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EQUIPMENT

WORKSHOP INSTRUCTIONS

PRE-ENGAGED STARTING MOTOR
WITH SELF-INDEXING DRIVE

MODEL M45G 12-VOLT

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1. GENERAL

This starting motor is a four-pole four-brush earth-return machine with series-parallel connected field coils.

A solenoid-operated pre-engaged drive assembly is carried on an extension of the armature shaft. The main features of this type of drive are as follows:

(*a*) Positive pinion engagement, preventing the pinion being thrown out of mesh whilst starting.

(*b*) Dual-purpose plate-clutch incorporated in the drive assembly giving over-speed and over-load protection.

(*c*) Self-indexing pinion to ensure smooth engagement between the pinion and the flywheel teeth before the starting motor begins to rotate.

(*d*) Armature braking system to ensure rapid return to rest when the starter button is released.

OPERATION

On depressing the starter button, a solenoid unit mounted on the starting motor yoke is energised and actuates a forked lever to engage the drive pinion with the engine flywheel.

On occasions of tooth-to-tooth abutment, axial movement of the pinion is arrested whilst a helically splined sleeve on which the pinion is carried, continues to move forward. This causes the pinion to rotate relative to the flywheel. When the teeth become aligned, spring pressure slides the pinion into mesh with the flywheel.

When the pinion is properly engaged with the flywheel teeth, a pair of contacts are closed in the rear of the unit. Closure of the contacts connects the motor to the battery, the armature rotates and the starter pinion commences to crank the engine.

When the engine fires and the starter push is released, the solenoid unit is de-energised and the spring-loaded plunger withdraws the starter pinion to its out-of-mesh position. The armature is brought rapidly to rest by the centrifugal action of a pair of spring-loaded brake shoes bearing against a brake drum inside the intermediate bracket.

Provision is made to ensure that in the case of the pinion jamming in mesh (this may occur with an engine which fails to start), there is sufficient slack in the engagement lever-to-solenoid plunger linkage to permit the solenoid switch contacts to open.

In the event of the drive remaining in mesh with the flywheel after the engine has run up to speed, the starting motor armature is protected from over-speeding by the plate clutch assembly. This clutch allows torque to be transmitted from the starting motor to the engine but not in the reverse direction which is free-running.

The clutch is set to slip at between two and three times normal starting torque, thus providing overload protection for the starting motor. Back firing is a typical example of overloading.

2. ROUTINE MAINTENANCE

(a) The starting motor requires no routine maintenance beyond the occasional inspection of the electrical connections which must be clean and tight.

(b) TWO YEARLY EXAMINATION

After the starting motor has been in service for two years, remove the starting motor from the engine and submit it to a thorough bench inspection. This inspection should be carried out by a qualified electrician and the following points checked:

(i) Brush wear. Renew brushes worn to, or approaching $\frac{5}{16}$" in length. See para. 4 (*d*) (ii).

(ii) Brush spring tension. Correct tension is 30—40 oz. Renew springs if tension has dropped below 25 oz.

(iii) Skim commutator if it is pitted or badly worn. See para. 4 (*d*) (iii).

(iv) Check bearings for excessive side play of the armature shaft. See para. 4 (*d*) (*vi*).

(v) Check pinion movement. See para. 4 (*f*).

(vi) Clean and lubricate the indented bearing inside the pinion sleeve using a bentonite based grease, such as Ragosine 'Bentone', for this purpose. This should be done any time when the drive becomes sluggish in operation.

(vii) Clean and lubricate the indented bronze bearing in the intermediate bracket. Use Ragosine 'Molypad' Molybdenised non-creep oil for this purpose. Ragosine oils and greases are marketed by the Rocol organisation.

3. PERFORMANCE DATA

(*a*) STARTING MOTOR

(i) Light running current: 90 amp. at 8,000—9,000 r.p.m.

(ii) Lock torque: 32.5 lb.-ft. with 900 amp. at 6.4 terminal volts.

(iii) Torque at 1,000 r.p.m.: 15.5 lb.-ft. with 570 amp. at 8.8 terminal volts.

These figures are based on the use of a fully charged 12-volt battery having a capacity of 115 amp.-hr. at the 10-hour rate.

(*b*) SOLENOID MODEL 6S. (For model 7S see SECTION E-2, Part C)

(i) Operating coil resistance: 0.23—0.27 ohm.

(ii) Holding coil resistance: 0.71—0.88 ohm.

(iii) Spring pressure to close contacts: 7—9 lb.

(iv) Spring pressure to push plunger home: 13—18 lb.

(v) Plunger movement to close contacts: 0.545″—0.555″.

(vi) Total plunger movement: 0.606″—0.663″.

4. SERVICING

(*a*) TESTING IN POSITION

Switch on the headlamps, operate the starter knob or push and watch for the following symptoms:

(i) *The lamps dim and the motor does not crank the engine.*

Check by hand-cranking that the engine is not abnormally stiff.

Check the battery by substitution.

(ii) *The lamps do not dim and the motor does not crank the engine.*

Check the starter circuit for continuity.

Check the solenoid unit, see Para. 4 (*d*) (i).

If the armature rotates, check for a defective drive mechanism.

(*b*) BENCH TESTING

(i) *Removing the starting motor from the engine*

Disconnect the battery. Disconnect and remove the starting motor from the engine.

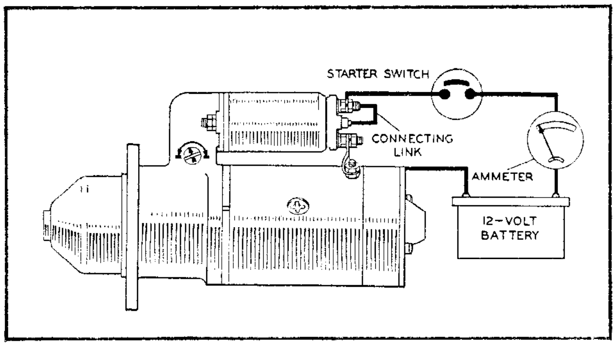

Fig. 1
Measuring light running current

(ii) *Measuring the light running current.*

With the starting motor securely clamped in a vice and using a 12-volt battery, check the light running current and compare with the values given in Para. 3. If there appears to be excessive sparking at the commutator, check that the brushes are clean and free to move in their boxes, and that the spring pressure is correct. See symptoms 7 and 8 in Para. 4. (*b*) (*iv*).

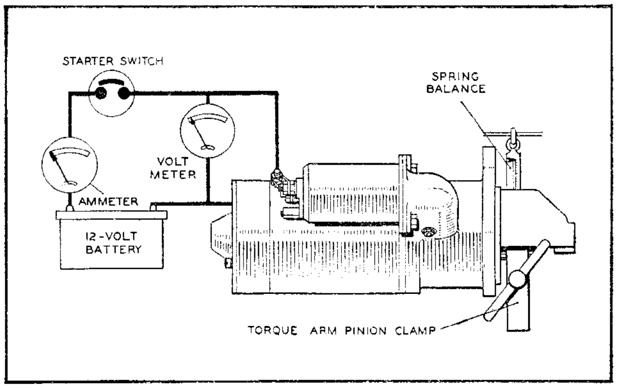

Fig. 2
Measuring lock torque and lock current

(iii) *Measuring lock torque and lock current.*

Carry out a torque test and compare with the values given in Para. 3. If a constant voltage supply is used, it is important to adjust this to be 6.4 volts at the starter terminal when testing.

(iv) *Fault diagnosis.*

An indication of the nature of the fault, or faults, may be deduced from the results of the no-load and lock torque tests.

Symptom	*Probable Fault*
1. Speed, torque and current consumption correct.	Assume motor to be in normal operating condition.
2. Speed, torque and current consumption low.	High resistance in brush gear, e.g. faulty connections, dirty or burned commutator causing poor brush contact.
3. Speed and torque low, current consumption high.	Tight or worn bearings, bent shaft, insufficient end play, armature fouling a pole shoe, or cracked spigot on drive end bracket. Short-circuited armature, earthed armature or field coils.

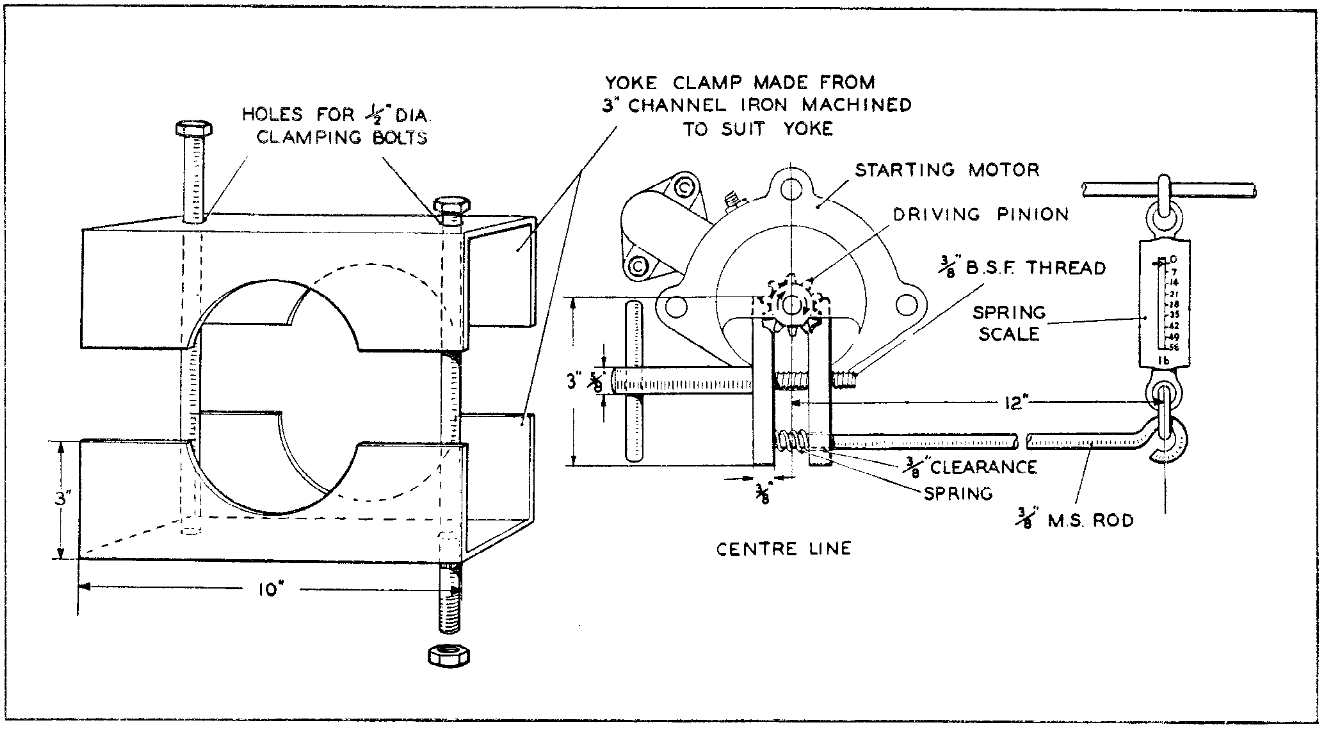

Fig. 3
Apparatus for measuring lock torque

4. Speed and current consumption high, torque low.	Short-circuited windings in field coils.
5. Armature does not rotate, no current consumption	Open-circuited armature, field coils, or solenoid unit. If the commutator is badly burned there may be poor contact between brushes and commutator.
6. Armature does not rotate, high current consumption.	Earthed field winding or short-circuited solenoid unit. Armature physically prevented from rotating.
7. Excessive brush movement causing arcing at commutator.	Low brush spring tension, worn or out-of-round commutator. 'Thrown' or high segment on commutator.
8. Excessive arcing at the commutator.	Defective armature windings, sticking brushes or dirty commutator.

(c) DISMANTLING

(i) Disconnect the copper link between the lower solenoid terminal and the starting motor yoke.

(ii) Remove the solenoid unit securing nuts. Withdraw the solenoid from the drive end bracket casting, carefully disengaging the solenoid plunger from the starter drive engagement lever.

(iii) Remove the cover band and lift the brushes from their holders.

(iv) Unscrew and withdraw the two through bolts from the commutator end bracket. The commutator end bracket and yoke can now be removed from the intermediate and drive end brackets.

(v) Extract the rubber seal from the drive end bracket.

(vi) Remove the nut securing the eccentric pin (see Fig. 4) on which the starter drive engagement lever pivots, and withdraw the pin.

(vii) Separate the drive end bracket from the armature and intermediate bracket assembly.

(viii) Remove the washer from the end of the armature shaft extension and slide the drive assembly and engagement lever off the shaft.

(ix) If it is necessary to dismantle the drive assembly proceed as described in Para. 5(b).

(x) Remove the intermediate bracket retaining ring from the armature shaft extension and slide the bracket and brake assembly off the shaft.

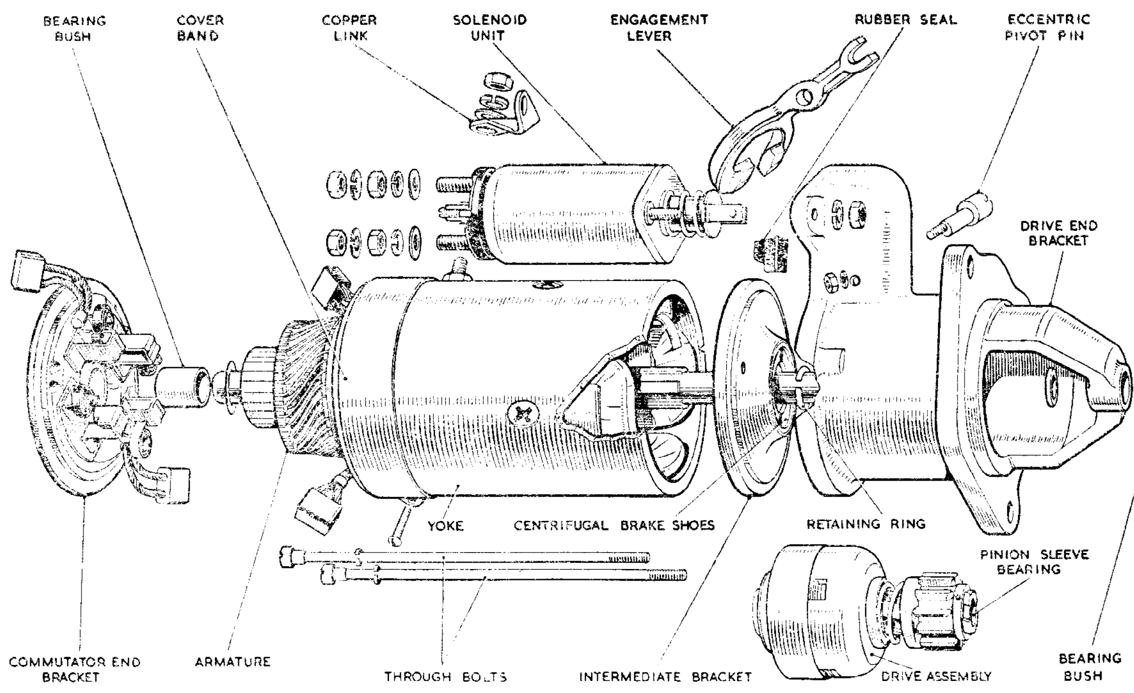

Fig. 4
Starting motor dismantled

(*d*) BENCH INSPECTION

After dismantling the motor, examine individual items.

(i) *Solenoid.*

The solenoid unit contains two coils; a closing coil which is by-passed when the plunger is drawn fully home, and a hold-on coil to retain the plunger in the fully home position. To check the individual coils, remove the existing connections and using a constant voltage 4-volt d.c. supply with cables of adequate size, proceed as follows:

Closing coil:

Connect the supply between the solenoid terminal marked 'STA' and the small centre terminal. This should actuate the plunger and cause a current of 14.8—17.4 amperes to pass.

Hold-on coil:

Connect the supply between the solenoid body and the small centre terminal. This should actuate the plunger and cause a current of 4.5—5.6 amperes to pass.

N.B. Do not carry out these tests while the solenoid unit is hot.

If a constant voltage supply is not available check the coil resistances, using an accurate method of measuring low resistance values, such as the Wheatstone Bridge. Connect the measuring instrument as for measuring the current and compare the resistances with those given in Para. 3. Also check the spring pressure and plunger travel with the figures given in Para. 3.

If, after testing, the solenoid is found to be faulty it should be replaced by a serviceable unit. Do not attempt to repair a faulty solenoid.

(ii) *Replacement of Brushes.*

The flexible connectors are soldered to terminal tags; two are connected to brush boxes, and two are connected to free ends of the field coils. Unsolder these flexible connectors and solder the connectors of the new brush set in their place.

The brushes are pre-formed so that 'bedding' to the commutator is unnecessary.

Check that the new brushes can move freely in their boxes.

(iii) *Commutator*

A commutator in good condition will be burnished and free from pits or burned spots. Clean the commutator with a petrol-moistened cloth. Should this be ineffective spin the

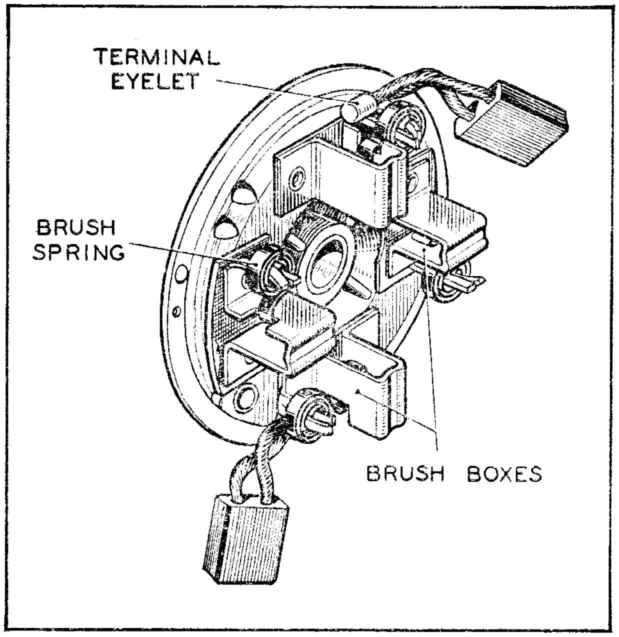

Fig. 5
Commutator end bracket

armature and polish the commutator with fine glass paper; remove all abrasive dust with a dry air blast. If the commutator is badly worn, mount the armature between centres in a lathe, rotate at high speed and make a light cut with a very sharp tool. Do not remove more metal than is necessary. Finally polish with very fine glass paper. The INSULATORS between the commutator segments MUST NOT BE UNDERCUT.

(iv) *Armature*

Lifted conductors:

If the armature conductors are found to be lifted from the commutator risers, overspeeding is indicated. In this event, check that the clutch assembly is disengaging correctly when the engine fires. See para. 5 for details.

Fouling of armature core against the pole faces:

This indicates worn bearings or a distorted shaft. A damaged armature must in all cases be replaced and no attempt should be made to machine the armature core or to true a distorted armature shaft.

Insulation test:

To check armature insulation, use a 110-volt a.c. test lamp. The test lamp must not light when connected between any one commutator segment and the armature shaft.

If a short circuit is suspected check the armature on a 'growler'. Overheating can cause blobs of solder to short circuit the commutator segments.

If the cause of an armature fault cannot be located or remedied, fit a replacement armature.

(v) *Field Coils*

Continuity test:

Connect a 12-volt test lamp and battery between the insulated terminal on the yoke and each individual brush (with the armature removed from the yoke). Ensure that both brushes and their flexible connectors are clear of the yoke. If the lamp does not light, an open circuit in the field coils is indicated. Replace the defective coils.

Insulation test:

Connect a 110-volt a.c. test lamp between the terminal post and a clean part of the yoke. The test lamp lighting, indicates that the field coils are earthed to the yoke and must be replaced.

When carrying out this test, check also the insulated pair of brush boxes on the commutator end bracket. Clean off all traces of brush deposit before testing. Connect the 110-volt test lamp between each insulated brush box and the bracket. If the lamp lights this indicates faulty insulation and the end bracket must be replaced.

Replacing the field coils:

Unscrew the four pole-shoe retaining screws using a wheel-operated screwdriver.

Remove the insulation piece which is fitted to prevent the inter-coil connectors from contacting with the yoke.

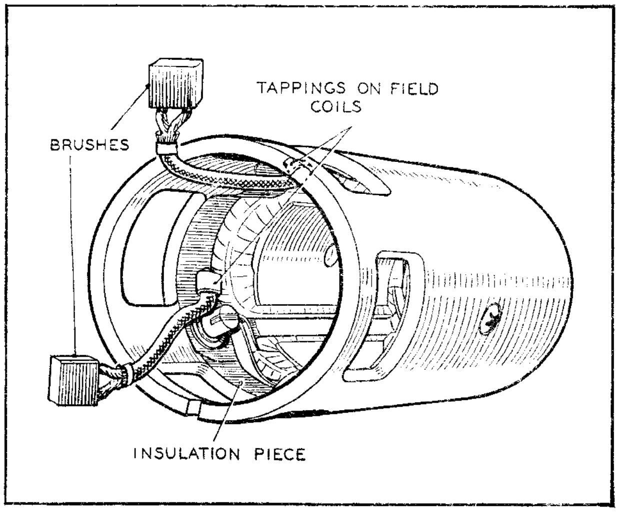

Fig. 6
Brush connections to field coils

Draw the pole shoes and coils out of the yoke and lift off the coils.

Fit the new field coils over the pole shoes and place them in position inside the yoke. Ensure that the taping of the field coils is not trapped between the pole shoes and the yoke.

Locate the pole shoes and field coils by lightly tightening the retaining screws.

Replace the insulation piece between the field coil connections and the yoke.

Finally, tighten the screws by means of the wheel-operated screwdriver while the pole pieces are held in position by a pole shoe expander (see Fig. 7.) or a mandrel of suitable size.

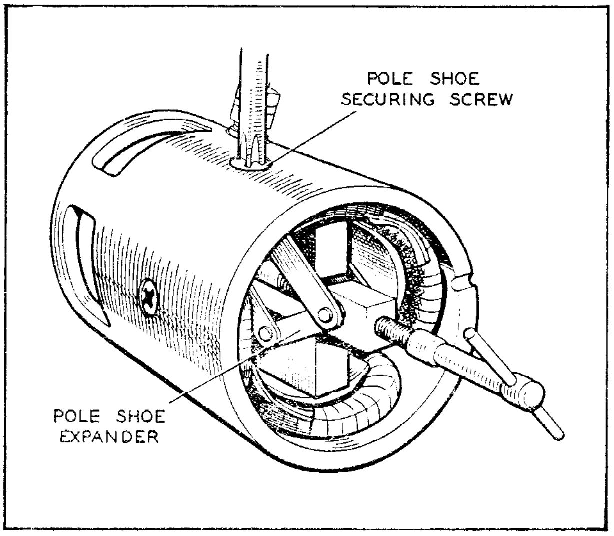

Fig. 7
Tightening pole shoe retaining screws using pole shoe expander

(vi) *Bearings and Bearing Replacement*

The commutator and drive end brackets are each fitted with a porous bronze bush and the intermediate bracket is fitted with an indented bronze bearing.

Replace bearings which are worn to such an extent that they will allow excessive side play of the armature shaft.

The bushes in the intermediate and drive end brackets can be pressed out, whilst that in the commutator end bracket is best removed by inserting a $\frac{11}{16}''$ tap squarely into the bearing and withdrawing the bush with the tap.

Before fitting a new porous bronze bearing bush, immerse it for 24 hours in clean engine oil (SAE 30—40). In cases of extreme urgency, this period may be shortened by heating the oil to 100°C for 2 hours and then allowing the oil to cool before removing the bush.

Fit new bushes by using a shouldered, highly polished mandrel approximately 0.0005″ greater in diameter than the shaft which is to fit in the bearing. **Porous bronze bushes must not be reamered out after fitting,** as the porosity of the bush will be impaired.

After fitting a new intermediate bearing bush, lubricate the bearing surface with Ragosine Molybdenised Non-creep oil.

(e) REASSEMBLY

After cleaning all parts, re-assembly of the starting motor is a reversal of the dismantling procedure given in Para. 4 (c), but the following special points should be noted:

(i) To facilitate fitting the solenoid unit to the drive end bracket, ease the drive assembly forward along the armature shaft.

(ii) Set the pinion movement before tightening the eccentric pivot pin securing nut. Para. 4 (*f*).

(*f*) SETTING PINION MOVEMENT

After complete assembly of the starting motor connect the small centre terminal on the solenoid unit by way of a switch to a 6-volt supply. Connect the other side of the battery to one of the solenoid fixing studs.

Close the switch (this throws the drive assembly forward into the engaged position) and measure the distance between the pinion and the washer on the armature shaft extension. Make this measurement with the **pinion pressed lightly towards the armature** to take up any slack in the engagement linkage. For correct setting this distance should be 0.020″—0.030″.

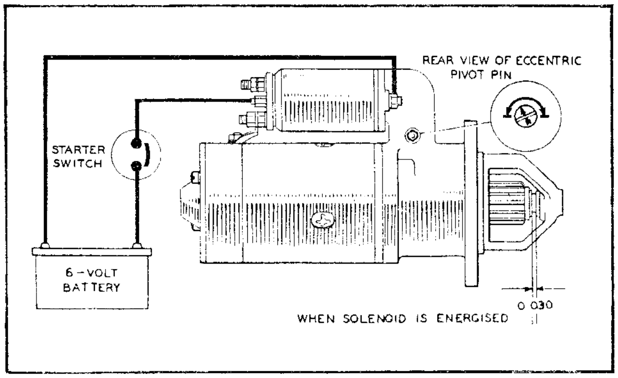

Fig. 8.
Setting pinion movement

To adjust the setting, slacken the eccentric pivot pin securing nut and turn the pin until the correct setting is obtained. Note that the arc of the adjustment is 180° and the head of the arrow marked on the pivot pin should be set only between the arrows on the arc described on the drive end bracket casting.

After setting, tighten the securing nut to retain the pin in position.

NOTE In the event of a replacement motor or drive end bracket being fitted, check the out-of-mesh clearance when assembling the starting motor to the engine. This should be $\frac{1}{8}''$ between the leading edge of the pinion and the engine flywheel with a tolerance each way of $\frac{3}{32}''$

5. SELF-INDEXING PLATE CLUTCH DRIVE

(a) GENERAL OPERATION

The drive assembly is mounted on the armature shaft extension with the clutch driving sleeve splined to the shaft. When the starter switch is operated the engagement lever pushes the drive assembly along the shaft to engage the pinion with the flywheel.

This movement clamps the clutch plates together and torque is transmitted to the barrel unit.

If, after the engine fires, the torque reverses direction, the moving member releases its pressure on the clutch plates and the clutch automatically disengages and releases the armature shaft—only the pinion and barrel unit are driven by the engine.

If the clutch is overloaded it slips at a torque two or three times greater than the maximum developed by the motor. This overload protection feature is effected by shim-setting the engagement pressure on the clutch plates. When the moving member exerts pressure on the clutch plates, pressure plates are compressed by the backing ring. This compression determines the amount of torque which can be transmitted by the clutch plates, and is pre-set by shims inserted between the backing ring and the clutch plates.

(b) DISMANTLING

(i) Remove the drive assembly from the armature shaft.

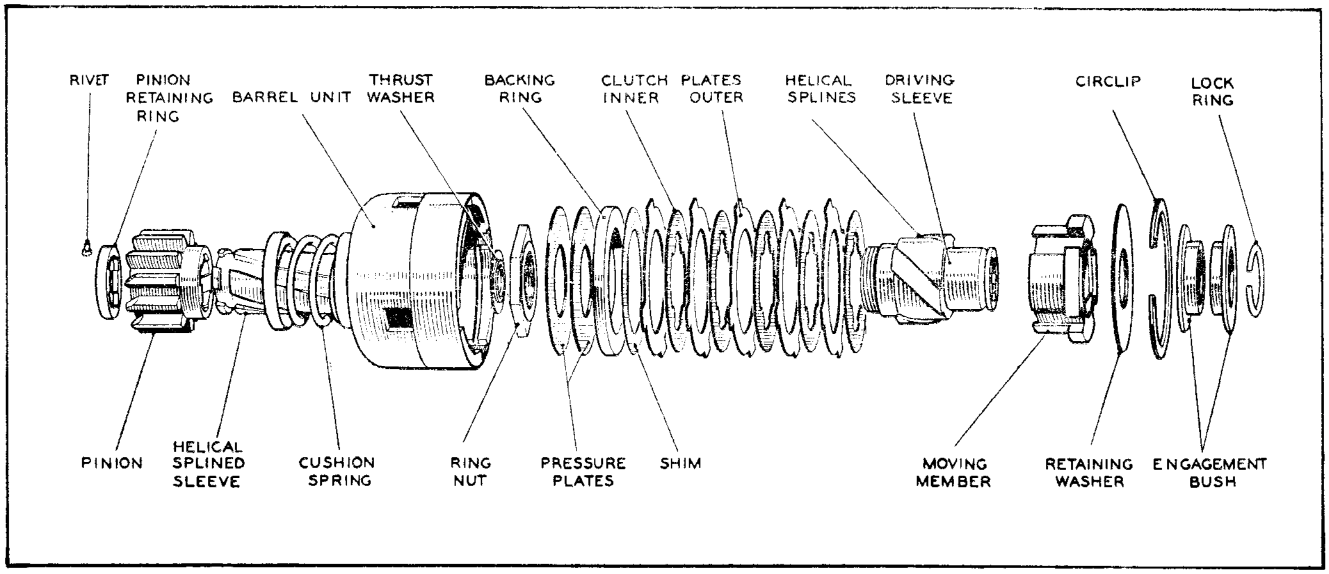

Fig. 9
Starter drive dismantled

The pinion is carried on a helically splined sleeve which is cleated to the barrel unit containing the plate clutch assembly. In the event of tooth-to-tooth engagement the forward movement of the pinion ceases while the helical splined sleeve continues to be pushed forward. This rotates the pinion relative to the flywheel gear ring. When the teeth become aligned for meshing the compressed cushion spring slides the pinion into mesh with the flywheel.

When the armature shaft rotates the drive, torque is transmitted from the shaft through the clutch driving sleeve, plate clutch assembly and barrel unit, to the driving pinion. The clutch is engaged by pressure from the moving member which rides up the helical splines on the driving sleeve when the armature shaft rotates.

(ii) Remove the lock ring from the driving sleeve.

(iii) Lift two halves of the engagement bush off the driving sleeve.

(iv) Using a suitable circlip extracting tool, extract the clutch retaining circlip from the barrel unit and withdraw the driving sleeve and clutch unit.

(v) The clutch assembly can now be dismantled by removing all the parts from the driving sleeve—with the exception of the two pressure plates which are held in position by the ring nut. To remove the ring nut, slide the driving sleeve on to the splined armature shaft and, using soft metal jaw plates, clamp the armature in a vice. File away the peened rim and use a spanner measuring $1\frac{5}{16}$" across the flats to remove the ring nut.

When re-assembling, fit a new ring nut and peen the rim over the notch in the driving sleeve to lock the nut in position.

(vi) To remove the pinion from the helically splined sleeve, knock out the rivet which secures the pinion retaining ring. The retaining ring, pinion, cushion spring with cup washers and the sleeve can now be separated.

(c) RE-ASSEMBLY

Reverse the dismantling procedure described in Para. 5 (b) noting the following important points:

(i) The correct cushion spring tension is 11 lb. measured with the spring compressed to $\frac{7}{8}$" in length and 16 lb. with the spring compressed to $\frac{1}{2}$" in length.

(ii) Check the slipping torque of the clutch as follows:

Fit the drive assembly on the splined armature shaft and clamp the armature between soft metal jaw plates in a vice.

Apply an anticlockwise torque to the pinion with a suitable 'torque wrench' fastened to the pinion teeth. The clutch should slip between 800—950 lb. in.

If the clutch slips at too low a torque figure, dismantle again and add shims one at a time until the correct figure is obtained.

If the clutch does not slip between the torque limits given, again remove the circlip—dismantle and remove shims one at a time until the torque test gives correct figures.

The correct adjusting shims are:

Part No.	*Thickness*
291374	0.006"
291378	0.005"
291379	0.004"

(iii) The assembled clutch unit and lever mechanism must be capable of being pushed to the full extent of the set travel. The assembly must move along the armature shaft extension smoothly and freely, but without slackness.

(iv) Before fitting the drive assembly to the armature shaft lightly smear the shaft and pack the space between the indented bearings inside the pinion sleeve, with a bentonite based grease such as Ragosine 'Bentone'.

METRIC EQUIVALENT

0.0005"	= 0.013 mm.	$1\frac{5}{16}$"	= 33.3 mm.
0.004"	= 0.102 mm.	3"	= 76 mm.
0.005"	= 0.127 mm.	10"	= 254 mm.
0.006"	= 0.152 mm.	12"	= 305 mm.
0.020"	= 0.508 mm.		
0.030"	= 0.760 mm.	25 oz.	= 708 g.
0.545"	= 13.8 mm.	30 oz.	= 850 g.
0.555"	= 14.1 mm.	40 oz.	= 1.13 Kg.
0.606"	= 15.4 mm.	7 lb.	= 3.18 Kg.
0.663"	= 16.8 mm.	9 lb.	= 4.08 Kg.
		11 lb.	= 4.99 Kg.
$\frac{3}{32}$"	= 2.4 mm.	13 lb.	= 5.90 Kg.
$\frac{1}{8}$"	= 3.2 mm.	16 lb.	= 7.26 Kg.
$\frac{5}{16}$"	= 8 mm.	18 lb.	= 8.16 Kg.
$\frac{3}{8}$"	= 9.5 mm.		
$\frac{1}{2}$"	= 12.7 mm.	800 lb.-in.	= 9.21 Kg.-m.
$\frac{5}{8}$"	= 15.9 mm.	950 lb.-in.	= 10.95 Kg.-m.
$\frac{11}{16}$"	= 17.5 mm.	15.5 lb.-ft.	= 2.14 Kg.-m.
$\frac{7}{8}$"	= 22.2 mm.	32.5 lb.-ft.	= 4.49 Kg.-m.