11 *fig.* 16). Slots in the gear, into which, the pin ends locate, permit the gear and wheel to rotate independently over a small range, determined by the slot length. A torsion spring connected between the wheel and gear maintains the wheel in the correct position when the breech is removed so that, upon fitting the breech, correct positioning is obtained between the wheel and index pin wheel.

Centre plate

13. A centre plate (*fig.* 10), attached by screws to the firing head locates spigots of the thrust nuts at their forward ends and also provides a housing for one end of the idler gear.

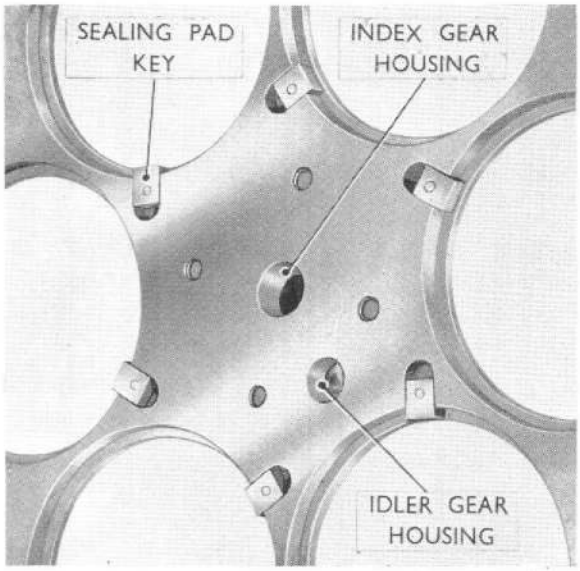


Fig. 9. Part of front plate showing keys

Operation of firing mechanism

14. Considering only one of the six sealing pads (*fig.* 8), which are all locked by the front plate, rotation of the firing gear, in the appropriate direction, causes the lugs on the firing pin to ride up the helical cam tracks of the firing gear; thereby compressing the firing spring. When the position shown in fig. 11 is reached, any further movement results in the firing pin lugs clearing the cam track and the firing pin is snapped downwards under the action of the firing spring. The consequent percussion of the firing pin on the cartridge cap ignites the cartridge.

15. The six firing gears (*fig.* 10) are so meshed that No. 1 and 4, 2 and 5, and 3 and 6 fire simultaneously. When No. 1 and 4 (*fig.* 12) are in the fired position, No. 2 and 5 are one-third cocked, and No. 3 and 6 are two-thirds cocked. After the

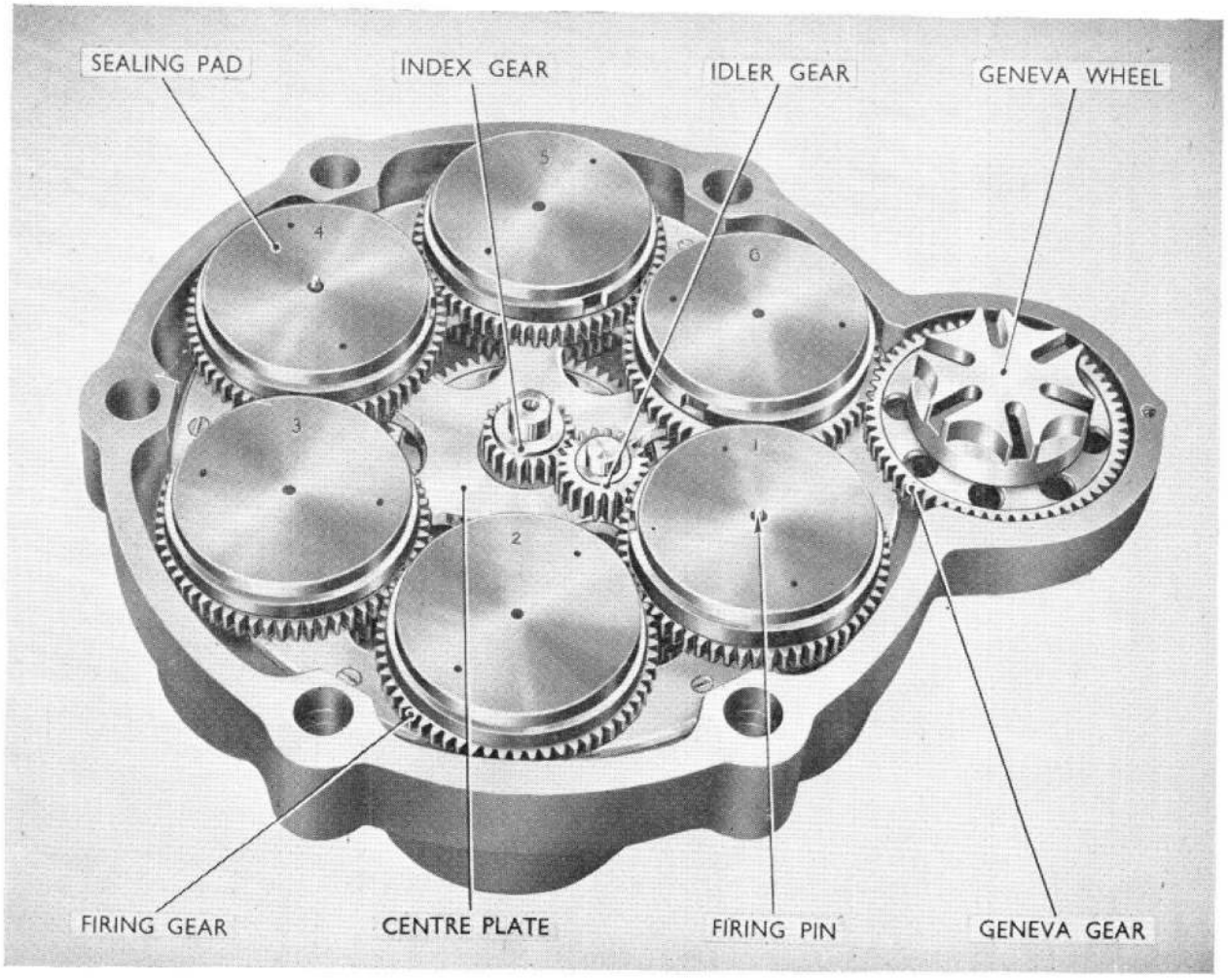


Fig. 10. Firing head with locking plate removed

next firing operation all the gears will have been rotated through 60 degrees. Thus No. 3 and 6 will be in the fired position, No. 2 and 5 will be two-thirds cocked, and No. 1 and 4 will be one-third cocked and so on. As gears No. 1, 3 and 5 (*fig.* 10) revolve in opposite directions to No. 2, 4 and 6, owing to the nature of the gear train, the slope of the cams and corresponding firing pin plugs are handed.

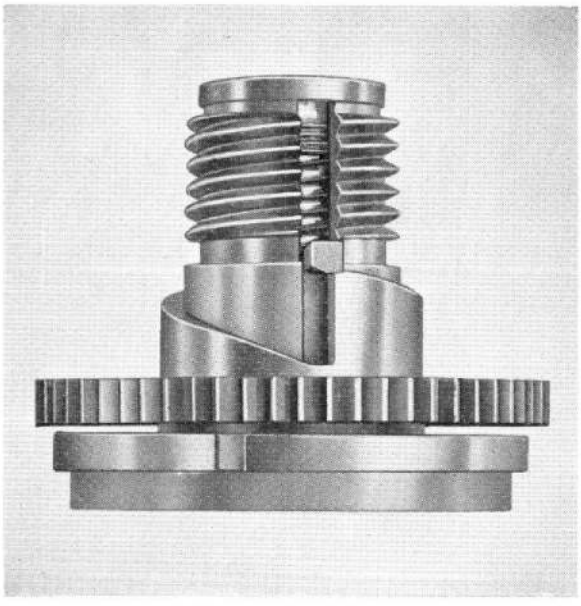


Fig. 11. Firing mechanism about to fire

Indexing and firing sequence

16. For each complete indexing operation, the indexing motor (*fig.* 16) driving through a reducing gear train, rotates the indexing wheel through one revolution. In so doing, the crank pin of the wheel engages a slot in the geneva wheel and rotates the wheel and geneva gear 60 degrees. The geneva gear transmits this motion to the six firing gears, and the firing pins are actuated as described in para. 14 and 15. When indexing is complete, the half-moon of the pin wheel locates in a curved cut-away in the geneva head, effectively locking the firing gear train in position.

Operation of pad retracting mechanism

17. By use of the handle assembly (*fig.* 2), the handle sleeve (*fig.* 6) is manually depressed and the ◄ stop ► pin moves down in line with the pin track. At the same time the handle sleeve engages the dogs of the indexing gear. The handle sleeve, centre gear, and indexing gear, are then rotated until the pin reaches the end of the pin track.

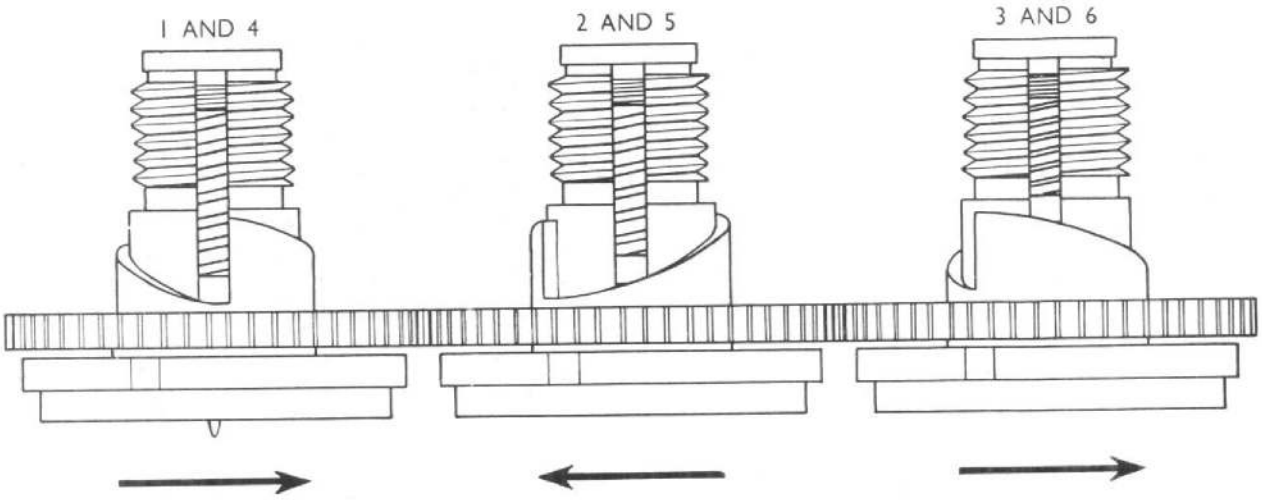


Fig. 12. Diagrammatic arrangement of firing pin positions

Pressure is now removed from the handle assembly, and the operating spring lifts the handle and pin upwards until the pin is located in the shallow slot (*fig.* 7).

18. Considering any sealing gear (*fig.* 4) the rotary motion of the centre gear is transmitted to the sealing gear and thus, through the torsion spring, to the thrust nut. The sealing pad (*fig.* 10) which screws into the thrust nut is locked against rotary movement by the front plate. As the thrust nut revolves, the sealing pad is screwed into it, thereby bringing the sealing pad away from the top of the cartridge cap. This operation occurs simultaneously with all six sealing gears. In addition, the rotary motion of the indexing gear is transmitted through the idler gear to the firing gears. This results in each firing pin being lifted by its respective cam. In the case of the two firing pins in the fired position, the tips of the pins are retracted into their respective sealing pads, clear of the cartridge cap, as shown in fig. 3. The position now is that the firing mechanism has been partly indexed independently of the indexing mechanism, as although No. 6 firing gear also rotates the geneva gear, these two gears being in mesh, the geneva wheel is locked against rotation by the half moon of the pin wheel, and the geneva gear moves independently by the arrangement described in para. 12. If the breech is removed, the geneva torsion spring will maintain the displacement between the geneva wheel and gear, thus ensuring that the wheel engages correctly with the pin wheel when the breech is replaced.

19. To bring the sealing pads forward again, the procedure described in para. 17 is reversed, the thrust nuts are caused to rotate in the opposite direction, and the sealing pads are screwed forward. In this operation however, the dogs of the indexing gear are not engaged, as in turning the handle back, the dogs on the sleeve move away from the dogs on the indexing gear. Consequently, neither the firing gears nor the geneva gear move. During the next indexing action proper, the geneva wheel is rotated by the pin wheel until the relative displacement between the geneva wheel and gear, caused by the partial operation of the firing mechanism when retracting the sealing pads, is taken up. The wheel then drives the gear, and consequently the firing mechanism, in the normal manner. It should be noted that the index gear is so geared to the geneva gear, through the idler gear, that at the conclusion of each firing operation the index gear comes to rest in the position shown in fig. 6; that is, in readiness for engagement again with the dogs of the handle sleeve.

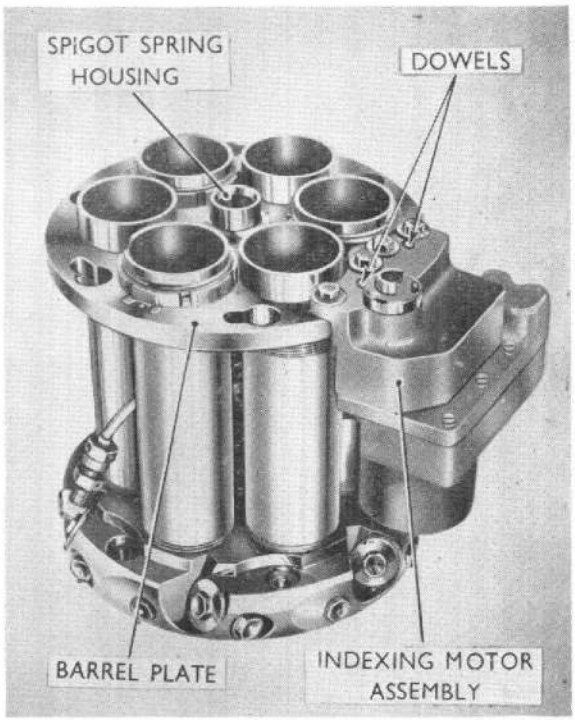


Fig. 13. Breech and nozzle body

Barrels

20. There are six barrels (*fig.* 13), each of which is screwed into the nozzle body (*see para.* 22). A grid (*fig.* 14) is located between each barrel and the nozzle body, and serves to prevent the cartridge charge moving forward into the nozzle body during firing. A barrel plate (*fig.* 13) fitting over the barrels at their top end, is located on flanges machined on No. 2, 4 and 6 barrels, and retained by three ring nuts and tab-washers. This plate locks No. 2, 4 and 6 barrels, and the three remaining barrels are locked at their base by Allen screws, one of which is seen in fig. 17. Threads machined on No. 1, 3 and 5 barrels (*fig.* 14) are for extraction purposes during servicing or repair.

Indexing motor and reducing train

21. The motor reduction driving gear train (*fig.* 15), the final shaft of which carries the pin indexing wheel, is housed in a small gearbox which is located by dowels and attached with bolts to the barrel plate (*fig.* 13). The gears are supported in ball races located in the base of the gear box and in the motor plate respectively (*fig.* 15). The motor plate supports the indexing motor, the drive shaft of which engages with the first gear of the reducing train. A cover fitting over the motor locates two electrical plugs through which the necessary electrical connections are made.

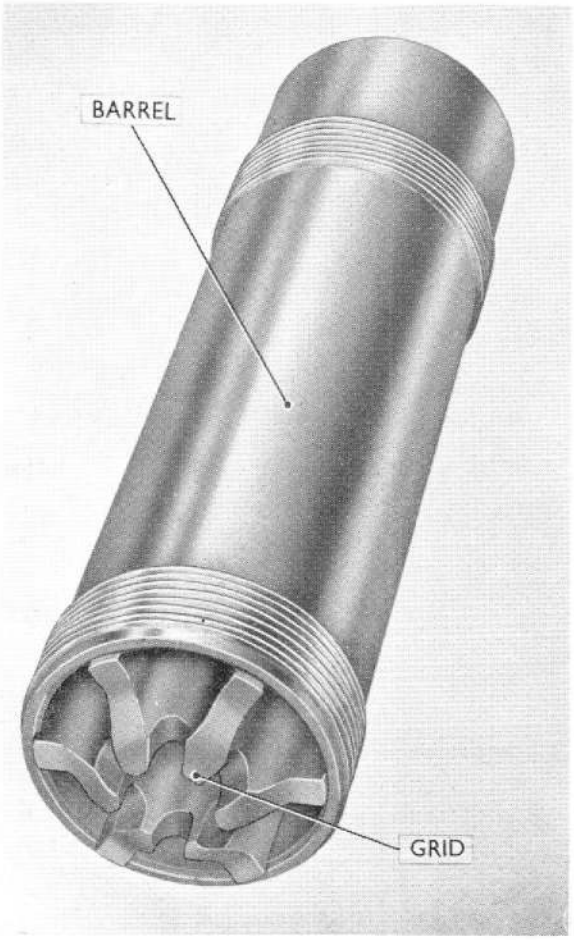


Fig. 14. Barrel and grid

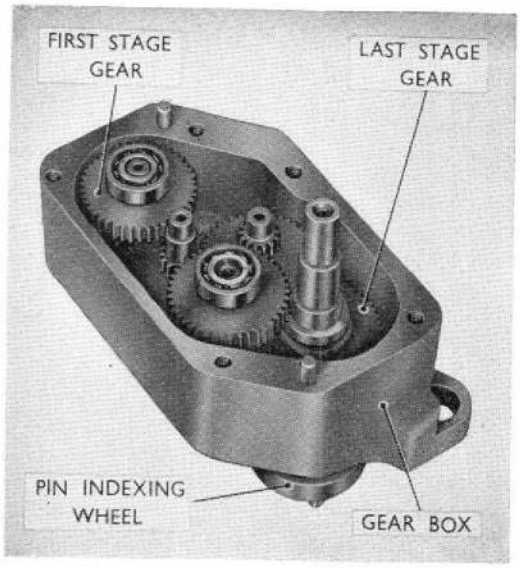


Fig. 15. Indexing motor reducing gear train

Nozzle body

22. The nozzle body (*fig.* 17) is located on the nozzle plate by dowels, and retained by studs which pass through the shroud ring and nozzle plate from the rotor housing, and thus retain the assembly. In addition, the nozzle plate is secured by three cheese-headed screws which pass through the flange of the shroud ring and into the rotor housing. In addition to receiving the barrels, the nozzle body also houses six safety discs, each of which communicates through a drilling with one combustion chamber. The gas passage from each combustion chamber is so shaped that, in conjunction with the nozzle plate, it forms a convergent-divergent nozzle through which the gases are directed on to the rotor blades.

STARTER ASSEMBLY

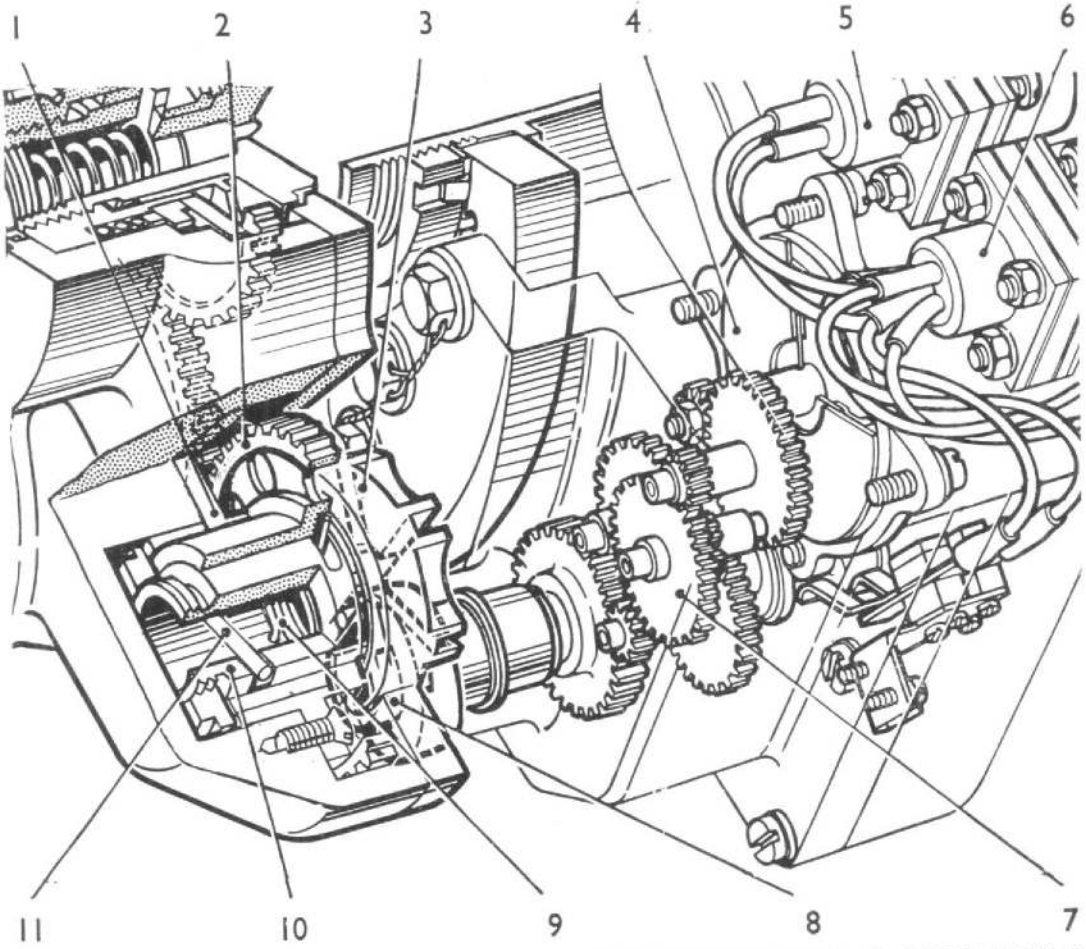
23. The starter assembly (*fig.* 1) comprises four separate sub-assemblies; the rotor housing (11), mounting flange and clutch housing (7) (the intermediate bearing housing line) and the oil pump assembly (6).

Starter body

24. The body of the starter (*fig.* 1) is constructed of three housings, ◄ the rotor housing, ► the bearing housing, and the clutch housing. The rear of the rotor housing receives the nozzle body, nozzle plate and shroud ring (*fig.* 18). The latter two components are jointly located on a shoulder in the housing and retained by screws. The nozzle body is dealt with in para. 22. Projecting from the front end of the rotor housing are six long studs which pass through and retain the bearing housing and clutch housing. The bearing housing is accurately located by two dowels, one of which is visible in fig. 21. The gearbox chamber, formed between the rotor and bearing housings, is made oil-tight by an O-ring.

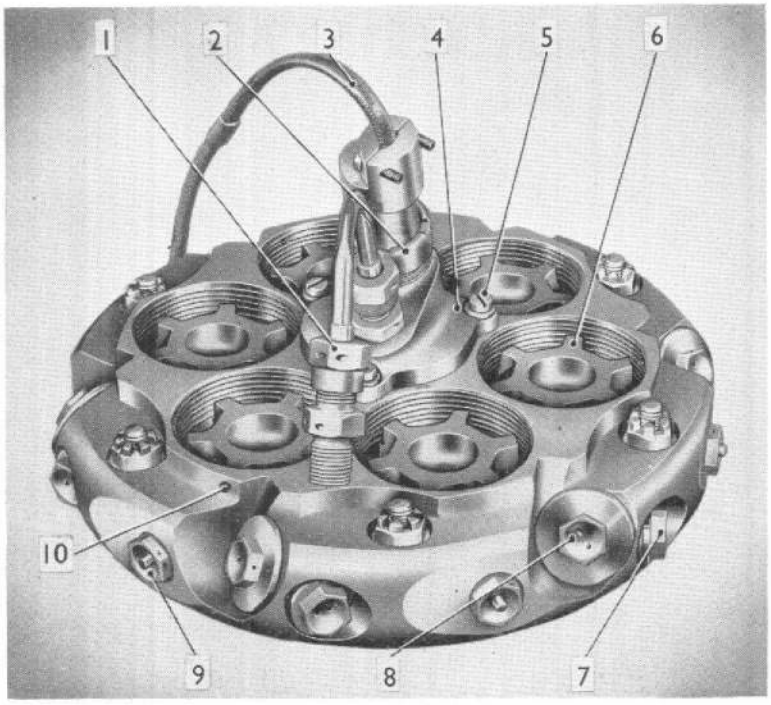
Twin rotor assembly

25. The rotor assembly (*fig.* 19 *and* 20), comprising two contra-rotating rotors, is located within the shroud ring in the rotor housing. The rotor



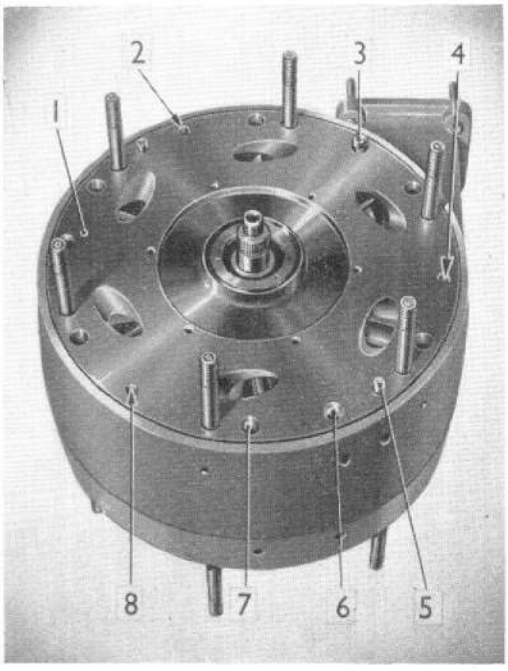
1 BUSH
2 GENEVA GEAR
3 GENEVA WHEEL
4 INDEXING MOTOR
5 OVERSPEED ELECTRICAL SOCKET
6 MOTOR ELECTRICAL SOCKET
7 MOTOR REDUCING TRAIN
8 PIN INDEXING WHEEL
9 TORSION SPRING
10 GENEVA WHEEL SHAFT
11 GENEVA WHEEL PIN

Fig. 16. Sectional perspective view of indexing motor and reduction gear train



1 OIL-PIPE
2 CABLE ASSEMBLY RING NUT
3 OVERSPEED CABLE
4 NOZZLE BODY OIL-PLUG
5 NOZZLE BODY OIL-PLUG RETAINER SCREW
6 GRID
7 and 8 BLANKING PLUGS
9 SAFETY DISC ASSEMBLY
10 ALLEN LOCKING SCREW HOLE

Fig. 17. Nozzle body assembly



1 NOZZLE PLATE
2 EXTRACTOR SCREW HOLE
3 RETAINING SCREW
4 EXTRACTOR SCREW HOLE
5 DOWEL (NOZZLE BODY PLATE)
6 RETAINING SCREW HOLE
7 GAS PASSAGE FROM SAFETY DISC ASSEMBLY
8 EXTRACTOR SCREW HOLE

Fig. 18. ◂ Rotor housing ▸

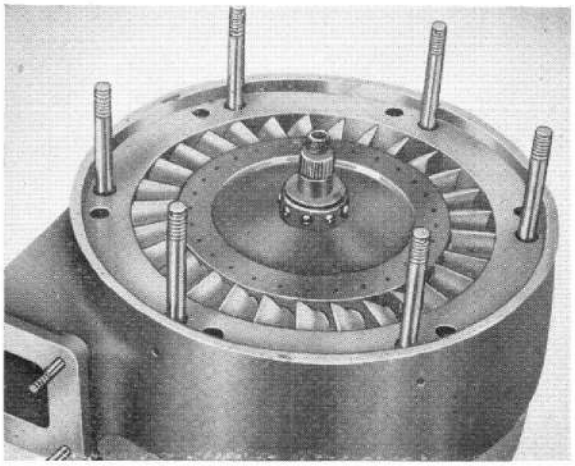


Fig. 19. Rotor assembly in shroud ring

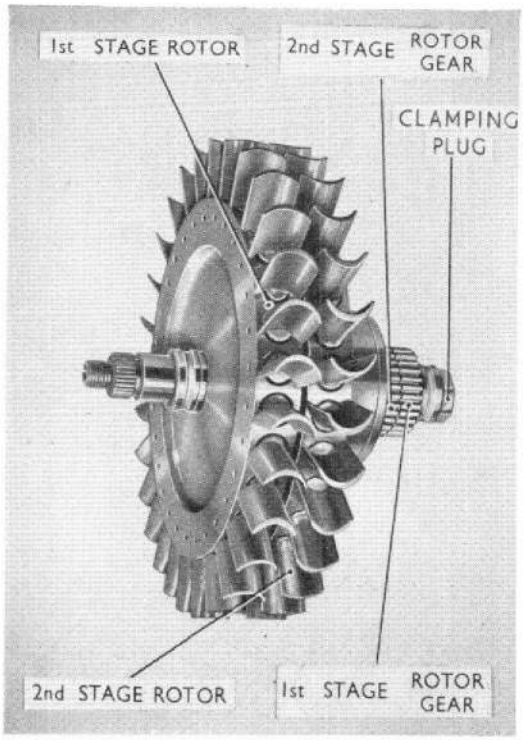
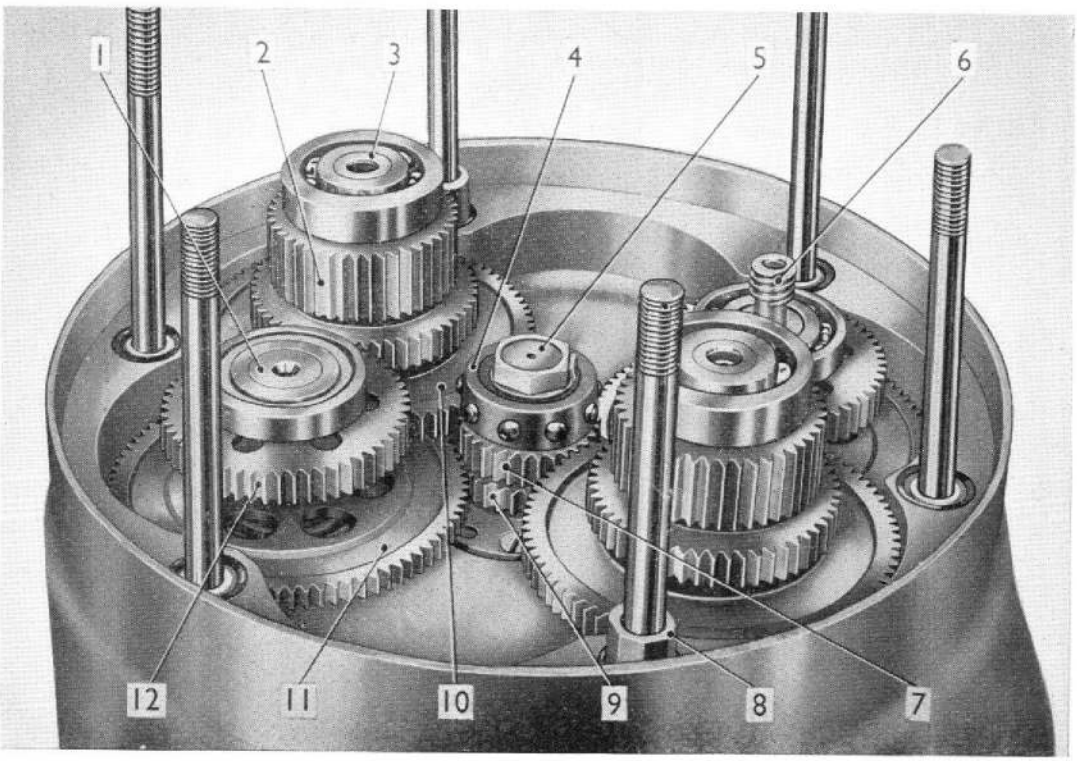


Fig. 20. Twin rotor assembly

blades are screwed into the rotors and locked with pins. The first stage rotor is supported in two angular contact ball races, one located in the nozzle plate, and the other in the bearing housing (*fig.* 22). Mounted on the shaft of the first stage rotor, between this latter bearing and the rotor itself, is the first stage rotor gear, an inner and outer spacing sleeve and the ball races of the second stage rotor, the assembly being retained by a ◄ clamping plug ► (5, *fig.* 21). The second stage rotor is located on its bearings between a screwed ring and the second stage rotor gear. The slightly greater length of the outer spacing sleeve over that of the inner effects pre-loading of the second stage rotor bearings, The first stage rotor bearings are preloaded by a thrust spring which is in compression between a spring retainer and a thrust plate which bears against the outer race in the intermediate bearing housing.

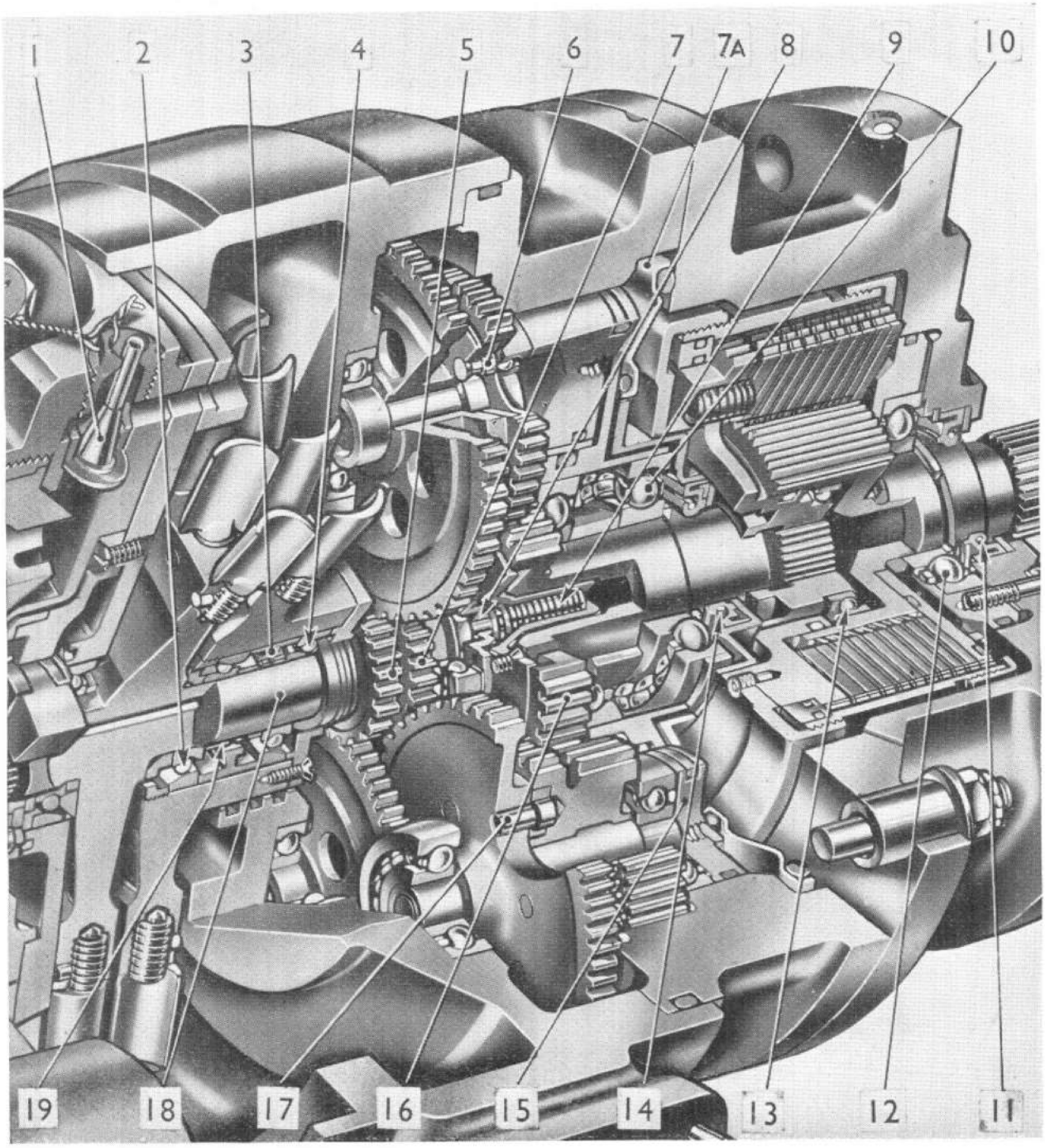


1 SECOND STAGE GEAR ASSEMBLY
2 FIRST STAGE FLEXIBLE DRIVE GEAR
3 FIRST STAGE GEAR ASSEMBLY
4 FIRST STAGE ROTOR BEARING
5 ◄ CLAMPING PLUG ►
6 OIL PUMP WORM DRIVE
7 FIRST STAGE ROTOR GEAR
8 DOWEL FOR BEARING HOUSING
9 SECOND STAGE ROTOR GEAR
10 FIRST STAGE LAYSHAFT GEAR
11 SECOND STAGE FLEXIBLE DRIVE GEAR
12 SECOND STAGE LAYSHAFT GEAR

Fig. 21. Rotor reducing and combining gear train

Reducing and combining gear train

26. The double reducing and combining gear train (*fig.* 21) comprises two first stage and two second stage gear assemblies, the layshafts of which are supported at each end in ball races. The rear races are located in the rotor housing (*fig.* 22), and the forward races locate in four housings machined through the bearing housing. Each gear assembly is located axially by a sealing plug which bears against the forward race, the plugs being retained in the race housings by the flange of the bearing housing. Interposed between the sealing plug and the race of the gear assembly carrying the worm drive is a cut-away distance piece which provides clearance for the worm-wheel assembly of the oil pump drive.



1 SAFETY DISC ASSEMBLY
2 REAR SECOND STAGE ROTOR BEARING
3 OUTER DISTANCE SLEEVE
4 FRONT SECOND STAGE ROTOR BEARING
5 SECOND STAGE ROTOR GEAR
6 FIBRE BUSHED PIN DRIVE (Second stage gear assembly)
7 FIRST STAGE ROTOR GEAR
7A O-RINGS HOUSING
8 THRUST PLATE
9 THRUST SPRING
10 FINAL DRIVE GEAR BEARING
11 FINAL DRIVE SHAFT OIL SEAL
12 FINAL DRIVE SHAFT BEARING
13 DRIVE SHAFT SUPPORTING BEARING
14 FINAL DRIVE GEAR OIL SEAL
15 SEALING PLUG
16 FINAL DRIVE GEAR
17 FIBRE BUSHED PIN DRIVE (First stage gear assembly)
18 FIRST STAGE ROTOR SHAFT
19 INNER LABYRINTH SLEEVE

Fig. 22. Sectional perspective view showing drive end of starter

27. Each first stage gear assembly (*fig.* 21) is meshed to one of the second stage gear assemblies to give two similar pairs situated on opposite sides of the rotor gears. In describing the action of the reducing and combining train, only one pair will be considered, as the function of both pairs is identical.

28. The first stage gear assembly (*fig.* 21) comprises a layshaft gear, integral with the layshaft, and a double type flexible drive gear which fits over the layshaft. The flexible drive gear rotates with the layshaft, the drive being obtained from fibre bushed pins (17 *fig.* 22) set in the flange of the layshaft gear which locate in drillings in the flange of the spring gear. The gear assembly is driven by the first stage rotor gear which meshes with the layshaft gear. The upper gear of the flexible drive gear meshes with the final drive gear (16 *fig.* 22).

29. The second stage gear assembly (*fig.* 21) comprises a layshaft gear, integral with the layshaft, and a single type flexible drive gear which fits over the layshaft. In this case the flexible drive gear is the large member and is in mesh with the second stage rotor gear. The flexible drive gear drives the layshaft and layshaft gear through fibre bushed pins as described above; and the first and second stage gear assemblies are combined by meshing the layshaft gear of the second stage gear assembly with the lower gear of first stage flexible drive gear.

30. The purpose of the fibre flexible drives is to permit any one of the rotor driven gears to flex slightly under load until the loading on each gear is substantially equal. This minimizes side loading on the rotor bearings and ensures a balanced drive to the final drive gear.

31. As a result of combining the two rotor drives, the rotors rotate at equal speeds but in opposite directions. The overall reduction ratio from the rotors to the final drive shaft is 4·34 to 1.

32. The shaft of the final drive gear is carried in two ball bearings (10 *fig.* 22) located in the bearing housing. The drive gear meshes with the two end gears of the first stage gear assemblies and the end of the final gear shaft is splined into the inner housing of the clutch.

Clutch assembly

33. The final drive shaft and the outer housing of the clutch assembly (*fig.* 24) are splined externally and internally respectively to receive a set of alternating steel and friction plates. The outer circumference of the friction plates and the flange of the inner housing are toothed to fit into the outer housing, and the inner circumference of the steel plates are toothed to fit over the drive shaft.

34. The clutch plates and inner housing are retained in position between a locking ring (*fig.* 23) dowel locked to the ◄ aluminium bronze clutch backing plate (22, *fig.* 30, *Sect.* 2, *Chap.* 2), ► and an adjuster ring screwed against the inner

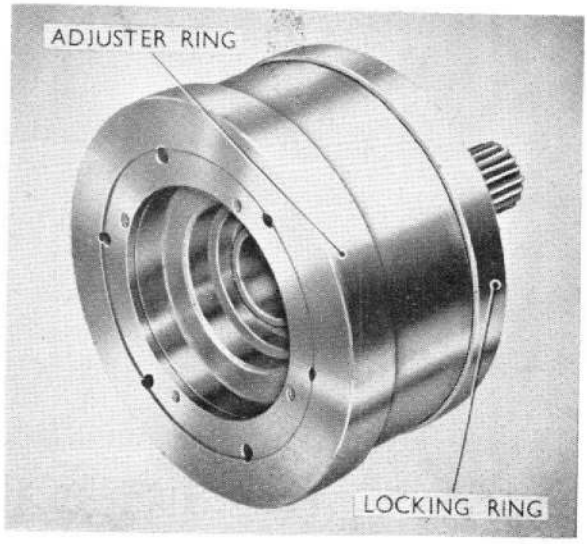


Fig. 23. Assembled clutch

housing, thereby compressing the rings of springs located in the housing flange. The adjuster ring is locked by four screws to the inner housing which is provided with a circle of screw holes to permit fine adjustment of the spring loading. The springs load the clutch plates to enable them to transmit the drive from the final drive gear to the final drive shaft, but permit the clutch to slip at a predetermined torque, thereby preventing possible damage to the engine and starter if the engine turning resistance becomes excessive. The clutch also absorbs the shock of the Bendix engagement mechanism within the engine.

35. The clutch assembly is supported at its forward end by a ball bearing and at its rear end by the shaft of the final drive gear (*fig.* 22). A further bearing shown in fig. 22 located between the inner housing and the final drive shaft, supports the shaft and also provides a bearing between these two components when the clutch slips, in addition to permitting relative axial movement during adjustment of the clutch.

Safety disc

36. Six safety disc assemblies (*fig.* 25) are located in radial housings machined in the nozzle body (1 *fig.* 22). Each assembly is retained by a safety disc holder; the spigot of the assembly passes through a drilling in the head of the holder, and the disc is firmly held between the end of the holder and a shoulder in the housing.

37. If gas pressure becomes excessive, which might occur with a partially blocked gas passage, the safety disc will shear. The assembly will then be displaced along the holder and the gases will pass through the ring of holes in the holder, through internal drillings in the nozzle and rotor housings (*fig.* 26) to the volute in the rotor housing from whence it will be exhausted to atmosphere. The projecting stem of the disc assembly will indicate which of the six discs has sheared.

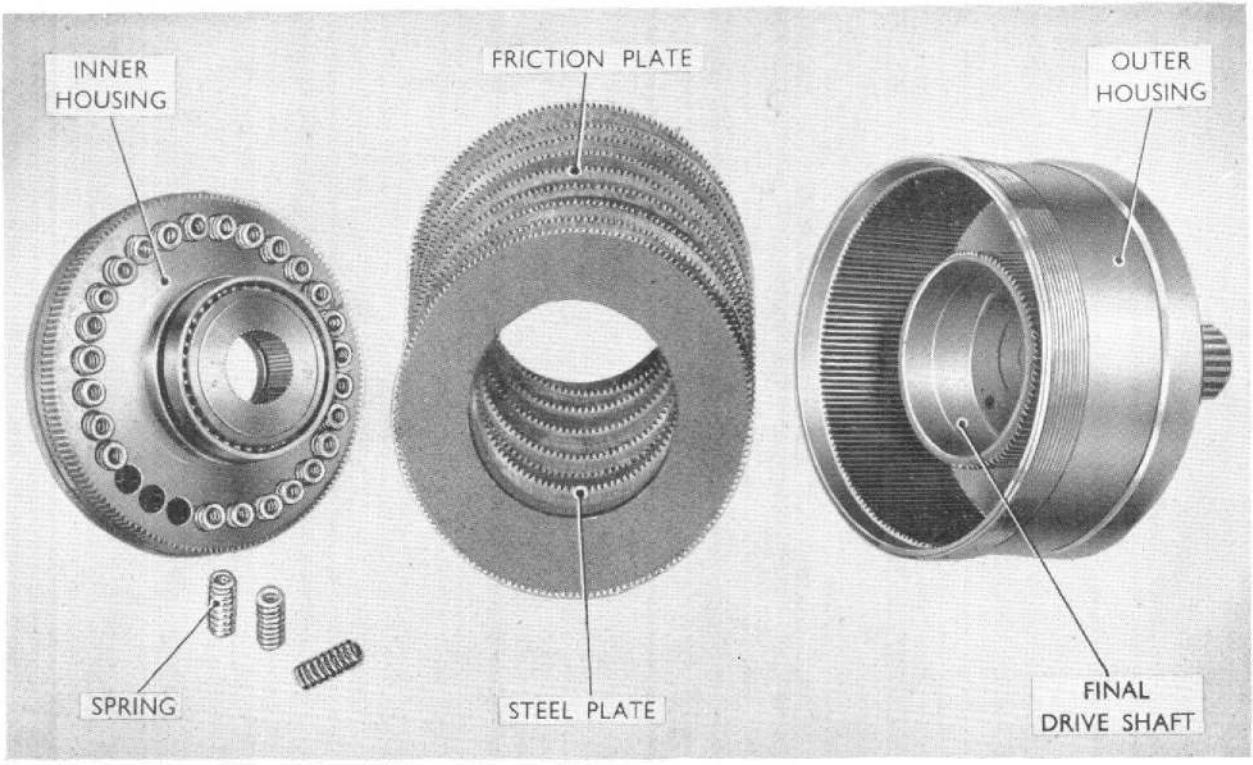


Fig. 24. Clutch assembly partially dismantled

Overspeed safety device

38. The purpose of the overspeed safety device is to limit the degree of overspeed which the starter would reach if operated against a light or zero load, which might arise through the fracture of a drive component or by clutch failure. The safety device also prevents a further start being made after such an overspeed has occurred. The mechanism comprises a brake (*fig.* 26) splined on to the end of the first stage rotor shaft, and a drum secured by screws to the nozzle plate.

39. ◄ Three brake shoes (*fig.* 27), hinged to the brake body by two pivot pins and one shear pin, are normally retained in the closed position by the upper and lower cam plates. The cam slots of these plates locate over slot pins, one in each shoe. The plates are locked against rotation by engagement with the overspeed shear pin each end of which is spigoted for location in a counter bore in each cam plate. ►

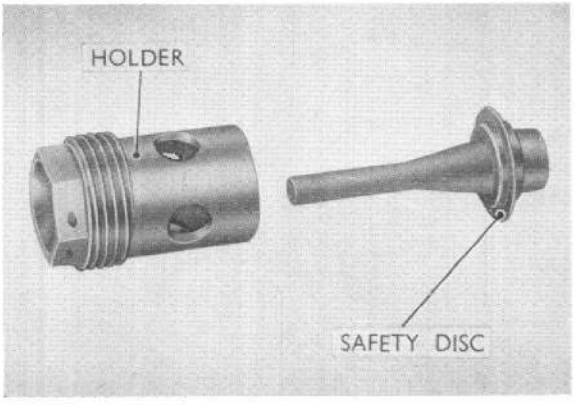


Fig. 25. Safety disc assembly

40. The cable assembly (3, *fig.* 17) of the overspeed fuse circuit has one end attached to a breeze plug in the motor cover and the other end located in the nozzle body oil plug. From the latter end, and protruding through the plug, are two contacts suitably insulated from each other which terminate within, but do not actually touch, one of the six cut-aways machined on the drum.

Operation of safety device

41. The set of the cam slots in the cam plates is such, that when the brake rotates with the rotor, the shoes, attempting to swing outwards under centrifugal force, tend to rotate the plates. This tendency is resisted by the shear pin until the speed becomes sufficiently great for the resultant forces on the plates to shear each end of the pin. This occurs at a predetermined speed in excess of the normal maximum operating speed. When this happens the shoes swing out and rub against the brake drum. The consequent friction retards the speed of the rotors and also abrades the drum locally. The products of this abrasion are forced into the cut-aways on the drum to establish electrical continuity between the two contacts of the overspeed cable assembly. The resultant short circuit blows a fuse in the engine control panel and renders the breech indexing motor inoperative.

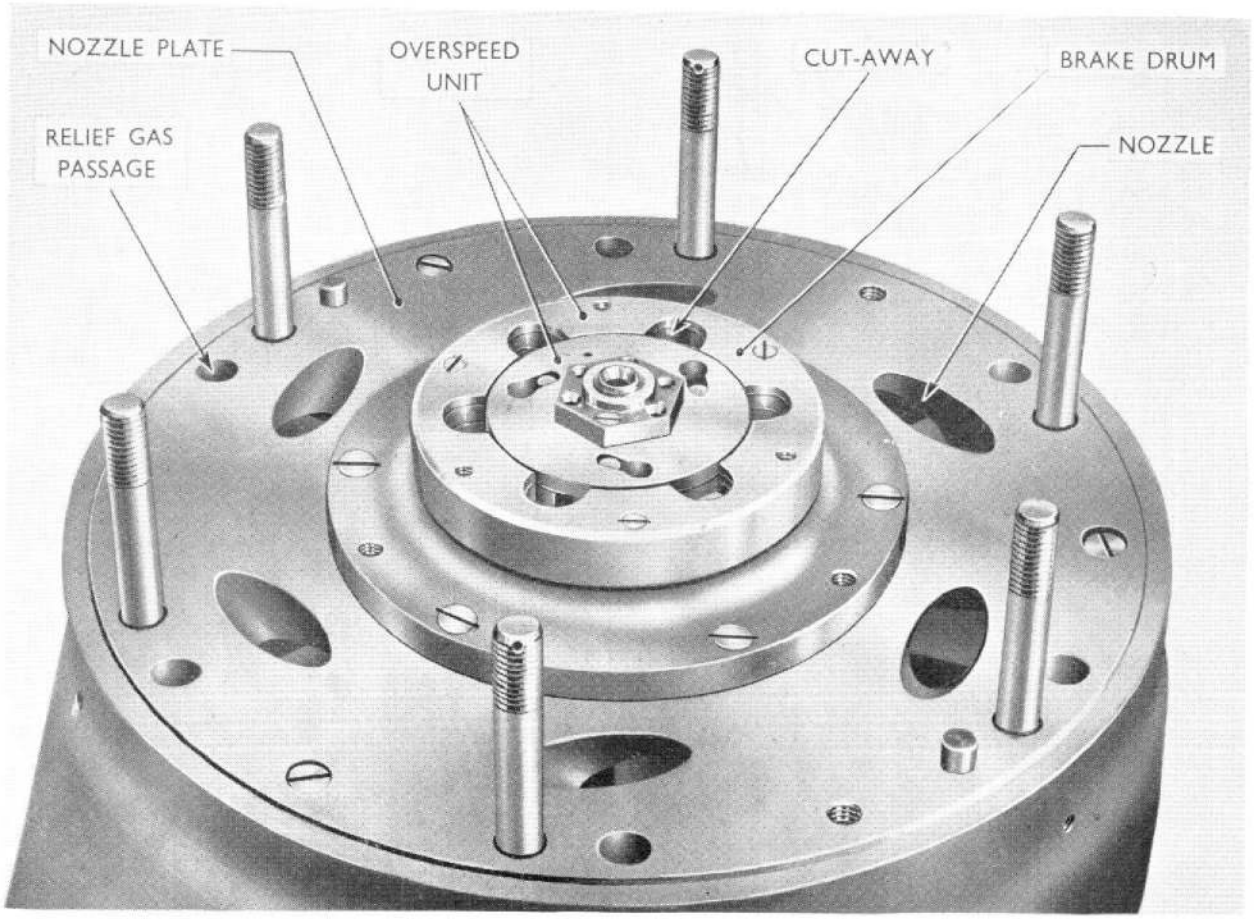


Fig. 26. Overspeed assembly unit

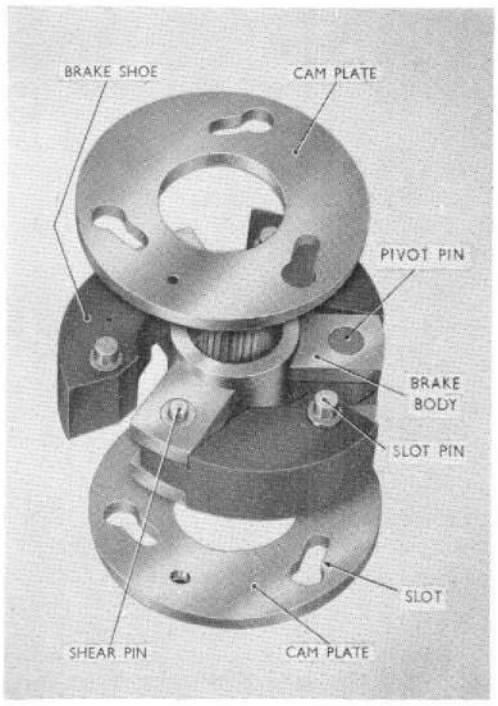


Fig. 27. Brake assembly

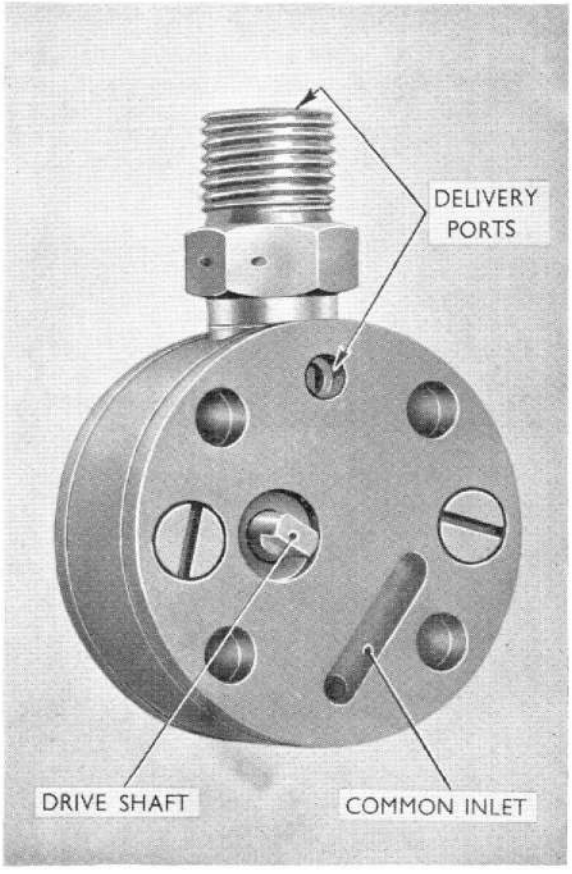


Fig. 28. Oil pump housing

Note . . .

Should the overspeed device operate, the starter must be removed from the aero-engine for dismantling, partial replacement of the complete overspeed unit and checking the clutch assembly.

Oil pump

42. The oil pump housing (*fig.* 28) is attached by four screws to the side of the bearing housing. The drive is taken from the end of one of the second stage rotor assemblies through a worm (6, *fig.* 21) and a worm-wheel assembly (*fig.* 29). The assembly is supported at one end by a plain tail shaft bearing (*removed in fig.* 29), and at the other end by a ball bearing. The end of the worm-wheel shaft is slotted to receive the tongued end of the pump shaft. The pump body houses two small spur gear pumps, one supplying oil to the combining and reducing trains, and the other supplying oil to the rotor bearings.

LUBRICATING SYSTEM

43. The pump draws oil from the sump of the engine through one of six holes in the starter mounting flange (9, *fig.* 30), and then through internal drillings in the clutch and intermediate bearing housings, to the common inlet side of the pumps (*fig.* 28). The six oil holes are connected by an annular duct in the mounting flange so that an oil passage is provided in whatever position the starter is mounted. The delivery side of the outer pump is taken through an external oil pipe to the nozzle body oil plug (4, *fig.* 17). From this point

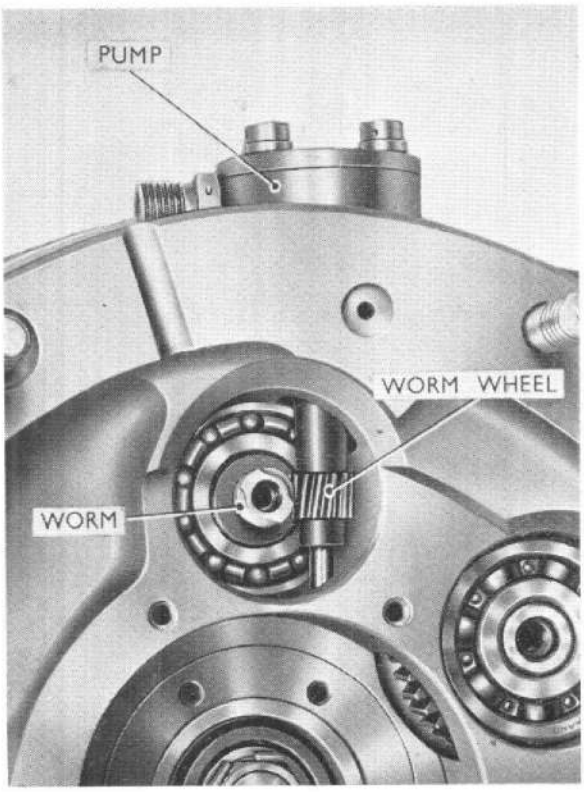


Fig. 29. Worm drive assembly for oil pump

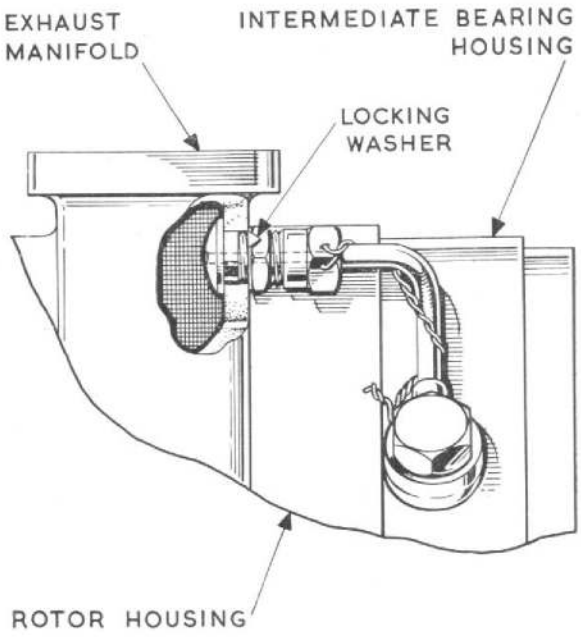


Fig. 29A. Oil drain pipe fitted to Mk. 4 starters

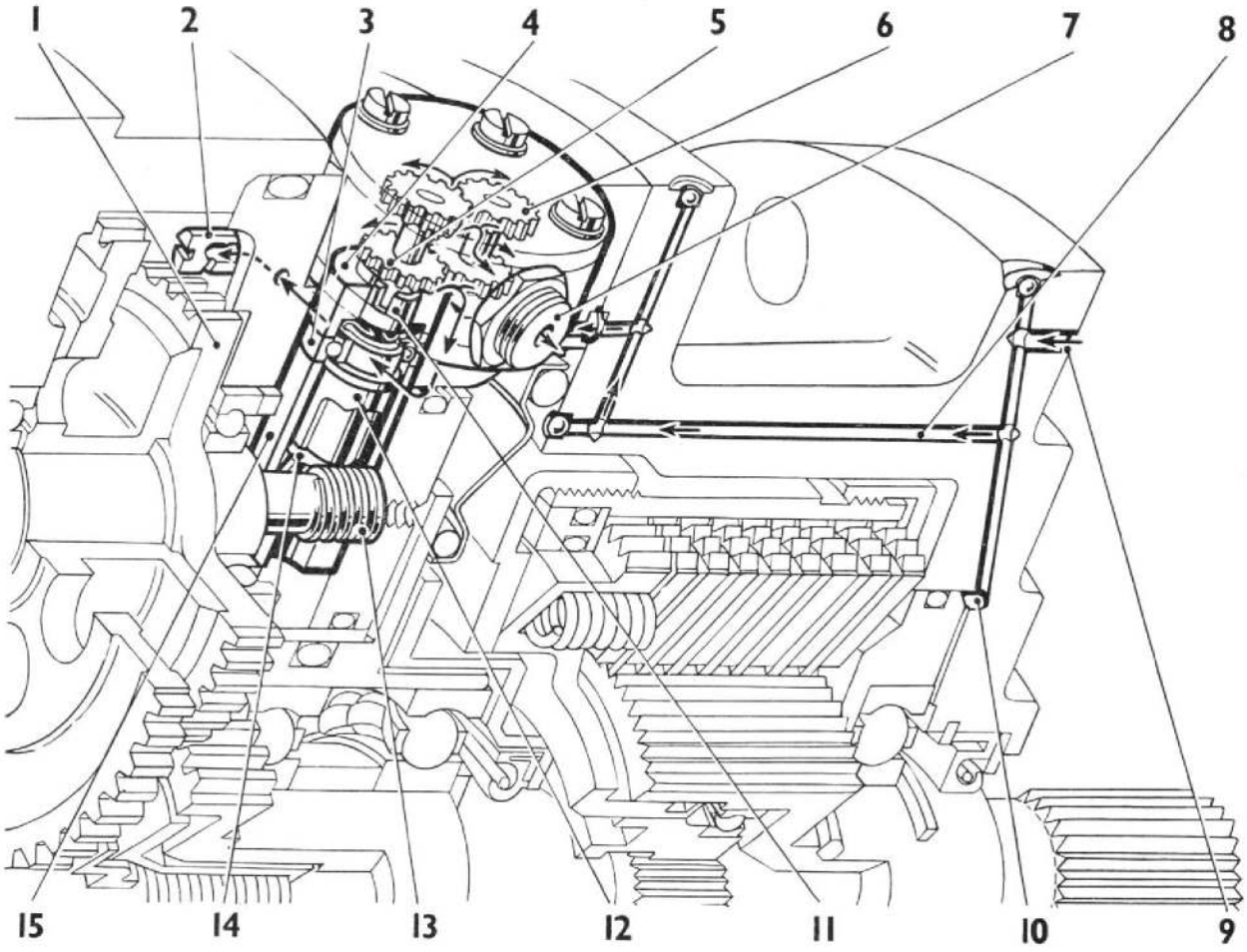
oil is injected into the central hole which is drilled throughout the length of the first stage rotor shaft. Radial drillings in the shaft permit oil from the shaft bore to enter the first and second stage rotor bearings, after which surplus oil drains into the gearbox chamber. The oil from the delivery side of the inner pump passes through two aligned holes in the pump and intermediate bearing housings, and along an internal drilling to an oil jet. This jet directs a small quantity of oil into the large gear of one of the second stage gear assemblies. The remainder of the reducing and combining gear train is splash lubricated from this point, the surplus oil collecting in the bearing chamber.

44. In the Mk. 3 starters the excess oil from the bearing chambers is drained to atmosphere or to collector box, depending on the type of installation, through one of three drain holes (*fig.* 1) in the bearing housing. The relevant drain hole will be that in the lowest position in any particular installation, the other two holes being plugged.

45. In the case of the Mk. 4 starter, a short pipe is provided to take the drain oil direct from the intermediate bearing housing to the exhaust gas outlet, thereby avoiding the use of a long pipe from the starter to atmosphere or to the collector box as with the Mk. 3 starter. This modified arrangement is illustrated in fig. 29A.

46. Those parts of the starter not directly lubricated as described above are, where necessary, packed with a suitable lubricant during assembly.

47. The clutch is protected against the ingress of oil by two main seals in a retaining plate (*fig.* 22) which exclude oil from the clutch chamber, and circular joint rings and gaskets prevent entry of oil into the clutch assembly in the event of failure of either main oil seal.



1 SECOND STAGE GEAR ASSEMBLY
2 OIL JET PIPE
3 DRIVE SHAFT BEARING
4 SPIGOT
5 SPIN GEAR TYPE PUMP (Inner)
6 SPIN GEAR TYPE PUMP (Outer)
7 OIL OUTLET TO ROTOR BEARING
8 OIL PASSAGE
9 OIL INLET PORT
10 ANNULAR GROOVE
11 SLOTTED DRIVE SHAFT END
12 PUMP DRIVE SHAFT
13 WORM GEAR
14 WORM WHEEL
15 TAIL SHAFT BEARING

Fig. 30. Sectional view of oil pump assembly

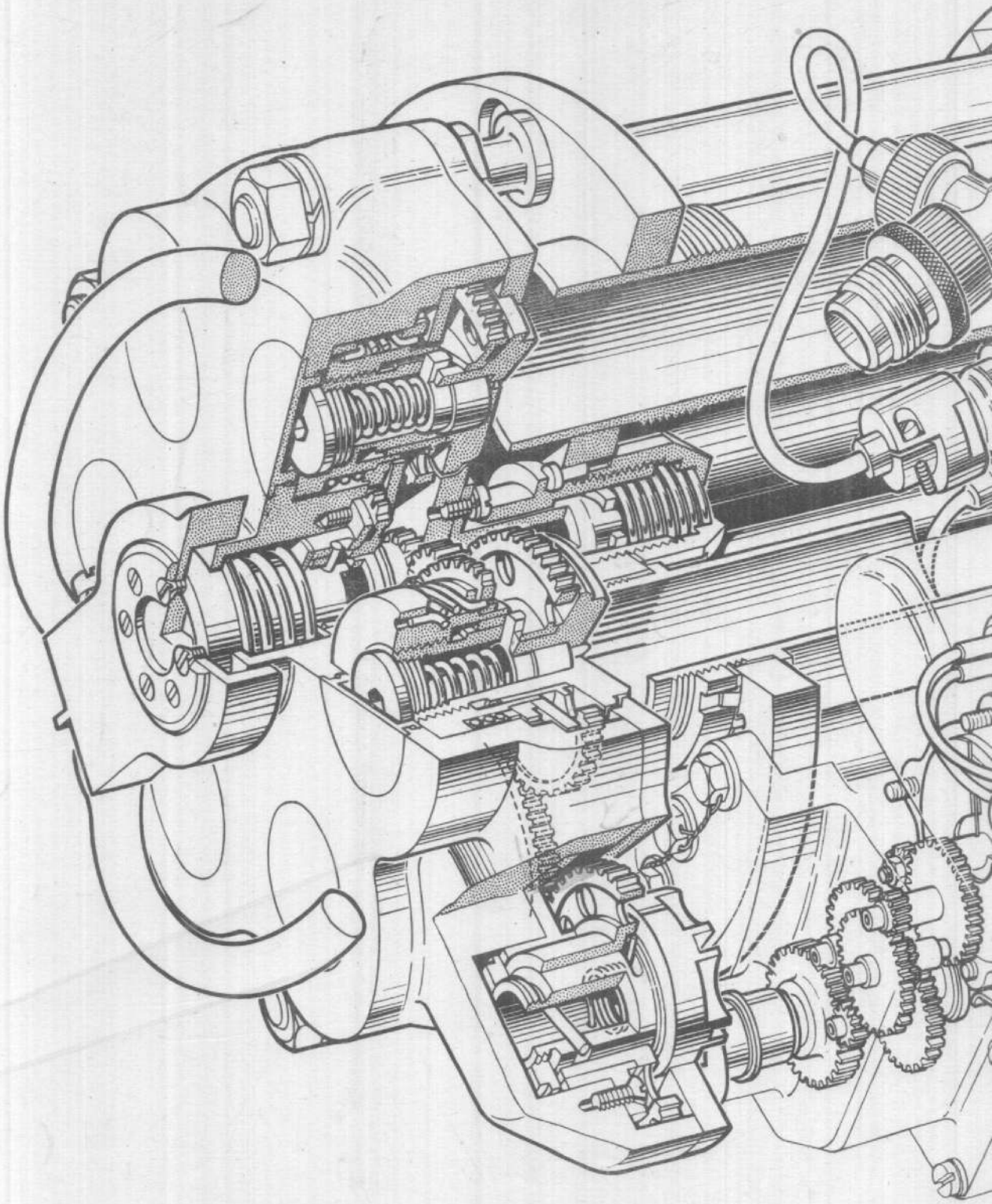


FIG. 31 SECTIONAL PERSPECTIVE VIE

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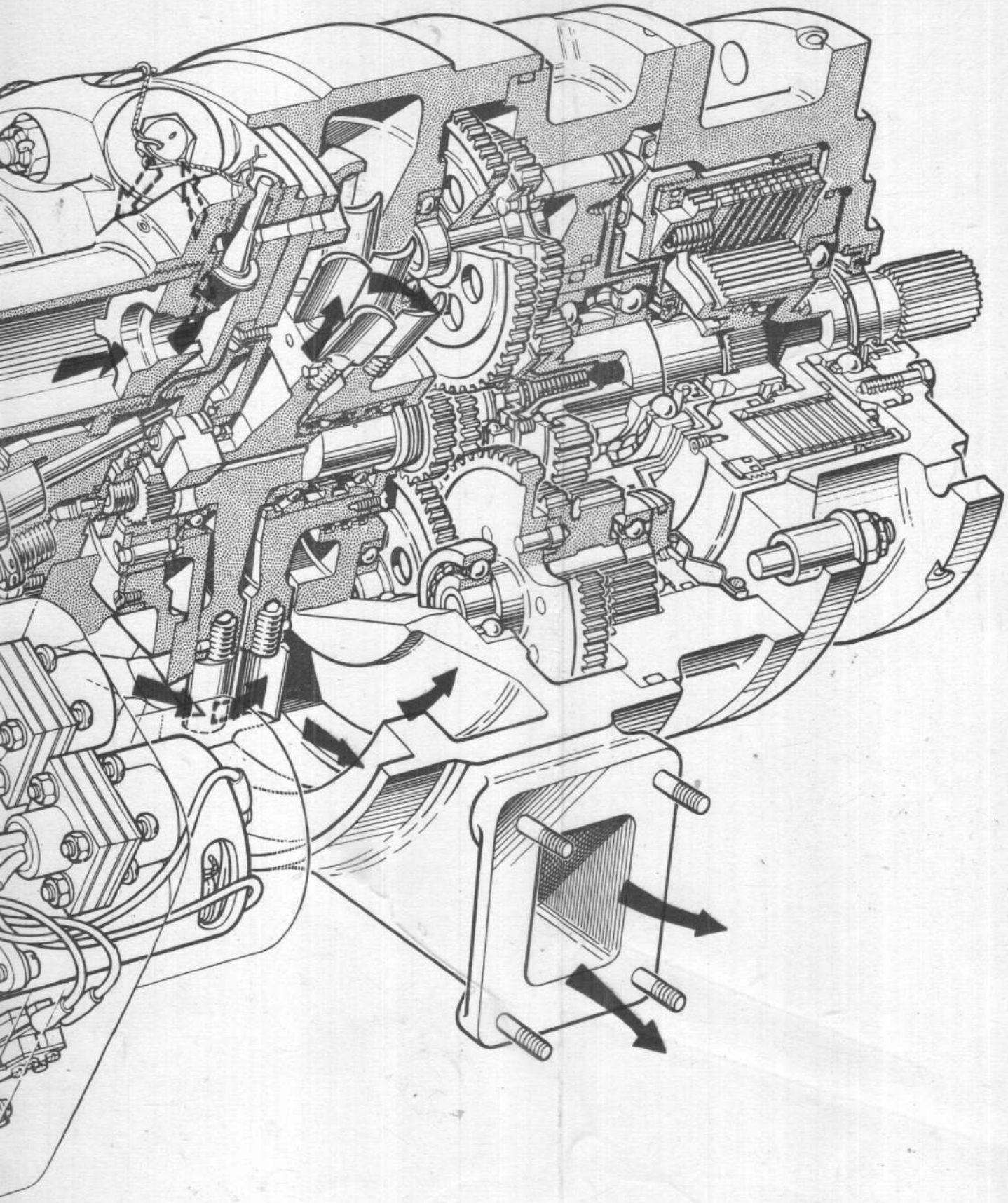

F PLESSEY TURBO-STARTER. TYPE T.S.C. 50 MK. 3

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