Chapter 1

STARTER MOTORS

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Introduction

1. Starter motors may vary considerably in design, but there are certain aspects of servicing which are common to all, or to most types, although some operation may be peculiar to certain individual types of machine. Only information in the former class is dealt with in this chapter; instructions which concern individual starters will be found in the relevant chapter of A.P.4343D, Vol. 1, Book 1.

2. It is essential that starters should be kept clean throughout their working life. Immediately it is observed, any defect, no matter how trivial, must be investigated and remedied.

STORAGE

3. Store in a clean, dry situation, as far as possible from any acid. Corrosive fumes are harmful, particularly to the electric motor. Any covers provided for the protection of splined shafts etc. or to prevent the ingress of dirt or foreign matter, are to be kept in position and must only be removed for testing or immediately prior to installation. It is important that starter motors are kept as dry as possible during storage as in some instances it may be necessary to detach the motor from the starter assembly before it can be dried.

SERVICING

Lubrication

4. Bearings are, as a rule, packed with grease during manufacture, and further attention is only to be given as laid down in the relevant Servicing Schedule. When packing bearings with lubricant, use only clean grease of the correct grade. Do not pack the bearings too full or excess grease will exude and cause electrical failure.

Brush gear

5. Before removing the brushes from their holders, always mark them to facilitate their return to the correct positions. The brushes should move freely in the boxes and bear evenly on the surface of the commutator. If the brushes are sticking, they must be wiped clean with a fluff free cloth moistened with gasoline, but if persistent, the sticking may be cured by rubbing down with fine glasspaper. To avoid failure during operational periods, new brushes must be fitted before the old ones have worn to their minimum permissible length. The connections and the pigtails are to be checked for looseness and fraying, and correct spring pressure must be maintained. Do not fit brushes until it has been ascertained that they are of the correct grade and type.

Bedding down brushes

6. If new brushes are received with contact faces not shaped to fit the commutator, they should be subjected to the bedding procedure described in A.P.4343, Vol. 1, Sect. 1, Chap. 2. To complete bedding, or when preformed brushes are fitted, the motor should be run until the brushes are bedded down evenly over their whole contact arc, and over at least 80 per cent of their contact area.

Commutator

7. Cleanliness is imperative; grease should be removed by wiping the commutator with a cloth moistened with gasoline. If the commutator is uniformly blackened by sparking it may be cleaned with glasspaper, grade 00, and finally polished with crocus paper, grade 000.

8. After removing the brushes, fold the glasspaper over a flat-ended piece of wood, and press it lightly on the commutator, whilst rotating the armature by hand. The width of the wood and of the glasspaper should be less than that of the commutator, and the glasspaper must be moved from side to side of the commutator in order to obtain an even action. The method of using the crocus paper is the same as that for the glasspaper.

9. Do not attempt to remove more than a surface film of discoloration by this method. If the blackening is localized it is probable that the armature windings are defective, and a test should be made with an armature drop tester.

◀ **10.** If the commutator is pitted, or if flats have developed, it must be skimmed; this may be done using a commutator resurfacing machine, if available, as instructed in A.P.4343S, Vol. 1, Book 2, Sect. 13; alternatively, it must be returned for repair. ▶

General

11. Dirt and dust are frequent causes of electrical failure. Take every opportunity to remove carbon or copper dust, using bellows or a blower, particularly after adjustment of the brushes.

Faults

12. If the starter fails to function, check the terminal voltage; the fault may be in the motor or its associated wiring. If a voltage, but no current reading can be obtained, the motor is probably faulty. Examine all connections, including those to the brushes and field coils, and see that the brushes are bedded down correctly.

13. If a heavy current flows, but the motor fails to function, a short-circuit may be suspected within the motor; alternatively, the automatic brake, if fitted, may be sticking. ⋈

Note . . .

Series motors should not be run without load at more than half their rated voltage.

◀ **Insulation resistance**

14. The insulation resistance, when measured with the appropriate insulation resistance tester, should be not less than 0·05 megohm between all live parts and the frame. If the reading is below this value, it may be improved by heating the machine in a drying oven, at a temperature not exceeding 100 deg. C. ▶

Chapter 2

STARTER MOTOR, ROTAX, TYPE C0200 SERIES

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LIST OF ILLUSTRATIONS

Introduction

1. The direct cranking combined hand and electric starters described in this series are designed to meet the starting requirements of engines of up to 350 h.p. They can be electrically operated from a ground starter trolley or from the aircraft general service battery; alternatively, they can be turned by hand. Information on the individual starter motors in the series is given in A.P.4343D, Vol. 1, Book 1, Sect. 1.

DESCRIPTION

2. Each starter consists of four main assemblies (*fig.* 1), the front housing, the rear housing or gearbox, the motor housing, and the hand crank housing. The electric motor is mounted at right-angles to the main gearbox and speed reduction is effected through a series of epicyclic gears with a ratio of 122 : 1. Power is transmitted to the starter jaws through a multi-plate clutch.

3. If the aircraft electrical system is unserviceable, or if the engine is being serviced, the engine may be cranked by using the hand turning device. When hand turning, only a part of the main reduction gearing is used, giving a gear ratio of 18 : 1 between the hand crank and the starter jaw.

Front housing

4. The front housing contains the clutch, oil seal, and engaging mechanism. It has an integral mounting flange through which pass the six long hex./hd. bolts securing the front housing to the rear housing.

5. A multi-plate clutch is built on a central splined nut, the whole assembly being housed in the bore of the clutch barrel. It is held by a clip located in a slot round the inside of the barrel.

6. The clutch (*fig.* 2) consists of a clutch spacer and alternate steel and phosphor-bronze clutch plates, commencing with one of steel. Following these are a clutch spring spacer, spring locating studs, six helical springs, a spring bearing ring, and a clutch adjusting nut.

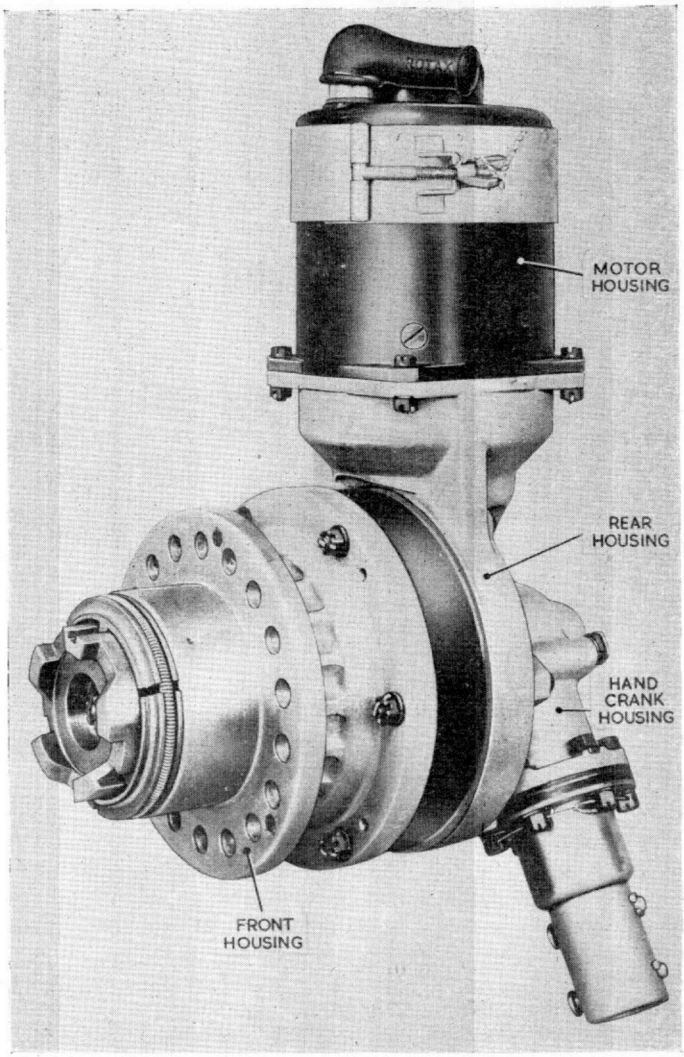


Fig. 1. Starter motor, Rotax, Type C0212

7. Under normal load conditions the clutch serves as a positive driving medium between the gears in the rear housing and the starter jaw mechanism.

8. The driving sequence is as follows. The internally splined clutch barrel is rotated by three planetary pinions mounted on its rear face. The barrel engages with similarly splined phosphor-bronze clutch plates which in turn drive the steel plates.

9. The plates mesh with and rotate the splined nut which actuates a quick thread screw shaft. The starter jaw is turned by the shaft to which it is attached by a meshing rod and nut.

10. In order to prevent axial shock being transmitted to the clutch assembly, the starter jaw is spring-loaded on the meshing rod.

11. A baffle plate, enclosing the forward part of the housing, is attached to the mounting flange. The starter jaw projects through the front part of the plate. In the baffle plate and encircling the jaw is a dual purpose friction and oil sealing ring.

Motor housing

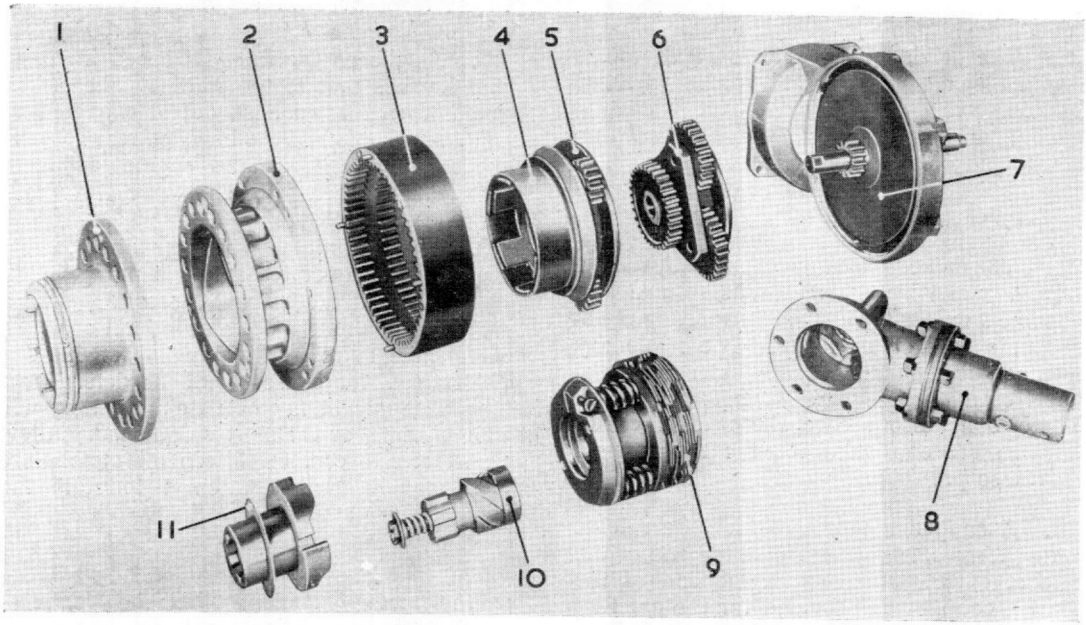
12. The four-pole, wave-wound, series motor is contained in a housing which is secured to the rear housing by four screws and castellated nuts. The yoke is a push fit in the motor housing and is held by four csk./hd. screws. These screws also secure the four pole-shoes.

13. At the commutator end, the armature shaft bearing is housed in the motor casing. A felt washer and ring prevents grease from the bearing travelling to the commutator. The bearing is secured to the shaft by a slotted ring nut and split pin. The driving end bearing is located in the top of the rear housing.

14. Each of the four brushes is electrically connected to the one diametrically opposite. The boxes are mounted on a brush ring forming a sub-assembly which is screwed to, but insulated from, the motor housing by an insulating ring and bushes. Access to the brushes is obtained by the removal of a cover band which is secured by a wing nut.

15. Brush spring pressure is not adjustable. It is maintained by a coil spring compressed between the brush at one end and the brush spring rest at the other.

16. One pair of brushes is connected to a terminal lug on the brush ring and to one end of the field coil. The remaining pair is connected to a terminal post extended through a bush in the end of the motor casing. The



1 CLUTCH COVER
2 FRONT HOUSING
3 ANNULAR GEAR
4 CLUTCH BARREL
5 SECOND STAGE PLANETARY PINIONS
6 FIRST PLANET CARRIER
7 CROWN GEAR WHEEL
8 HAND CRANK HOUSING
9 CLUTCH PLATES
10 QUICK-THREAD SCREW SHAFT
11 STARTER JAW

Fig. 2. Exploded view of front and rear housings

extension forms a terminal for the external cable connections. The remaining field coil is brought out to a similar post. Each post is fitted with washers and a bush to insulate it from the motor housing.

Rear housing

17. The driving end of the armature shaft (*para.* 13) rotates in a bearing located in the upper part of the rear housing. Protruding through the bearing is the driving pinion which is bolted and keyed to the shaft. This pinion engages with a large crown wheel supported by a shaft in a double ball bearing.

18. On the forward side of the crown gear wheel, and integral with it, is the first sun gear of the epicyclic train. It engages with the three planetary pinions located by studs on the first planet carrier, integral with which is the second sun gear.

19. The first planet carrier runs in a plain bearing. It is mounted on the main shaft which runs through the hollow centre of the crown wheel shaft. The main shaft is housed in the clutch barrel at its forward end and is supported in a ball bearing in the hand crank housing at its rear end.

20. The second sun gear drives the last stage of gearing, comprising three planetary pinions rotating on studs mounted in the end of the clutch barrel. When the planetary system turns, the pinions mesh with the teeth on the annular gear which is supported between the front and rear housing.

Hand crank housing

21. The hand crank housing is secured to the rear housing by five bolts. To enable the mounting of the hand crank housing to be varied to suit different installations, twelve bolt holes are provided in the rear housing. A spacer plate is located between the two housings; it is secured by the five bolts which clamp the crown gear double ball race in position.

22. A driven bevel gear, keyed to the end of the crown gear shaft, is retained by a nut that also secures the crown gear in its bearing.

23. The driving bevel gear is keyed to the end of the crown gear shaft where it is secured by a large ch./hd. screw. Access to the screw is obtained by the removal of a screwed plug in the end of the hand crank housing. The shaft is supported by two ball bearings separated by a spacing collar.

24. The end of the hand crank shaft, remote from the driving bevel gear, is splined and engages with the spring-loaded rotating member of a ratchet assembly. The stationary member of the assembly is fastened to the hand crank housing by six nuts and bolts. These bolts also secure the ratchet cover, through the end of which the hand crank shaft also protrudes.

25. A cupped spacer, in which the ratchet spring locates, is housed inside the end of the ratchet cover. At the extreme end of the shaft a coupling is provided for the external cranking handle or hand crank shafting.

OPERATION

External supply

26. Do not use the aircraft battery to operate the starter more than is necessary. Whenever possible, power should be taken from a heavy duty ground starter battery, using the external supply socket with the ground/flight switch in the GROUND position.

General

27. A solenoid switch in the cockpit energizes a relay which completes the motor circuit. When the motor is energized, the clutch barrel is rotated via the driving pinion, crown gear and two stage epicyclic train. The clutch barrel causes the splined nut assembly to rotate through the medium of the multiplate clutch.

28. The oil-seal friction ring which encircles the jaw, prevents it and the screw shaft from turning. As the shaft is in engagement with the rotating splined nut, and the former is prevented from moving, the nut causes the screw shaft and jaw to move into engagement with the engine jaw. When the shaft reaches the end of its travel and further forward movement is not possible, the friction of the oil seal and jaw is overcome and the starter motor turns over the engine.

29. As the engine fires, its speed increases and exceeds that of the starter. The starter jaw is then thrown back out of engagement, due to the action of the bevelled rear faces of the starter jaw teeth and engine jaw teeth upon one another.

30. The optimum working time of the clutch, when operated under slipping conditions, is from three to five seconds, with a rest of one minute between operations. If, after three to four attempts, the engine has not started, the cause should be determined. This is important as otherwise the battery will be run down or the starter damaged. Allow the starter to cool for fifteen minutes before making any further attempt to start the engine.

WARNING

The starter button must NOT be pressed when the engine is being turned by hand or serious injury to the operator may result.

SERVICING

31. Information on the care and servicing of starter motors will be found in Chapter 1 of this Section to which reference should, if necessary, be made.

Bearings

32. The bearings are packed with grease during manufacture and will, under normal circumstances, require re-packing only during major servicing.

Brushes

33. Remove the cover band and check the length of the brushes. The portion of brush remaining should be not less than $\frac{3}{8}$ in. It is advisable to renew the brush before this length is reached in order to avoid failure during operational periods. Check the security of the brush pigtails and of the field connections to the brush holders.

34. Before completing the inspection, see that the cables leading to the starter are free from oil or abrasion, and check all locking devices.

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