

**Chapter 16****STARTER MOTORS, ROTAX, C4600 SERIES****LIST OF CONTENTS**

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**Introduction**

1. Starter motors in the C4600 series are dual purpose units designed for starting engines by direct cranking and for driving hydromatic propeller feathering pumps. Differences between individual types will be found in Appendices to this chapter.

2. The motor, when operating in a clockwise direction, transmits torque through a 124:1 reduction gearing and a multi-plate clutch to operate the engaging mechanism of the jaw and so turn the engine. When running anti-clockwise, the jaw is withdrawn fully

and the feathering pump drive shaft is driven through reduction gearing of 3.35:1 and an overrunning assembly. To maintain constant speed on the pump drive, a shunt winding is incorporated in the field assembly. Reversal of rotation is achieved by changing the polarity of the armature, as distinct from the normal method in reversible aircraft electric motors, of reversing the polarity of the field.

**DESCRIPTION**

3. Each starter comprises three main assemblies (*fig. 1*), the front housing, the rear

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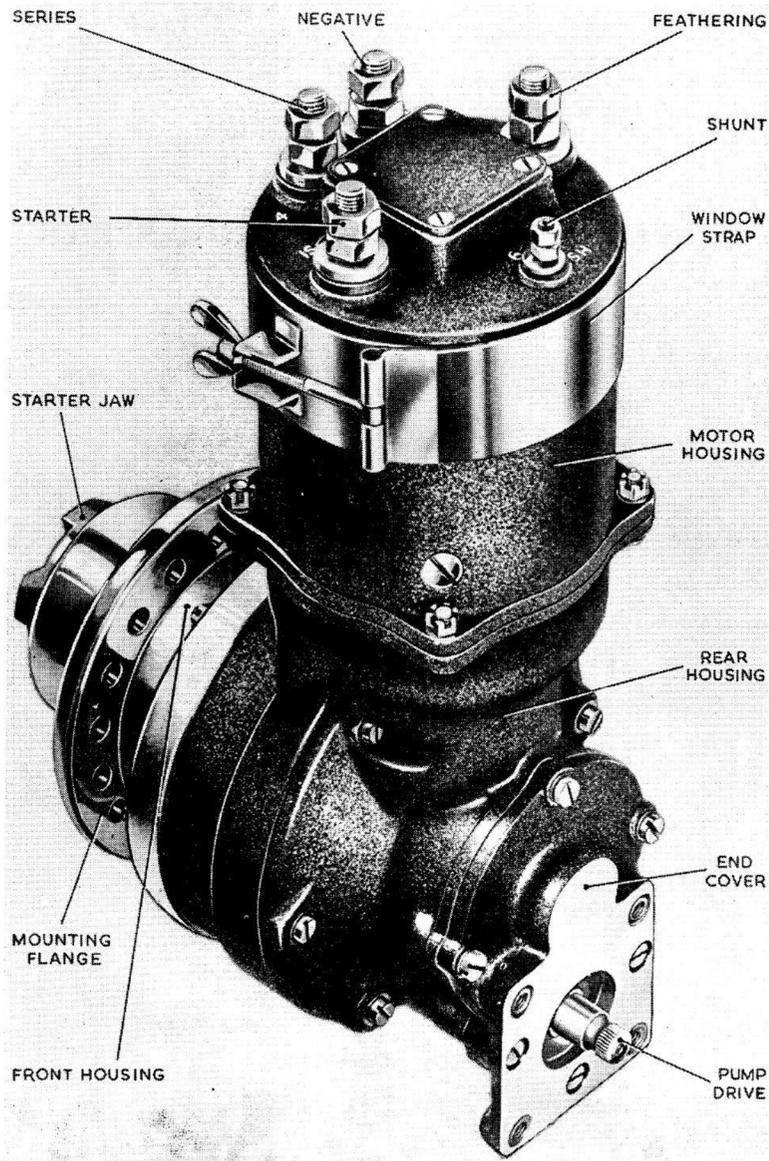


Fig. 1. Typical C4600 series starter motor

housing and the motor housing, which is mounted at 90 deg. to the front housing. All the housings are of an aluminium alloy.

#### Front housing assembly

4. The front housing (*fig. 2*) which contains the clutch, oil seal, and engaging mechanism, has an integral mounting flange. Through this housing pass the six long, round-head bolts securing the front housing to the rear housing.

5. A multi-plate clutch, built on a central splined nut, is employed, the whole assembly being housed in the bore of the clutch barrel, where it is secured by a clip or snap ring, which locates in a slot around the inside of the barrel.

6. Referring to *fig. 2*, it will be seen that the clutch consists of the following components. Firstly, a clutch spacer or backing washer, alternate steel and phosphor-bronze clutch plates (commencing and finishing with one

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of phosphor-bronze), a clutch spring spacer, spring locating studs, ten helical springs, a spring bearing ring, and, lastly, a clutch adjusting nut.

7. The clutch serves as a positive driving medium, under all normal load conditions, between the gears in the rear housing and the starter jaw mechanism. The driving sequence is as follows. The internally-splined clutch barrel is rotated by six planetary pinions mounted on its rear face. The barrel engages with similarly splined phosphor-bronze clutch plates. These in turn drive the steel plates.

8. The steel plates mesh with, and rotate the splined nut. This nut actuates a quick-thread screw shaft (*fig. 2*), the starter jaw being turned by the screw shaft to which it is attached by a meshing rod and nut.

9. The starter jaw is spring-loaded on the meshing rod to prevent any axial shock being transmitted to the clutch assembly.

10. Attached to the mounting flange, and enclosing the forward part of the housing is, a baffle plate, through the front of which projects the starter jaw. Assembled in the baffle plate, and encircling the jaw, is a dual-purpose friction and oil-seal ring.

#### Motor housing assembly

11. The motor is a 4-pole, compound-wound, short-shunt machine, the armature being wave-wound. It is contained in a housing which is secured to the rear housing by four screws and slotted nuts (*fig. 2*). The yoke is a push fit in the motor housing, and is held in position by four csk/hd. screws. The four pole pieces are each secured by two csk/hd. screws.

12. Two ball bearings carry the armature shaft. At the commutator end, the bearing is housed in the motor casing, a felt washer preventing the grease from the bearing travelling to the commutator. A slotted ring nut and split pin secure the bearing to the armature shaft. At the driving end, the bearing is located in the top of the rear housing.

13. Each of the four brushes is electrically connected to the one diametrically opposite. The boxes are mounted on a brush block (*fig. 2*), which is screwed to the motor housing. Access to the brushes is gained by the removal of a cover band or window strap, secured by a wing nut.

14. Brush spring pressure, which is not adjustable, is maintained by a coil spring compressed between the brush, at one end, and the brush spring rest at the opposite end.

15. Each diametrically-opposite pair of brushes is connected to a terminal post. The two terminal posts extend through bushes in the end of the motor casing to form terminals for external cable connections. These terminal posts correspond with the IS and IF markings on the end of the motor casing. The remaining three terminal posts 4,—and 6 are connected to the shunt and series field coils, as shown in *fig. 3*.

#### Rear housing assembly

16. As mentioned in para. 12, the driving end of the armature shaft is supported by a ball bearing in the upper part of the rear housing. Protruding through the bearing is the driving pinion (*fig. 2*), which is secured by a long screw and keyed to the shaft. This pinion engages with a large crown wheel supported by an integral shaft in a double ball bearing.

17. On the forward side of the crown gear wheel, and integral with it, is the first sun gear of the epicyclic train. This gear engages with three planetary pinions, which are located by screws, on the first planet carrier, integral with which is the second sun gear. The first planet carrier runs on a plain bearing on the extended boss of the crown wheel. The rear part of the boss is extended and is supported by a ball bearing in the rear end cover of the rear housing.

18. The second sun gear drives the last stage of gearing, comprising six planetary pinions, which rotate on screws mounted in the end of the clutch barrel assembly. When the planetary system turns, the pinions mesh with the teeth of the annular gear, which is spigoted between the front and rear housings.

19. Keyed to the rear end of the crownwheel shaft is the stationary part of the free-wheel device; the movable part includes a gear wheel, that meshes with the toothed wheel of the pump drive shaft which is carried in plain bearings. The free-wheel device turns freely in one direction, but in the other direction the wedging action of three spring-loaded rollers produces a positive drive of the pump shaft.

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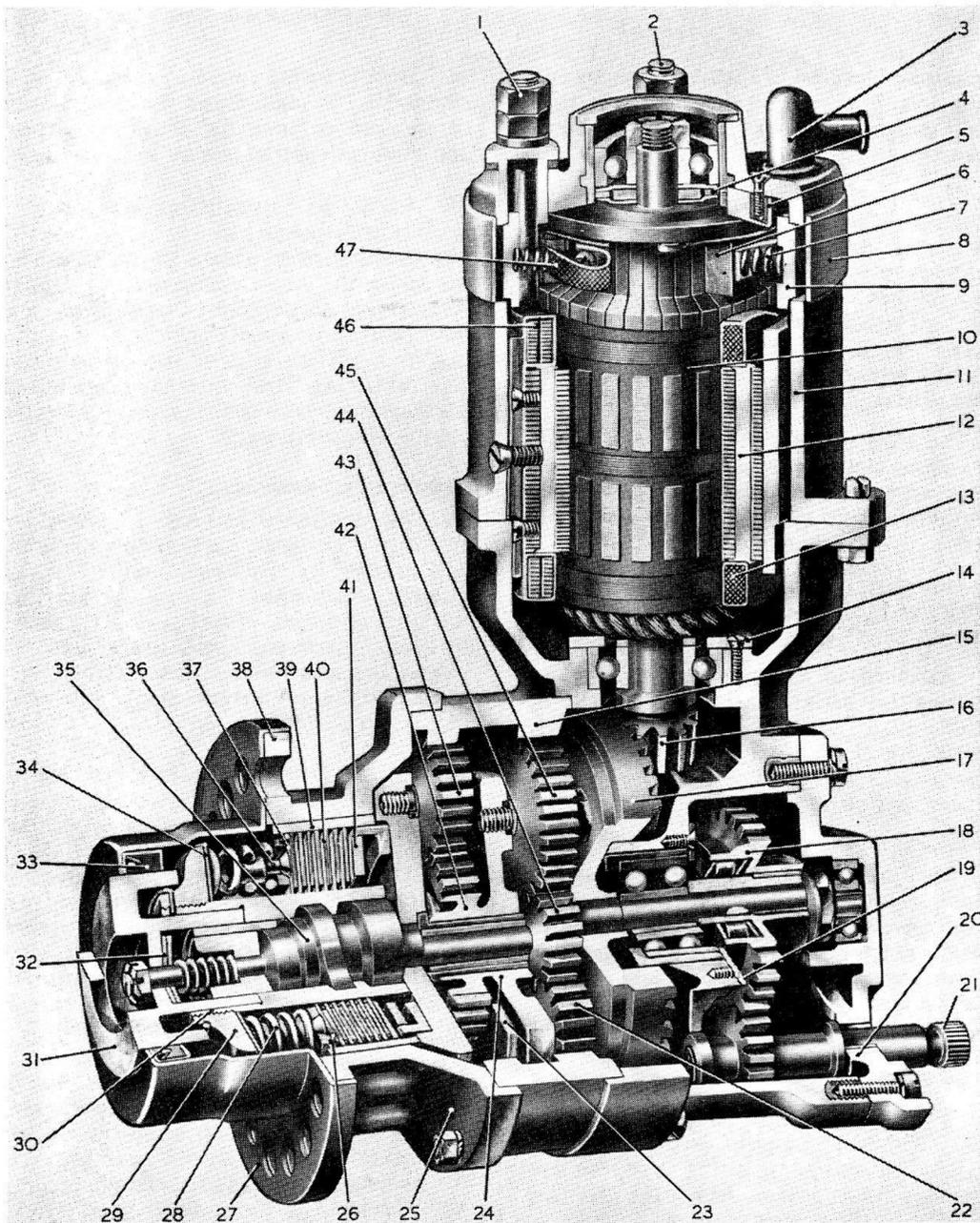


Fig. 2. Sectional view of starter motor

### INSTALLATION

20. Before a starter is mounted on an engine, ensure that the engine jaw corresponds with the starter jaw. There should not be less than  $\frac{3}{32}$  in. clearance between the engine jaw and the starter jaw when the latter is fully retracted. Fig. 3 shows the wiring diagram. Care should be taken to ensure that the leads

are connected to their correct terminals. For example, if the IF and IS leads are interchanged, feathering of the propeller would occur when the starter push-switch was operated.

### OPERATION

21. Whenever possible the power should be taken from a heavy-duty ground starter

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KEY TO FIG. 2

- |    |                       |    |                                 |
|----|-----------------------|----|---------------------------------|
| 1  | SERIES FIELD TERMINAL | 25 | FRONT HOUSING                   |
| 2  | BRUSH GEAR TERMINAL   | 26 | BARREL SNAP RING                |
| 3  | SHUNT FIELD TERMINAL  | 27 | BAFFLE PLATE                    |
| 4  | FELT WASHER           | 28 | CLUTCH SPRING                   |
| 5  | BRUSH BLOCK           | 29 | CLUTCH ADJUSTING NUT            |
| 6  | BRUSH ASSEMBLY        | 30 | SPLINED NUT                     |
| 7  | BRUSH SPRING          | 31 | STARTER JAW                     |
| 8  | WINDOW STRAP          | 32 | OIL SEAL WASHER                 |
| 9  | BRUSH SPRING REST     | 33 | OIL SEAL                        |
| 10 | ARMATURE              | 34 | SPRING BEARING RING             |
| 11 | MOTOR HOUSING         | 35 | QUICK-THREAD SCREW SHAFT        |
| 12 | POLE PIECES           | 36 | SPRING LOCATING STUDS           |
| 13 | SHUNT FIELD COILS     | 37 | CLUTCH SPRING SPACER            |
| 14 | BEARING RETAINER      | 38 | MOUNTING FLANGE                 |
| 15 | ANNULAR GEAR          | 39 | CLUTCH BARREL                   |
| 16 | BEVEL DRIVING PINION  | 40 | CLUTCH PLATES                   |
| 17 | CROWN WHEEL           | 41 | CLUTCH SPACER OR BACKING WASHER |
| 18 | FREE-WHEEL ASSEMBLY   | 42 | SECOND SUN GEAR                 |
| 19 | BEARING RETAINER      | 43 | SIX PLANET PINIONS              |
| 20 | END COVER             | 44 | FIRST SUN GEAR                  |
| 21 | PUMP DRIVE SHAFT      | 45 | PLANET PINION                   |
| 22 | PLANET PINION         | 46 | SERIES FIELD COILS              |
| 23 | PLANETARY RING        | 47 | BRUSH CONNECTION                |
| 24 | FIRST PLANET CARRIER  |    |                                 |

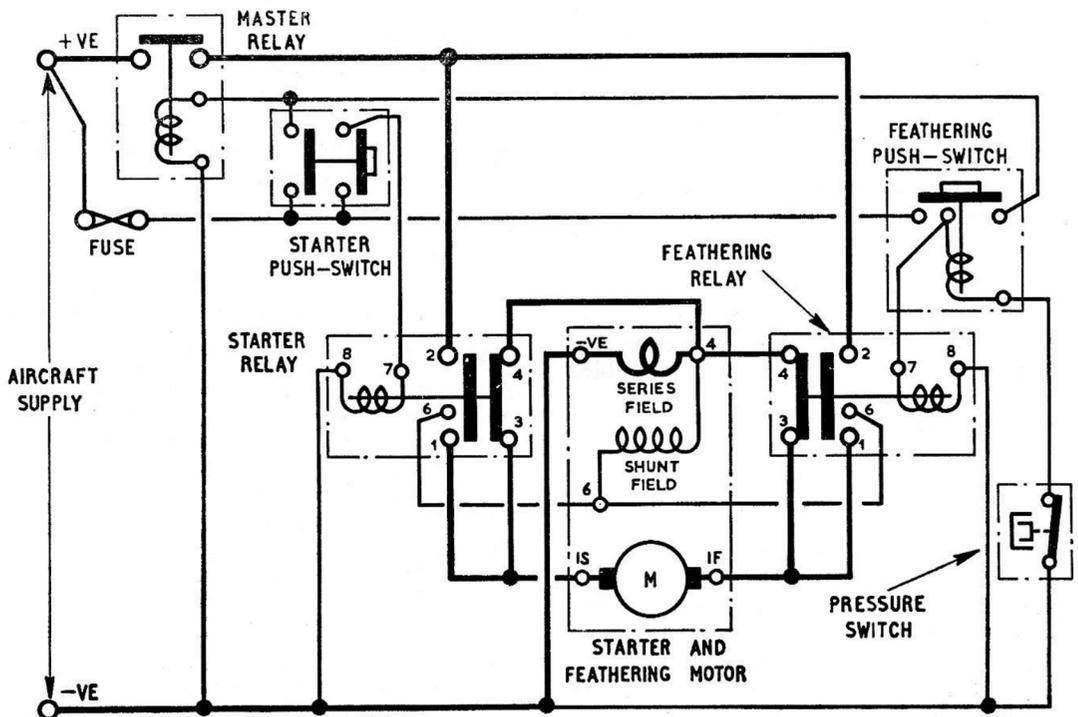


Fig. 3. Typical installation wiring diagram

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battery, using the external supply socket, with the ground/flight switch in the GROUND position.

22. Referring to fig. 3, actuation of the starter push-switch energizes the master relay solenoid and the starter relay solenoid. The master relay connects the heavy-duty circuits to battery positive, whilst the starter relay connects terminal 15 of the motor, through the heavy contact terminals 1 and 2, to the master relay. Terminals 6 of the starter relay and motor are then also connected to the positive supply.

23. After passing through the armature from 15 to 1F, the current travels, by way of the contact plate and terminals 3 and 4 of the feathering relay to the series field coil, thence to battery negative. As the shunt winding between terminals 6 and 4 is connected across the armature, a current, proportional to the volts drop across the armature, will flow through this winding. The motor will then be energized, causing the armature to turn in a clockwise direction.

24. As the gearing and clutch assembly rotates, the jaw is momentarily held by the large oil seal. The screw shaft reacting with the splined nut quick-thread moves forward causing the starter and engine jaw to engage. When the screw shaft reaches its full extent of travel, the drag of the oil seal on the starter jaw is overcome and the starter jaw rotates, transmitting its motion to the engine jaw. When the engine speed exceeds that of that starter jaw, the bevel surfaces of the jaws forcing against each other throw the starter jaw into its fully-retracted position. The engagement and the release of the starter and engine jaws are therefore automatic upon the operation of the starter.

25. The optimum working time of the clutch is three to five seconds, with one minute rest between each operation. It is permissible, however, under emergency conditions, to operate the motor on load, for a period of up to one minute with a subsequent rest of 15 minutes. It is detrimental to the starter to run it for longer periods than those quoted.

26. To bring the feathering circuit into operation, a separate switch, the feathering push-switch, must be operated. The closing of this switch completes three solenoid circuits simultaneously. Firstly, the solenoid circuit inside the switch itself which maintains the switch in the "on" position until the feathering cycle is complete. Secondly, the

master relay solenoid and, lastly, the feathering relay solenoid. The motor will now be energized in a similar way to that described in para. 22 and 23, except that the polarity of the armature has been reversed, causing the armature to rotate in an anti-clockwise direction.

27. The free-wheel device between the two stages of the two-stage gear train from the armature to the pump drive shaft, now that the armature is rotating in an anti-clockwise direction, engages with the last gear train and drives the pump shaft.

28. As soon as the propeller is feathered and a predetermined oil pressure has been attained, the pressure cut-out switch operates, breaking the solenoid circuit of the feathering push-switch. Immediately, this switch returns to the "off" position and all circuits are then inoperative.

29. To unfeather the propeller, push the feathering switch and hold it in until the unfeathering cycle has been completed.

### SERVICING

30. These starters should be serviced in accordance with the general chapter in A.P.4343, Vol. 1, Sect. 15, and the relevant Servicing Schedule.

#### Lubrication

31. The main bearings of the starter are packed one third full with grease XG-290 (Ref No. 34B/9105057) during manufacture, and will normally require lubricating at major servicing periods only.

#### Brushgear

32. The minimum length beyond which brushes must not be used is 0.473 in. from a new length of 0.550 in. when the commutator is at its minimum permissible diameter of 1.375 in. Brushes should be renewed at periods prescribed in the relevant Servicing Schedule, and whenever examination reveals that they will not remain serviceable for the period that must elapse before the next servicing.

33. Brush spring pressure should be between 41 and 45 oz., when the spring is compressed from a free length of 0.781 in. to 0.843 in.

#### Insulation resistance test

34. The insulation resistance, when measured with a 250-volt insulation resistance tester between all live parts and the frame, should be not less than 50,000 ohms.

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## Appendix 1

### STARTER MOTOR, ROTAX, TYPE C4602

#### LEADING PARTICULARS

<b>Starter motor, Type C4602</b>	....	....	....	<b>Ref. No. 37F/3013</b>
<i>Voltage</i>	....	....	....	24 d.c.
<i>Brush spring pressure</i>	....	....	....	41 to 45 oz.
<i>Brush grade</i>	....	....	....	CM5H
<i>Clutch setting</i>	....	....	....	350 lb. ft.
<i>Resistance values at 20 deg. C—</i>				
<i>Armature</i>	....	....	....	0.0104 ohms $\pm$ 10 per cent
<i>Series field</i>	....	....	....	0.00267 ohms $\pm$ 10 per cent
<i>Shunt field</i>	....	....	....	8.720 ohms $\pm$ 10 per cent
<i>Weight</i>	....	....	....	23 lb. 3 oz.
<i>Overall dimensions—</i>				
<i>Height to top of terminals</i>	....	....	....	11.718 in.
<i>Length</i>	....	....	....	8.563 in.
<i>Width (dia.)</i>	....	....	....	5.312 in.
<i>For use as starter motor</i>				
<i>Direction of rotation (viewed from jaw end)</i>	....	....	....	Clockwise
<i>B.H.P.</i>	....	....	....	2.2
<i>Speed of rotation (approx.)</i>	....	....	....	55 r.p.m.
<i>Normal working load</i>	....	....	....	250 lb. ft.
<i>Normal working current</i>	....	....	....	150 amp.
<i>Rating</i>	....	....	....	30 sec.
<i>Jaw travel</i>	....	....	....	0.312 in. (approx.)
<i>For use as feathering pump motor</i>				
<i>Direction of rotation (viewed from jaw end)</i>	....	....	....	Anti-clockwise
<i>B.H.P.</i>	....	....	....	1.1
<i>Speed of rotation (approx.)</i>	....	....	....	3,000 r.p.m.
<i>Normal working load</i>	....	....	....	2 lb. ft.
<i>Normal working current</i>	....	....	....	50 amp.
<i>Rating</i>	....	....	....	60 sec.

1. The starter motor, Type C4602, is generally similar to that described and illustrated in the main chapter. The jaw has five teeth, and projects 1.750 in. beyond the mounting flange. Later models of the starter,

however, have a solid jaw fixing on the screwshaft and meshing rod, in place of the spring-loaded fixing illustrated in fig. 2 of Chap. 16.

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## Appendix 2

### STARTER MOTOR, ROTAX, TYPE C4603

#### LEADING PARTICULARS

<b>Starter motor, Type C4603</b>	....	....	....	<b>Ref. No. 37F/5750</b>
<i>Voltage</i>	....	....	....	24 d.c.
<i>Brush spring pressure</i>	....	....	....	41 to 45 oz.
<i>Brush grade</i>	....	....	....	CM5H
<i>Clutch setting</i>	....	....	....	350 lb. ft.
<i>Resistance values at 20 deg. C—</i>				
<i>Armature</i>	....	....	....	0.0104 ohms ± 10 per cent
<i>Series field</i>	....	....	....	0.00267 ohms ± 10 per cent
<i>Shunt field</i>	....	....	....	8.720 ohms ± 10 per cent
<i>Weight</i>	....	....	....	23 lb. 3 oz.
<i>Overall dimensions—</i>				
<i>Height to top of terminals</i>	....	....	....	11.718 in.
<i>Length</i>	....	....	....	8.563 in.
<i>Width (dia.)</i>	....	....	....	5.312 in.
<i>For use as starter motor</i>				
<i>Direction of rotation (viewed from jaw end)</i>	....	....	....	Clockwise
<i>B.H.P.</i>	....	....	....	2.2
<i>Speed of rotation (approx.)</i>	....	....	....	55 r.p.m.
<i>Normal working load</i>	....	....	....	250 lb. ft.
<i>Normal working current</i>	....	....	....	150 amp.
<i>Rating</i>	....	....	....	30 sec.
<i>Jaw travel</i>	....	....	....	0.312 in. (approx.)
<i>For use as feathering pump motor</i>				
<i>Direction of rotation (viewed from jaw end)</i>	....	....	....	Anti-clockwise
<i>B.H.P.</i>	....	....	....	1.1
<i>Speed of rotation (approx.)</i>	....	....	....	3,000 r.p.m.
<i>Normal working load</i>	....	....	....	2 lb. ft.
<i>Normal working current</i>	....	....	....	50 amp.
<i>Rating</i>	....	....	....	60 sec.

1. The starter motor, Type C4603, is generally similar to that described and illustrated in the main chapter, but has a twelve-tooth jaw which projects 1.609 in. beyond the mounting flange. In consequence,

the front housing and baffle plate are slightly modified from that shown in fig. 2. Later models of the starter have a solid jaw fixing on the screwshaft and meshing rod, in place of the spring-loaded fixing illustrated.

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