SECTION B—5
ISSUE 2, AUGUST 1962
Supersedes Issue 1, September 1955

LUCAS

Quality

EQUIPMENT

WORKSHOP INSTRUCTIONS

PRE-ENGAGED STARTING MOTORS

MODELS M3, M325, M35G, M418G and M45G

WITH ROLLER CLUTCH DRIVES

MODELS 4SD, 5SD and 6SD

AND ACTUATING SOLENOIDS

MODELS 6S, 9S and 10S

JOSEPH LUCAS LTD · BIRMINGHAM 19 · ENGLAND

D/862/D Printed in England

PRE-ENGAGED STARTING MOTORS

MODELS M3, M325, M35G, M418G and M45G

WITH ROLLER CLUTCH DRIVES

MODELS 4SD, 5SD and 6SD

AND ACTUATING SOLENOIDS

MODELS 6S, 9S and 10S

1. GENERAL

(*a*) THE PRE-ENGAGED STARTING MOTOR

(*i*) The purpose of the pre-engaged (or 'positive engagement') starting motor is to prevent premature pinion ejection. This is a problem to be countered in those engine applications where violently fluctuating cranking resistances are met, or where, as in six-volt starting motors, armature acceleration is limited and the pinion is unable to follow an accelerating flywheel. Typical applications include the starting of diesel engines ; the low-temperature starting of petrol engines ; the starting of single and twin-cylinder petrol engines at any temperature ; and also the starting of four-cylinder engines when used to power vehicles having only six-volt (as opposed to 12 or 24-volt) electrical systems.

(*ii*) The reader is referred to SECTIONS B–4, B–6 and associated Supplementary Pages of this Manual for information on starting motors for diesel engines —when versions of the heavier-duty plate type clutch are used.

(*iii*) Except on occasions of tooth-to-tooth abutment, for which special provision is made, a pre-engaged starting motor is connected to the battery only after the pinion has been meshed with the flywheel ring gear, through the medium of a manually or electro-magnetically operated linkage mechanism. After the engine has started, the current is automatically switched off before the pinion is retracted. On reaching the out-of-mesh position, the spinning armature is, in many units, brought rapidly to rest by a braking device. This device frequently takes the form of a pair of moulded shoes driven by a cross peg in the armature shaft

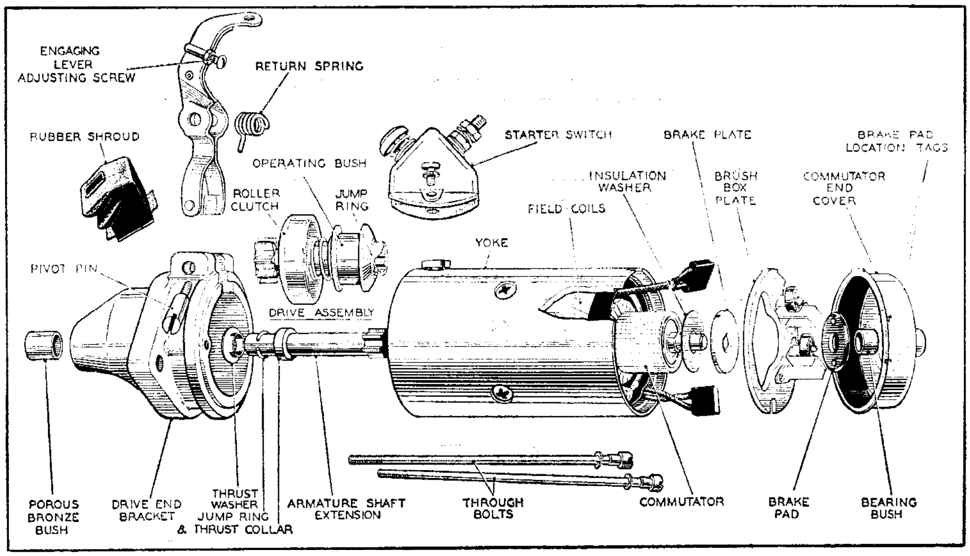

Fig. 1

Manually pre-engaged starting motor, model M3, with models 4SA switch and 4SD drive

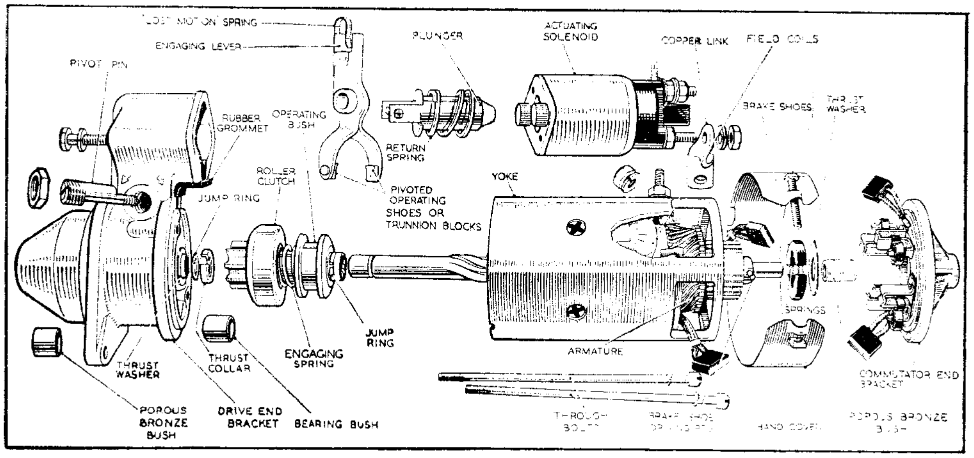

Fig. 2
Solenoid pre-engaged starting motor, model M325, with models 9S solenoid and 4SD drive

and spring-loaded (and centrifuged) against a steel ring insert in the commutator end bracket. Thus, with the supply switched off and the armature subjected to a braking force, the possibility is minimised of damaged teeth resulting from attempts being made to re-engage a rotating pinion.

(*b*) TOOTH-TO-TOOTH ABUTMENT

(*i*) The manually or electro-magnetically actuated linkage mechanism referred to in para. 1 (*a*) (*iii*) consists essentially of a pivoted engaging lever having two hardened steel pegs (or trunnion blocks) which locate with and control the drive through the medium of a groove in an operating bush. This bush is carried, together with the clutch and pinion assembly, on an internally splined outboard driving sleeve—the whole mechanism being housed in a cut-away flange-mounting snout-shaped end bracket. The operating bush is spring loaded against a jump ring in the driving sleeve by an engagement spring located between the bush and the clutch outer cover. The system return or drive demeshing spring is located on the engaging lever pivot of manually operated starting motors and round the solenoid plunger of electro-magnetically operated starting motors.

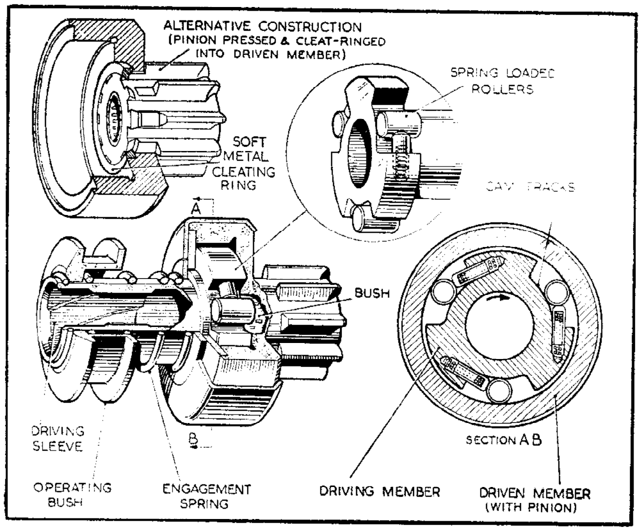

Fig. 3
Roller clutch drive, model 4SD

(*ii*) On occasions of tooth-to-tooth abutment (between the ends of the starter pinion teeth and those of the flywheel ring gear), the pegs or trunnion blocks at the 'lower' end of the engaging lever can move forward by causing the operating bush to compress the engagement spring, thus allowing the 'upper' end of the lever to move sufficiently rearwards to close the starter switch contacts. The armature then rotates and the pinion slips into mesh with the flywheel ring gear under pressure of the compressed engagement spring.

(*c*) "PUSH-SCREW" ENGAGEMENT

(*i*) The bore of the driving sleeve is splined to mate with complementary splines on the armature shaft. The splining may be either straight or helical. Straight splines are less common and usually applied to hand or foot operated engagement mechanisms, where ample force is available to compress the engagement spring on occasions of tooth-to-tooth abutment. When straight-splined units are solenoid operated, as in some smaller machines, the larger and more powerful solenoid, model 10S, is fitted.

(*ii*) An undesirable tendency of a straight-splined drive is that, in the event of tooth-to-tooth abutment, it

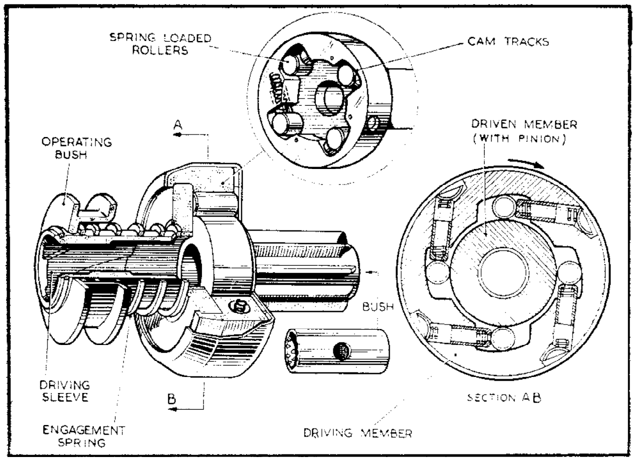

Fig. 4
Roller clutch drive, model 5SD

is possible for torque to be transmitted from the pinion to the flywheel in some position of partial meshing. This condition cannot occur with the "Push-screw" drive, in which the shaft and driving sleeve are helically splined. When tooth abutment prevents axial movement of the drive, these splines serve to augment pinion pressure due to the engagement spring and to transfer torque from the armature to the drive, in order to effect engagement. Full cranking torque is exerted as soon as (and not before) complete meshing has occurred. A weaker engagement spring is used, as the torque exerted by the armature assists engagement. In turn, this permits a smaller solenoid, model 9S, to be used with starting motors having yoke sizes of up to $3\frac{1}{2}$" (89mm.) dia., i.e., models M3, M325 and M35.

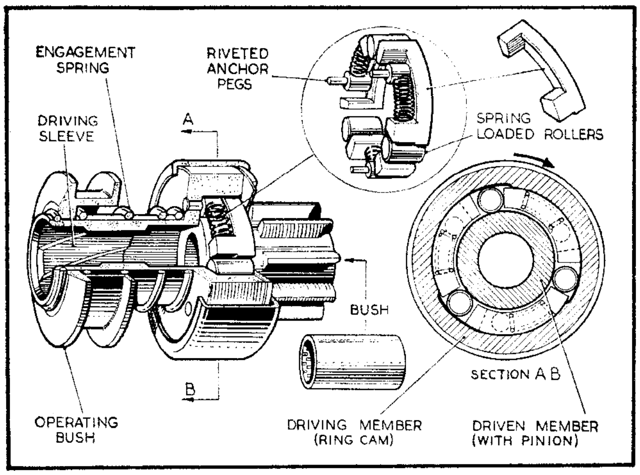

Fig. 5
Roller clutch drive, model 6SD

(*d*) "LOST MOTION" (SWITCH-OFF) DEVICES

(*i*) As it is desirable that the starter switch contacts shall not close until the pinion has meshed with the flywheel ring gear, so it is important that these same contacts should always re-open before the pinion has been retracted—or can be opened in the event of a starter pinion remaining for some reason enmeshed with the flywheel ring gear. To ensure this, a measure of "lost motion" is designed into some part of the engagement mechanism, its effect being to allow the starter switch or solenoid contacts (which are always spring-loaded to the open position) to open before pinion retraction begins.

(*ii*) With hand or foot operated starting motors, carrying the small yoke mounted starter switch, model 4SA, it is the geometry of the engagement linkage that, with provision for fine adjustment, ensures the correct early opening of the contacts. The adjuster consists of a nut-locked screw in the engaging lever. The head of this screw contacts with and actuates the switch spindle-and-contact assembly as the pinion approaches full engagement with the engine ring gear.

(*iii*) With solenoid operated starting motors, several methods of obtaining "lost motion" have been

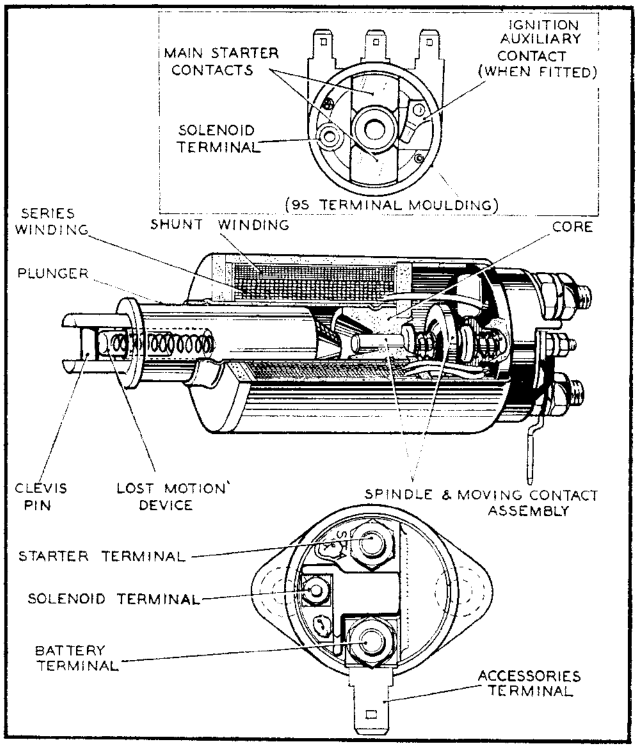

Fig. 6
Solenoid, model 10S, with (inset) underside view of model 9S terminal moulding showing ignition coil ballast resistor shorting contact, when fitted

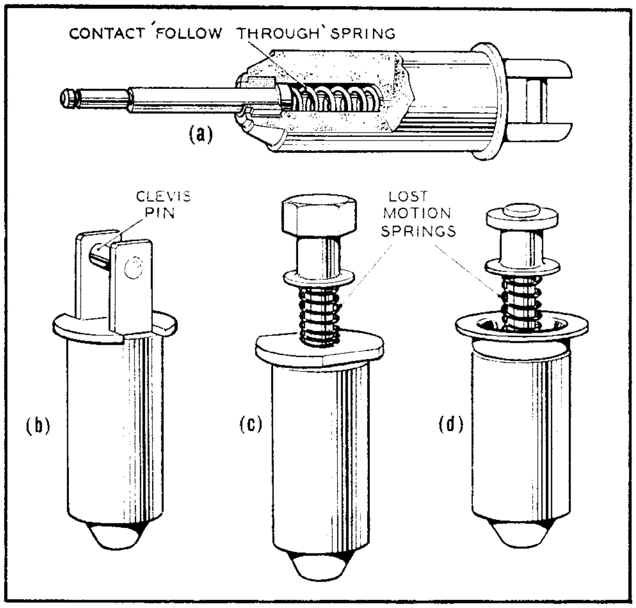

Fig. 7

Solenoid plungers

(a) Incorporating spring loaded spindle and plain clevis link, used in solenoid model 6S in conjunction with a shepherd's-crook-shaped "lost motion" spring on engaging lever.

(b) Plain clevis link type, as used in solenoid model 9S in conjunction with, either, a shepherd's-crook-shaped "lost motion" spring on engaging lever, or a helical "lost motion" spring and split operating bush on drive assembly.

(c) Early design for model 9S incorporating "lost motion" spring.

(d) Later design for model 9S incorporating "lost motion" spring.

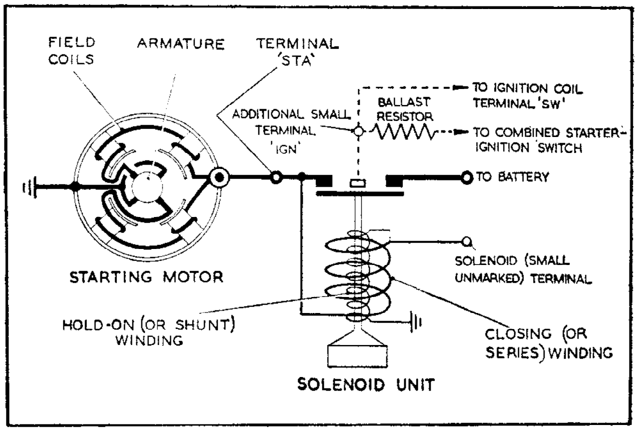

Fig. 8

Electrical circuit of solenoid engaged starting motor, showing ignition coil ballast resistor shorting contact, when fitted

adopted, but each depends upon the yielding of a weaker spring to the stronger system return (drive de-meshing or disengagement) spring of the solenoid plunger.

This initial yielding results in the switch contacts being fully opened within the first $\frac{1}{8}$" (3.18mm.) of plunger return travel—this action being followed by normal drive retraction.

(*iv*) When space permits, current practice is to locate the weaker ("lost motion") spring inside the solenoid plunger. Here, enclosed at the outer end by a retaining cup, it forms a plunger-within-a-plunger and is spring-loaded against the tip of the engaging lever inside the plunger clevis link. This practice is followed in solenoid model 10S and in the diesel starter solenoid model 7S.

(*v*) In some other devices, the clevis link is dispensed with and the "lost motion" spring is sleeved on to a central stem which protrudes from the rear of the solenoid plunger. Here it serves to spring-load a sliding (engaging lever) collar against the riveted or hexagon headed outer end of the stem.

(*vi*) In model M35G, Part No. 25067 (G.M.—Holden's vehicles), the "lost motion" spring is associated with the lower end of the pivoted engaging lever—the solenoid plunger carrying only a plain clevis link. This machine has a drive fitted with a split operating bush, the two halves being separated by a jump ring and spring-loaded together by the engagement spring at the front and the "lost motion" spring at the rear.

(*vii*) A plain clevis link is also fitted to solenoid plungers used in conjunction with yet another form of "lost motion" device, namely, a shepherd's-crook-shaped leaf spring which is riveted to the slotted 'upper' end of an engaging lever, as shown in Fig. 2. Two plungers used with this device are illustrated in Fig. 7 (*a*) and (*b*), relating to solenoid models 6S and 9S, respectively.

(e) ROLLER CLUTCHES

(*i*) Torque developed by the starting motor armature must be transmitted to the pinion and flywheel through an over-running or free-wheeling device which will prevent the armature from being rotated at an excessively high speed in the event of the engaged position being held after the engine has started. The roller clutch performs this function.

(*ii*) The operating principle of the roller clutch is the wedging of several plain cylindrical rollers between converging surfaces. The convergent form is obtained by matching cam tracks, either, to a perfectly circular bore (model 4SD) or to the outer surface of a cylinder (models 5SD and 6SD). Both types are produced and each has its advantages. The rollers, of which there are usually three or four, are spring-loaded and, according to the direction of drive, are either free or wedge-locked between the driving and driven members.

(*iii*) In model 4SD, three rollers are used and, as mentioned in (*ii*) above, these run on cam tracks cut in cavities in the inner member—this member being driven by the armature and the outer, cylindrical, member carrying the pinion.

Alternative constructions, integral or fabricated, are employed in the production of model 4SD—the pinion and outer member being machined integral in drives for smaller machines, but separately for larger sizes (maximum loading values permitting). In the latter form, these components are splined and pressed together and finally secured with a cleating ring inserted under pressure.

(*iv*) However, present trends in engine design and operation, relating to compression ratios, starting temperatures and carburation, have necessitated higher pinion-to-ring gear ratios resulting in high and often sustained over-run speeds of up to 30,000 r.p.m. To meet these conditions, the peripheral speeds and inertia of the pinion assembly is reduced by associating the pinion with the clutch inner member. If, in addition, the cam tracks are cut in the clutch outer member, the centrifugal action of the rollers on over-run can be usefully employed—their outward thrust being against the slower rotating outer member and away from the high speed inner member. As previously mentioned, this arrangement is utilised in the design of models 5SD and 6SD.

(*v*) In model 5SD, four rollers are used and the cam tracks in the outer member are cut in cavities similar to the inner member cavities of model 4SD.

(*vi*) In model 6SD, employing three rollers, the cavities or working pockets of models 4SD and 5SD have been superseded by a three-lobed ring cam in the outer member. Three riveted pegs provide

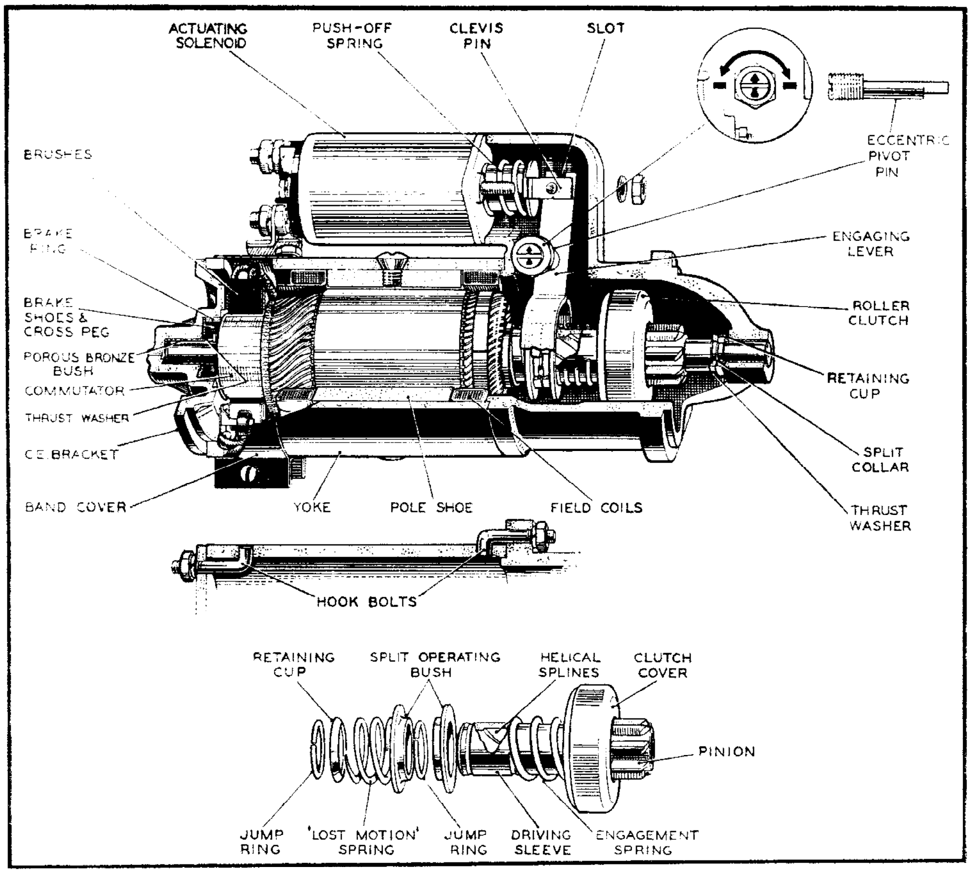

Fig. 9

Solenoid pre-engaged starting motor, model M35G, with split operating bush, hook bolts, and models 10S solenoid and 4SD drive

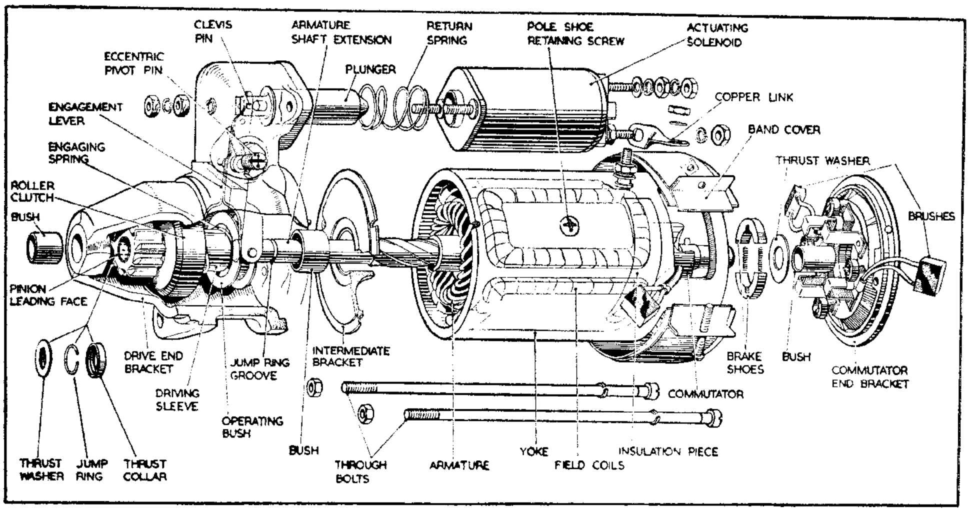

Fig. 10
Solenoid pre-engaged starting motor, model M418G, with models 10S solenoid and 4SD drive

reaction anchors for the springs. The merits of this clutch are its simplicity and efficiency.

(*vii*) The clutches are sealed in a rolled over steel outer cover and cannot be dismantled for subsequent reassembly.

(*f*) STARTER SOLENOIDS

(*i*) Starter solenoids are electro-magnetic actuators mounted pick-a-back fashion on the yokes of pre-engaged starting motors. They contain a soft iron plunger (linked to the engaging lever), the starter switch contacts, and a coil consisting of two windings, i.e., a heavy gauge pull-in or series winding, and a lighter gauge hold-on or shunt winding.

Initially, both windings are energised in parallel when the starter device is operated, but the pull-in winding is shorted out by the starter switch contacts at the instant of closure—its duty having been effected.

Magnetically, the windings are mutually assisting.

(*ii*) Normally, an earth return starter solenoid has three terminals, two large and one small, but some carry an additional small terminal marked 'IGN' and are used in conjunction with ignition coil model BA7. These units have an auxiliary phosphor bronze fixed contact which serves to short out the ignition coil ballast resistor during starting, thus ensuring that the terminal voltage (and therefore the performance) of the coil at this time remains almost unaffected by the drop in battery voltage.

(*iii*) Like the roller clutch assemblies, starter solenoids considered in this SECTION of the Workshop Manual are each sealed in a rolled-over steel outer case or body and cannot be dismantled for subsequent reassembly.

(*iv*) Starter solenoid model 6S (in which the plunger and the moving contact spindle formed a single assembly) is now obsolete, smaller machines being now fitted with model 9S and larger machines with model 10S—the latter models having separate plunger and spindle assemblies.

(*g*) SPECIAL FEATURES

(*i*) A feature peculiar to those of model M35G machines having 37-slot armatures is that the end brackets are each secured to the yoke by two short hook bolts, there being insufficient space between the larger field coils used in these machines to accommodate the conventional pair of through bolts.

(*ii*) Oil sealing is provided in those starting motors subject to oil ingress, or whose drive mechanisms are located or operate in excessive oil mist such as occurs, for example, when engagement is made with certain automatic transmission systems.

Sealing is effected with an intermediate bracket incorporating an oil seal, and a rubber bag or shroud to isolate all that part of the engagement mechanism (including the solenoid plunger) above the eccentric pivot pin.

2. MAINTENANCE

Every 24,000 miles, 2,800 running hours or 2 years, whichever occurs first.

(*a*) INSPECTION OF BRUSHGEAR AND COMMUTATOR

(*i*) Remove the starting motor from the engine and clean it, preparatory to slackening and sliding back the inspection window band cover.

(*ii*) See that the brushes are of adequate length and are free to move in the brush boxes. Damage will be caused to the commutator if brushes are permitted to wear until, depending on the design, either the embedded ends of the flexible connectors become exposed at the running surface or the spring arms make contact with the brush boxes. See table below for detailed data.

(*iii*) Check that the commutator is free from pitting and burning. If necessary, clean with a petrol moistened cloth. Should this be ineffective, rotate the armature and polish the commutator with fine glass paper. Afterwards, blow out all abrasive dust with a dry air blast.

(*iv*) A badly worn commutator can be re-skimmed by first rough turning and then diamond turning—**but the insulators must not be undercut.**

(*b*) BRUSHGEAR DATA

	Model	*Length of Brush when half the available wearing length has been worn away :* *	*Minimum Spring Pressure on Brush when half the available wearing length has been worn away :*	*Minimum Spring Pressure on New Brush :*
(*i*)	M3	13/32″ (10.3 mm.)	25 oz. (0.71 kg.)	34 oz. (0.96 kg.)
(*ii*)	M325	13/32″ (10.3 mm.)	30 oz. (0.85 kg.)	38 oz. (1.08 kg.)
(*iii*)	M35G	7/16″ (11.1 mm.)	35 oz. (0.99 kg.)	38 oz. (1.08 kg.)
(*iv*)	M418G	13/32″ (10.3 mm.)	32 oz. (0.91 kg.)	36 oz. (1.02 kg.)
(*v*)	M45G	9/16″ (14.3 mm.)	43 oz. (1.22 kg.)	52 oz. (1.47 kg.)

*Starting motor brushes do not wear at a constant rate. The rate of wear accelerates as spring pressures decrease—due to shortening of the brushes through wear, and to the reduction of commutator diameter through wear or skimming.

The time taken to wear away the first half of the available wearing length normally extends well beyond that to reach the point of major engine overhaul. After this, the rate of wear accelerates. For this reason, we recommend that brushes are renewed when worn to the lengths quoted above.

3. TEST DATA

(*a*) STARTING MOTORS

Model	Clearance Between Pinion and Thrust Washer (or Jump Ring) in Fully Engaged Position:[1]		Voltage to be Applied to Solenoid Shunt Winding (i.e. Copper Link Removed)[3] when Checking Pinion Clearance:	Typical Lock Torque and Maximum Current (inclusive of solenoid current, when applicable) at the Voltage quoted:				Typical Torque at 1,000 r.p.m. and Maximum Current (inclusive of solenoid current, when applicable) at the Voltage quoted:				Typical Light Running Current (inclusive of solenoid current, when applicable) at 12 volts, and Speed:		Voltage to be applied to Solenoid Shunt Winding (i.e. Copper Link Removed) when checking Starter Switch; See para. 4 (*c*) (*i*):
	In.	Mm.	Volts	Volts	Lb.-ft.	Kg.-m.	Amp.	Volts	Lb.-ft.	Kg.-m.	Amp.	Amp.	R.p.m.	Volts
(*i*) M3														
33-slot armature; yoke length $4\frac{1}{16}$" (103mm.); solenoid operated:	0.005–0.010	0.127–0.254	6.0	7.0	4.5	0.62	260	8.7	3.3	0.46	245	60	6,500– 7,500	6.0
33-slot armature; yoke length $4\frac{23}{32}$" (121mm.); manually operated:	0.005–0.010	0.127–0.254	—	7.0	5.8	0.80	262	8.8	3.0	0.41	215	50	6,500– 7,500	—
(*ii*) M325														
29-slot armature:	0.020–0.030	0.508–0.762	6.0	7.0	7.5	1.04	350	8.5	4.5	0.62	250	65	8,000– 9,000	7.0
Renault 25309 only:	0.005–0.010	0.127–0.254	7.0	7.0	7.5	1.04	350	8.5	4.5	0.62	250	65	8,000– 9,000	8.0
33-slot armature:	0.005–0.010	0.127–0.254	7.0	7.1	7.8	1.08	350	8.8	5.2	0.72	235	65	8,000– 9,000	7.0
(*iii*) M35G														
29-slot armature:	0.005–0.010	0.127–0.254	12.0	7.0	7.2	0.99	336	8.5	4.5	0.62	266	70	9,000–10,000	8.0
37-slot armature:	0.005–0.010	0.127–0.254	12.0	7.0	8.6	1.19	280	9.4	4.3	0.59	210	60	5,500– 6,000	7.2
G. M.–Holden's 25067 only:	0.610–0.630[2]	15.49–16.00	12.0	7.0	8.6	1.19	280	9.4	4.3	0.59	210	60	5,500– 6,000	6.0
(*iv*) M418G														
23-slot armature:	0.005–0.010	0.127–0.254	12.0	7.5	17.5	2.42	660	9.0	9.0	1.24	450	85	5,500– 6,500	10.0
37-slot armature:	0.005–0.010	0.127–0.254	12.0	7.2	17.0	2.35	458	9.3	7.0	0.97	260	70	5,800– 6,500	6.0
(*v*) M45G														
37-slot armature:	0.005–0.010	0.127–0.254	12.0	7.35	18.8	2.60	435	9.75	6.7	0.93	220	70	5,800– 6,500	10.0

1 Before measuring, push drive assembly lightly in direction of retraction.
In solenoid actuated machines, adjustment effected by turning eccentric pivot bolt in D.E. bracket.
Arrow head on bolt to point upwards between ends of semi-circular marker arrow on casting.
In manually operated machines, adjustment effected by turning switch actuating screw in engaging lever.
Both forms of setting are secured with a lock nut.

2 Measured between the vertical mounting face of the D.E. bracket fixing flange and the leading edge of the pinion.

3 If the time taken to carry out this checking and re-setting is likely to be prolonged, the solenoid shunt winding may overheat. To obviate this condition, leave the copper link in place and apply only 4 volts between the solenoid (small unmarked) terminal and earth—thus energising both shunt and series windings. This mode of connection should not cause the armature to rotate.

(*b*) STARTER SOLENOIDS

(*i*) Model	6S	9S	10S
(*ii*) Resistance[1] of closing or series winding (measured between terminal 'STA' and small terminal)	0.23—0.27 ohm	0.40—0.46 ohm	0.36—0.42 ohm (0.28—0.32)[2]
(*iii*) Resistance[1] of hold-on or shunt winding (measured between small terminal and solenoid outer case)	0.71—0.88 ohm	1.10—1.35 ohm (1.35—1.60)[3]	1.49—1.71 ohm (1.1—1.3)[2]
(*iv*) Force required to close contacts : Plunger return spring in place	7—9 lb. (3.18—4.08 kg.)	—	—
Plunger return spring removed	—	4—6 lb. (1.81—2.72 kg.)	4.5—8 lb. (2.04—3.63 kg.)
(*v*) Force required to push plunger fully home : Plunger return spring in place	13—18 lb. (5.90—8.16 kg.)	—	—
Plunger return spring removed	—	7—11 lb. (3.18—4.99 kg.)	9—13 lb. (4.08—5.90 kg.)
(*vi*) Spindle movement to close contacts	0.545″—0.555″ (13.8—14.1 mm.)	0.109″—0.142″ (2.8—3.6 mm.)	0.092″—0.171″ (2.3—4.3 mm.)
(*vii*) Total spindle movement (inclusive of contact follow-through)	0.606″—0.663″ (15.4—16.8 mm.)	0.170″—0.210″ (4.3—5.3 mm.)	0.203″—0.221″ (5.1—5.6 mm.)
(*viii*) Maximum voltage drop[4] measured across starter switch contacts, with hold-on winding energised at 10 volts	150mV. at 300A.	200mV. at 200A.	150mV. at 300A.
(*ix*) Maximum voltage drop[4] measured across ignition coil ballast resistor shorting contacts (when fitted), with hold-on winding energised at 10 volts	—	100mV. at 5A.	100mV. at 5A.

[1] The resistance values given in (*ii*) and (*iii*) above should be checked by the Wheatstone Bridge method, or by some other equally accurate method suitable for the low quantities involved.

[2] Applicable only to 76705 at date of publication.

[3] Applicable only to 9S solenoids manufactured before November 1959.

[4] The 'maximum' voltage drop values given in (*viii*) and (*ix*) above are applicable to new units. In service, higher values (consistent with satisfactory functioning) are permissible. Since consecutive readings can differ, the test should be repeated several times before a unit is accepted or rejected for further service.

4. SERVICING

Kits of Sundry Parts are available for servicing purposes containing such replacement items as pole shoe retaining screws, dowel pegs, insulating bushes, and assorted washers and nuts.

(a) GENERAL NOTES

(i) The symptomatic fault checks and procedures for testing, dismantling, replacement of parts and the reassembly of these starting motors is broadly as given previously for other similar units in SECTIONS B–2, B–4 and B–6. When necessary, reference should be made to these SECTIONS for information which, in the interests of conserving space, may not have been repeated here.

(ii) When reassembling, the following parts should be tightened to the torques specified :

M45G Through Bolts (High Tensile Steel) :	8.0 lb.-ft. (1.11 kg.-m.)
Other Through Bolts (also Hook Bolts) :	6.0 lb.-ft. (0.83 kg.-m.)
Solenoid Fixing Bolts :	4.5 lb.-ft. (0.62 kg.-m.)
Nuts on Solenoid Copper Main Terminals :	20 lb.-in. (0.23 kg.-m.)

(iii) The cranked ends of hook bolts (when used) are push-fitted into the yoke—internally at the C.E. and externally at the D.E.

(iv) When refitting a C.E. bracket containing a brake ring insert, see that the moulded brake shoes seat squarely, and then turn them so that the ends of the cross peg in the armature shaft engage correctly with the slots in the shoes.

(v) When the starting motor pinion is in the fully retracted non-operative position, the distance between the engaging edge of the pinion and the flywheel ring gear is determined by the sum of all the endwise manufacturing and tolerances of the starting motor and engine components.

The nominal dimension for this pinion out-of-mesh clearance is $\frac{1}{8}'' \pm \frac{1}{32}''$ (3.17 mm. $\pm$0.8 mm.).

(b) CHECKING ROLLER CLUTCH DRIVES

A roller clutch drive assembly in good condition will:—

(i) Provide instantaneous take-up of the drive in the one direction.

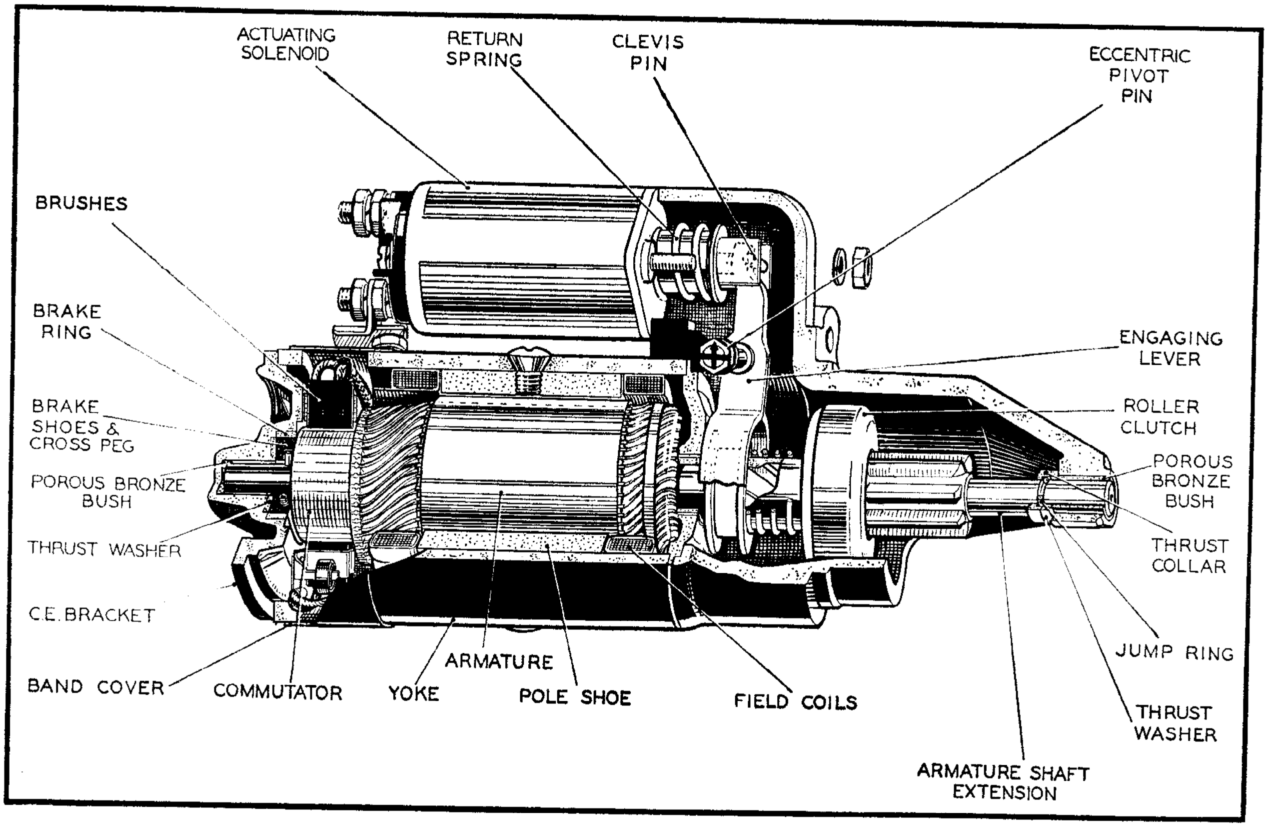

Fig. 11
Solenoid pre-engaged starting motor, model M45G, with models 10S solenoid and 5SD drive

(*ii*) Rotate easily and smoothly in the other.

(*iii*) Be free to move round or along the shaft splines without roughness or tendency to bind.

Similarly, the operating bush must be free to slide smoothly along the driving sleeve when the engagement spring is compressed.

Trunnion blocks (when fitted) must pivot freely on the pegs of the engaging lever. All moving parts should be smeared liberally with Shell Retinax 'A' grease, or an equivalent alternative.

(c) CHECKING OPENING AND CLOSING OF STARTER SWITCH CONTACTS

The following checks assume that pinion travel has been correctly set, using the eccentric pivot pin in solenoid operated machines and the switch actuating screw in manually operated machines.

When necessary, replace the solenoid or 4SA switch.

(*i*) *Solenoid Operated Machines*

Remove the copper link connecting solenoid terminal 'STA' with the starting motor terminal.

Connect, through a switch, a supply of appropriate voltage (see end column in table on page 8) between the solenoid (small unmarked) terminal and large terminal 'STA'.

Connect a separately energised test lamp circuit across the solenoid main terminals.

Insert a stop in the drive end bracket to restrict the pinion travel to that of out-of-mesh clearance—normally, a nominal $\frac{1}{8}$" (3.17mm.). An open-ended spanner(s) of appropriate size and thickness can often be utilised for this purpose—its jaws embracing the armature shaft extension.

Energise the shunt winding.

The solenoid contacts should close fully and remain closed, as indicated by the test lamp being switched on and emitting a steady light.

Switch off and remove the stop.

Switch on and hold the pinion assembly in the fully engaged position.

Switch off and observe the test lamp.

The solenoid contacts should open, as indicated by the test lamp being switched off.

(*ii*) *Manually Operated Machines*

Insert a stop in the drive end bracket, as in (*i*) above, to restrict the pinion travel to $\frac{1}{8}$" (3.17mm.) from the fully retracted position.

Operate the engaging lever to its fullest extent. The switch contacts should fully close.

Release the engaging lever and remove the stop. Operate the engaging lever to its fullest extent and hold the pinion assembly in the fully engaged position.

Release the engaging lever. The switch contacts should open—with the pinion assembly held in the fully engaged position.