JOHN LANGAN, A.M.I. Prod.E., CONCLUDES HIS INFORMATIVE ARTICLE WHICH TELLS YOU JUST HOW TO SET ABOUT

# BUILDING YOUR OWN MOTOR

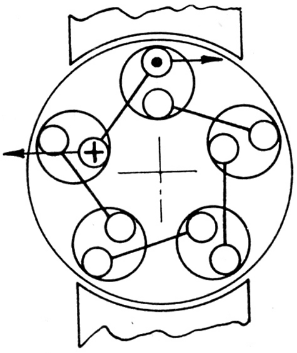


FIG. 24

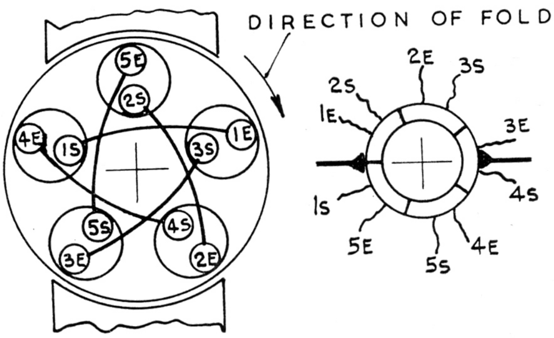



FIG. 25

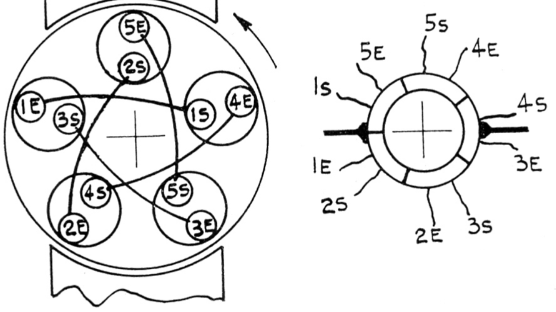



FIG. 26.

MAKE sure the coils are all wound one way and distinguish the start and end of the coil by means of pieces of sticky paper marked "S" (for start) and "E" (for end). Having wound sufficient coils, then also mark the paper tabs with the coil number. This is useful when you come to solder the wires to the commutator.

In fitting the coils into the slots you may wonder why the coil is not made to go from one slot to the next adjacent slot, and so on around the armature. Fig. 24 shows such an arrangement and by taking the forces acting on one coil as an example it will be seen at once that this does not give an efficient arrangement for causing rotation, since the forces are against each other on the same side of the armature centre line. To produce maximum torque therefore, the coil must extend further across the armature, so that the forces induced are across the centre. For this reason, when using five poles it is convenient to place the coils across every other slot as in Fig. 25.

In fitting the coils it is essential that there shall not be any short circuit from the coils through to the armature plates. This can easily happen when pressing the coils into the slots and scraping the wire against the armature plates. To prevent this, various insulating materials have been used, such as 0.005 in. "Empire" cloth, oilsilk and goldbeaters' skin, but there is now available a very thin electricians' sticky tape. The one I have used is $\frac{1}{2}$ in. wide and 0.004 in. thick. This is applied to the slots, and overlaps the width of the armature plates as in Fig. 27. Leakage from the coils direct through the shaft is prevented by fitting a $\frac{5}{16}$ in. length of plastic tubing on to the shaft at each end of the armature plates.

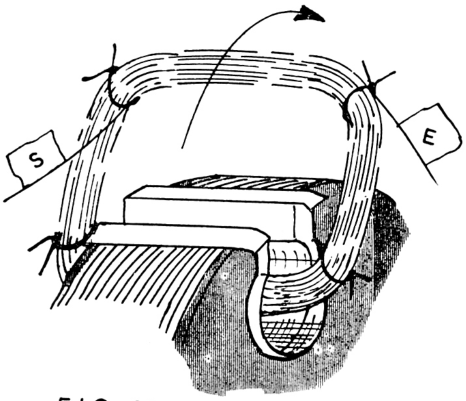



FIG. 27

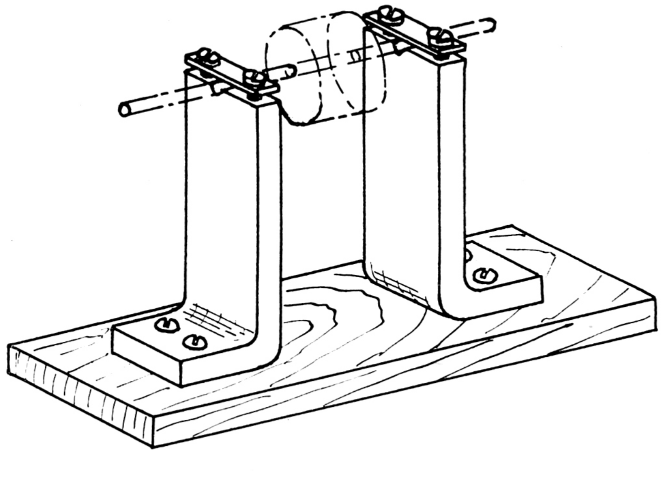


FIG. 30.

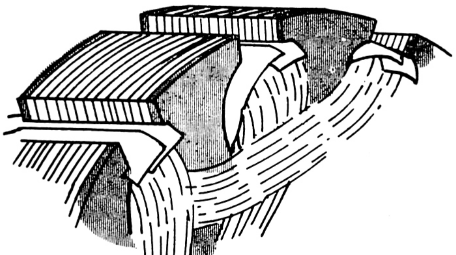


FIG 28

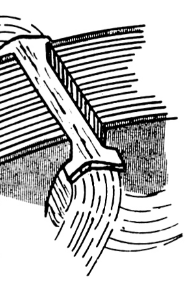


FIG 29

Place the separate coils on the table in sequence and with the starts and ends arranged the same. On one of my motors I must have got a coil the wrong way round; the completed motor seemed perfectly all right with no leaks, but it just would not keep turning. By passing a current through the coils and going around the armature with a compass, I soon located one coil which made the needle point north when all the others pointed south. The wires at this stage had been shellacked together, so that there was nothing for it but to cut all the wire off and fit a new set of coils.

Fitting coils is a " three handed " sort of job, and I found a simple stand to hold the armature whilst folding over the coils a most useful piece of equipment. I made my stand from the metal brackets of two old telephone relays, but the general idea is as shown at Fig. 30. Place the coils in the slots as Fig. 27 and fold them over each in sequence. It is as well to adopt a direction for this, say, relative to the commutator end of the armature, as a change of direction will affect the sequence of the order for soldering the wire ends on the commutator as shown in Figs. 25 and 26. With all the coils squeezed neatly into the slots, bring all the wire ends across the slots so as to have them all at the commutator end, and then fold back the insulating tape into the slots to seal in the wire, see Fig. 28. Finally, key the coils into the slots by means of a slip of 0.010 in. thick fibre (Fig. 29). The commutator, an excellent job from George Mellor, may now be pressed on to the shaft, taking care to first fit the ebonite washer (Fig. 31).

Carefully check that the distance of the commutator from the armature plates is correct to suit the general arrangement, Fig. 1, and also that the slots of the commutator are in true relationship to the coils. It will be remembered that a coil which is horizontal to the magnetic field of the magnet has to be short circuited, and this is the key to starting the sequence of wire connections to the commutator. Whatever the brush gear position relative to the magnet, assuming coil No. 1 to be across the magnet field, then the brush must be across the gap of the commutator segments of this coil's " start " and " end " connections. The other connections to the commutator then follow. Figs. 25 and 26 show such connections depending on how the coils have been fitted to the armature. With coil No 1 in this short circuited position, the other coils form an electrical circuit as shown at Fig. 32 from which it will be noted that the current flowing through the coils, via the commutator, enters coils Nos 2 and 3 from the " start " end, and enters Nos 5 and 4 from the " end."

Noting the position of coils 2, 3, 4 and 5 in the magnet field, and also the current direction, we can see from Fig. 32 that the forces induced in these coils are all producing a torque on the armature shaft in the same direction, and, therefore, continuous rotation is assured. The ebonite washer between the commutator and the coils will be seen to have five slots and the coil ends are fitted into these to lead them to the commutator for soldering. In this way the wires are also protected from rubbing against the adjacent edge of the magnet. Durafix applied when pressing on the commutator and its ebonite washers will help to keep them in position. With the armature complete, carefully warm it in the oven to remove any sign of damp and then soak it in shellac varnish. An empty jar from the large size of meat paste is very useful for this job. Allow the armature to harden and then fill in any

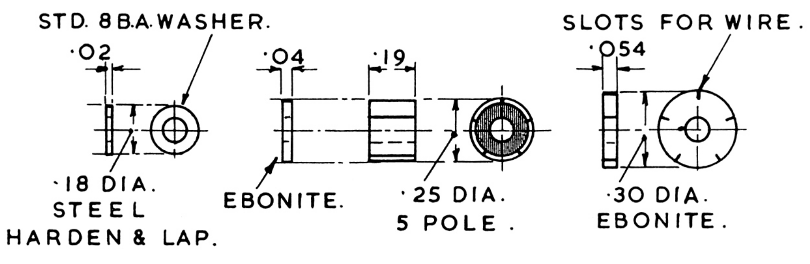



FIG. 31 COMMUTATOR & WASHERS.

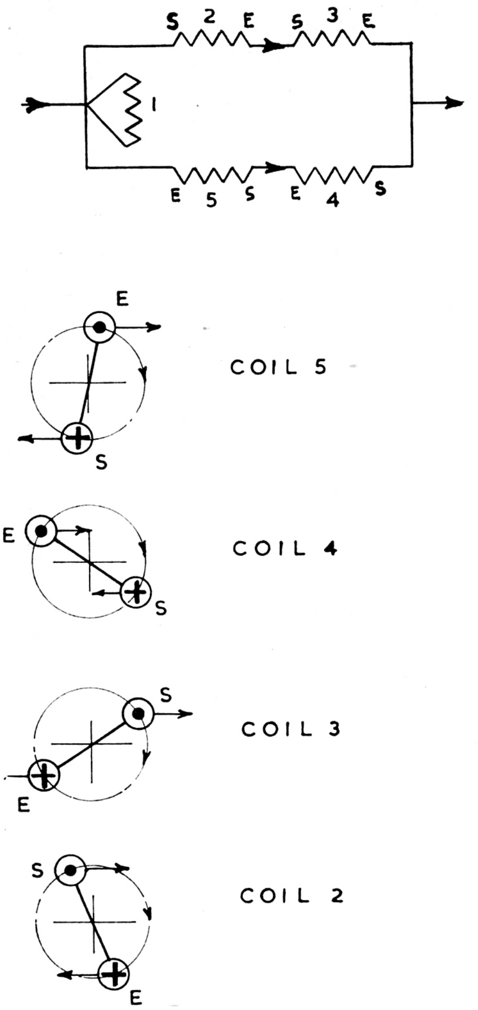



FIG. 32

hollows with Durafix. The armature is now put into the lathe and the outside diameter of the plates skimmed up with a sharp tool. This removes the varnish and also makes the finished size for the armature. Make sure that you use the tailstock as a steady for this operation, otherwise the armature shaft will be out of true when finished.

At each end of the armature it is necessary to have a thrust bearing and for this purpose plain 8 B.A. (small) steel and brass washers are used. The steel washers are hardened or toughened by putting a number of them on to a piece of wire and holding them in a gas flame until cherry red and then plunging them into water. The washers are then rubbed on an oilstone to obtain a smooth and flat finish. A brass washer, also smooth and flat, is placed between two steel washers to form a complete thrust bearing.

Proceeding now to the more mechanical parts which are shown in the photograph together with a completed motor. We shall commence with the manufacture of the main body, Fig. 33. This is made from a length of $\frac{7}{8}$ in. dia., 16 gauge, hard solid drawn brass tube which is cut and then trimmed to length in the lathe. Skim up the outside diameter to 0.87 in. dia. and mark of the position of No. 1 jaw of the lathe chuck. Any further work on the body is then repeated in this position. The body is then bored as shown so that the magnet, pole pieces (which are in one piece at this stage) and the end cover are all push fits. To enable these items to be held in place it is necessary to mark out the body for drilling and tapping. For this purpose I made some additions for my "EW" lathe to enable me to index spacing accurately and also scribe lines with the aid of the cross-slide. These attachments are shown in the photograph and comprise a plunger mechanism in the main gearwheel on the lathe spindle. The wheel as shown has been marked for certain divisions of the circle. On the cross-slide I have a retractable scriber which after bolting down is moved forward to have a slight pressure contact with the job so that all scribed lines have the same pressure. By this means, lines may be scribed on the brass body horizontally and at various spacings by indexing, and also circular lines scribed by simply turning the lathe spindle by hand. Line the pointer up to the end of the brass tube and, by means of moving the cross-slide along the bed, measure off and scribe the position of the holes along the tube as shown (Fig. 33). The marking of the horizontal lines to give the spacing of the holes is shown at Fig. 33, "A" to "G."

"A." Start with index gear at zero. We have two holes for the pole piece

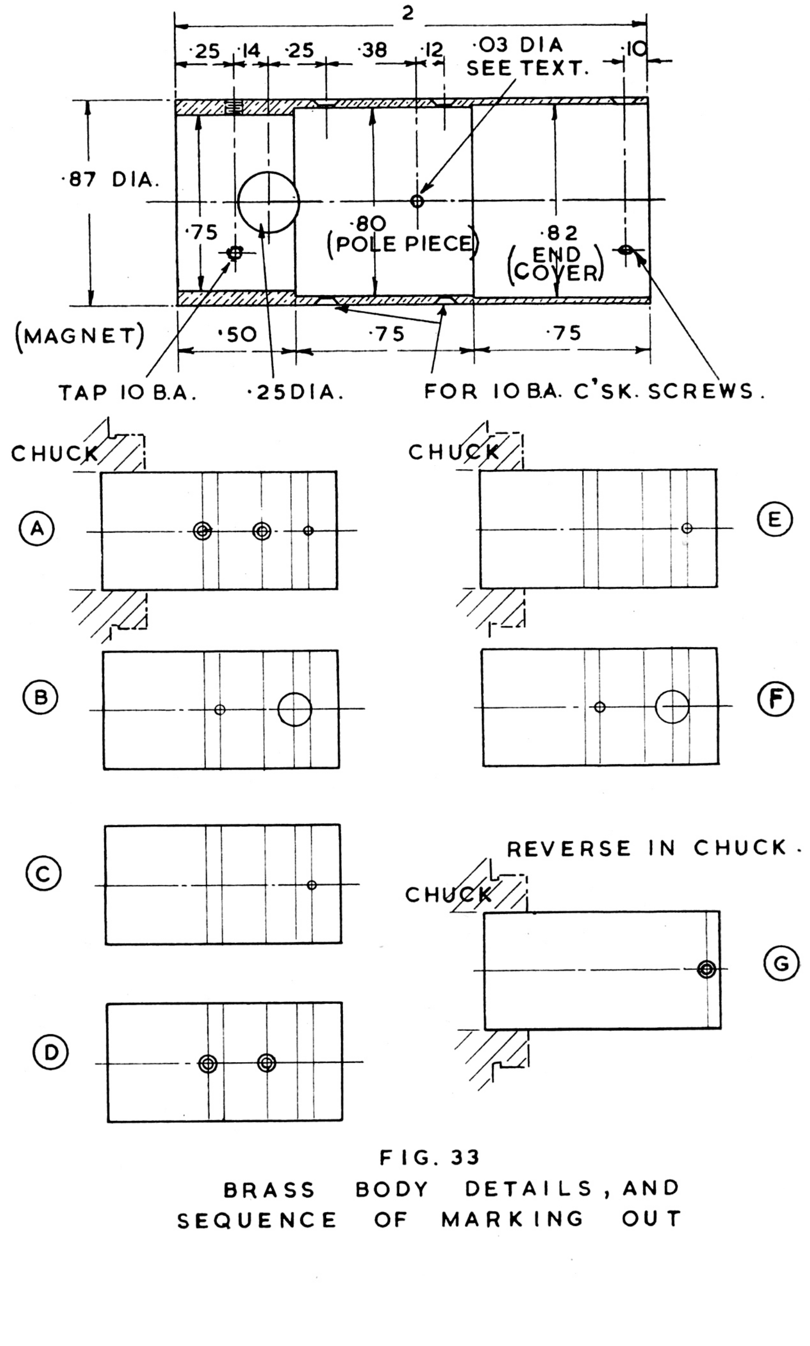



FIG. 33

BRASS BODY DETAILS, AND SEQUENCE OF MARKING OUT

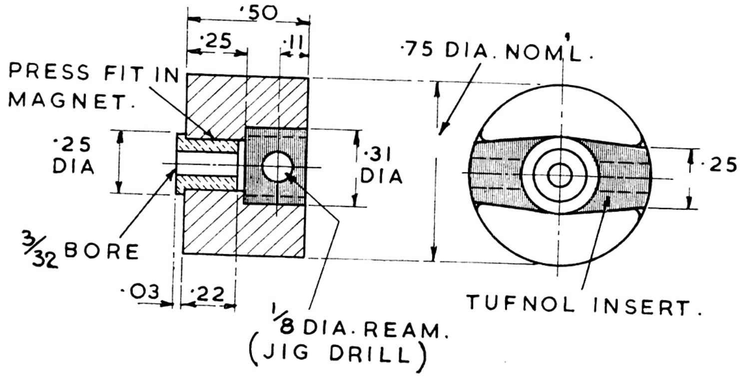
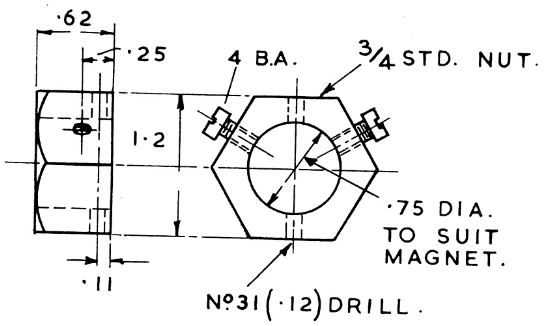



FIG. 34 MAGNET WITH INSERT & BEARING.




DRILL JIG FOR BRUSH GEAR. FIG. 35

and a tapped hole for gripping the magnet.

"B." Index quarter turn. Scribe for 0.03 in. hole at the centre of the armature and a ¼ in. hole to clear brush gear.

"C." Index 1/12 turn (1/3 from start). Tapped hole for magnet.

"D." Index 1/6 turn (1/2 from start). Two holes for pole piece.

"E." Index 1/6 turn (2/3 from start). Tapped hole for magnet.

"F." Index 1/12 turn (3/4 from start). 0.03 in. hole at the centre of the armature and a ¼ in. hole to clear brush gear.

"G." Reverse the body in the lathe chuck and reset at zero. Mark off three holes for the end cover. On my motor these holes are not equally spaced as I have to allow for some cutting away to get the motor under the back end of the tender.

Fig. 34 shows the standard ¾ in. dia. Eclipse button magnet into which a bronze bearing is pressed. The bearing is drilled and reamed for the 3/32 in. shaft only after it is fitted into the body. At the other side of the magnet the slot is filled with a piece of Tufnol held in by Araldite. In view of glueing this insulation into a magnet the Araldite was left for a few days to cure slowly. The maximum space was then turned out of the Tufnol so as to clear the commutator.

The problem now was to drill a hole across the Tufnol truly through the centre and at the correct distance from the face to fit the brush gear. For this purpose I made a simple drill jig from a standard ¾ in. nut as shown in Fig. 35. The thread was removed from the nut by boring to suit the magnet diameter. If you intend to make a number of motors it is advisable to purchase the magnets in one group to ensure they are the same size. A brass plug was turned to fit the jig leaving a tiny pip at the face. Blue the jig with spectro colour to assist marking out. With the plug in position it was then possible to scribe two parallel lines across the nut face by using a set square against the pip and so obtain a central position for the two holes. To obtain an equal position for the distance of the holes from the nut face a piece of material was made the correct thickness and used as a gauge with which to scribe a line whilst the nut face was on a flat surface. With a scribed line across the Tufnol face of the magnet and lined up to the centre line on the jig it was a simple matter to drill the holes for the brush gear. The holes were then reamed to obtain a good size and smooth finish.

The brush gear details are shown in Fig. 36. These are, however, the last

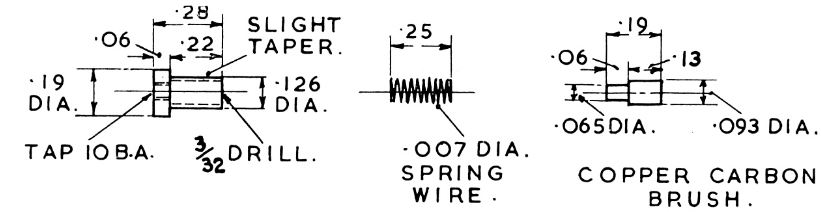
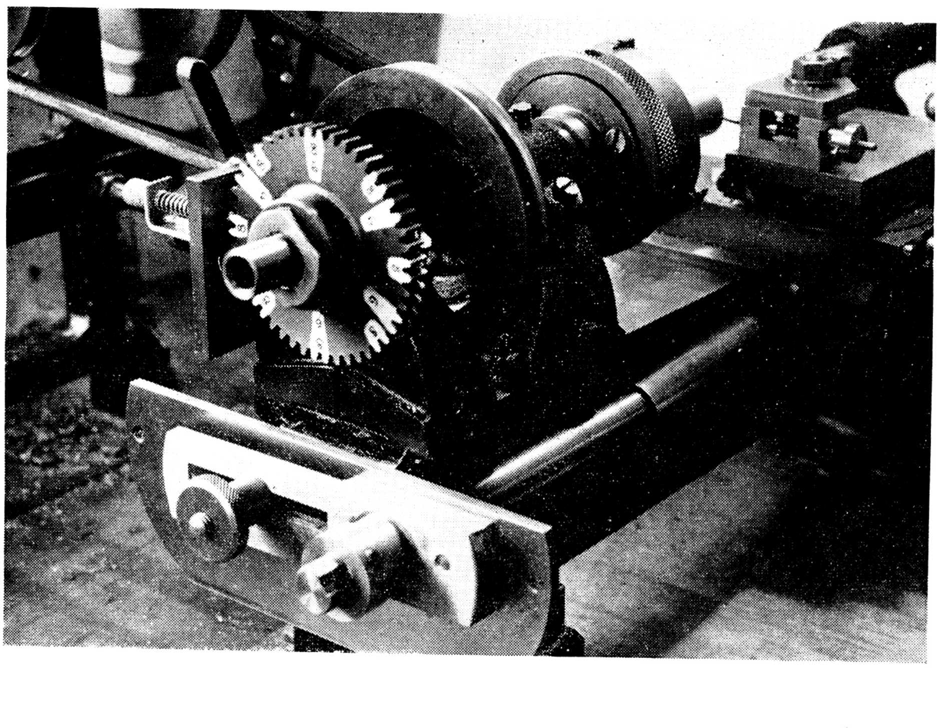



FIG. 36 BRUSH GEAR.



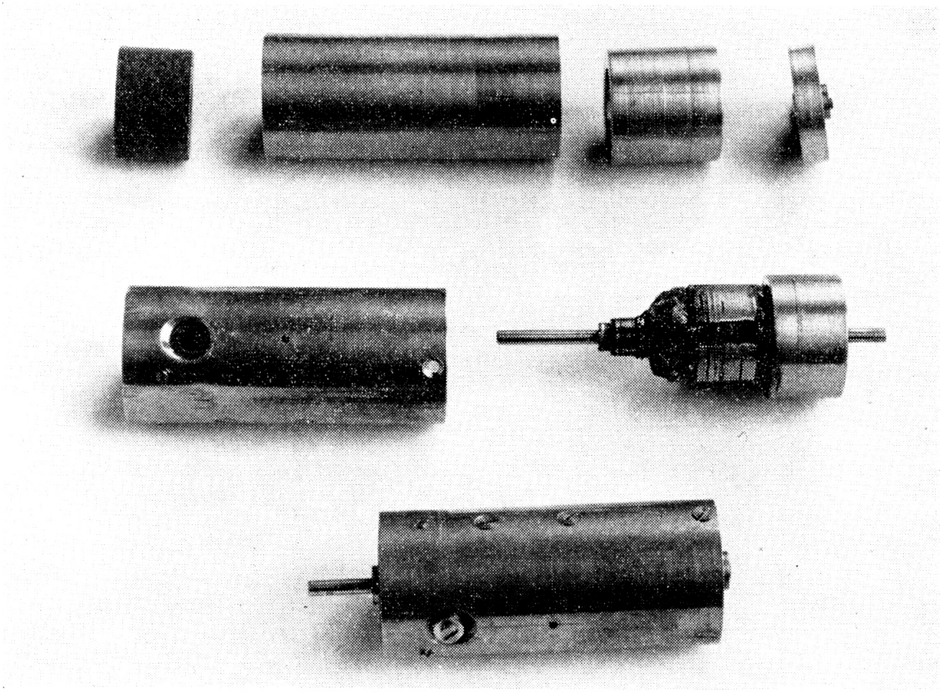
Indexing in lathe.

items to be fitted when assembling the motor due to the spring loaded brushes having to pass over the collars. Note that the 10 B.A. tapped hole in the brass cup which holds the spring, receives a short screw. These screws are only for holding the connecting current wires (to save soldering) and should not influence the brush spring pressure.

The springs are made in the lathe, using a 0.055 in. dia. arbor. Wind the wire close and tight and afterwards stretch evenly to make a compression spring. Use the cup as a gauge for snipping the spring off to length. This will give about 10 turns of wire. When winding springs in the lathe a little practice is required in order to judge the moment to switch off. The over-run of the lathe puts on quite a few turns of wire.

The copper carbon brushes are made from much larger brushes which were obtained from the "Ex Government" shops. The larger brush was first cut up into strips about ⅛ in. square by using a fine toothed piercing saw. These were then turned to size in the lathe.

It will be seen from Fig. 37 that the pole pieces allow for a maximum area to be against the magnet and are of a spiral shape rather than the parallel type usually used. In larger motors the armature is very often wound with the slots spiral and this reduces the air noise created as the poles move past each other. This way of winding is not so easy in very small motors. The easier way of making the poles spiral was tried some years ago and I have since used this type on all my motors. Although my reason for doing so was not for noise prevention, but the belief that some improvement in slow starting and running might be achieved. The pole pieces are first turned in one piece as at Fig. 37 and it is essential to keep them like this until they have been secured to the body by the 10 B.A. screws. The magnet requires to be in position when marking off from the main casing to ensure correct relationship along the body of all the components. When secured, it is possible to put a 0.03 in. drill through the hole in the casing and make a centre mark on each side of the pole piece. Remove the pole piece and from the centre mark describe the 0.38 in. dia. circle as shown. With an adjustable square it is now possible to mark off the 16 deg. angle. Cut and file along the lines and be sure to remove all burrs. The separate pole pieces may now be replaced in position in the brass body. There is nothing difficult in making the pole pieces, but I did find that, due to having only a small lathe, it was a great help to have the steel bar first drilled with ½ in. bore.



The various components and a complete motor. Brian Monaghan took the pictures.

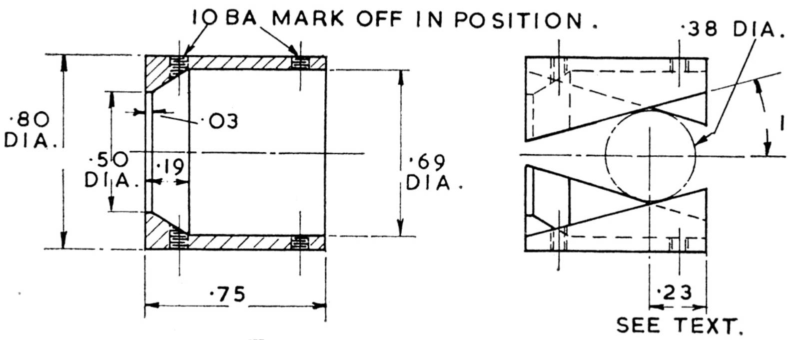



FIG. 37 SPIRAL POLE PIECES.

The end cover at Fig. 38 is a simple turning job with a bronze bearing pressed in. Once again, as in the case of the magnet, it is essential to drill and ream the bronze bearing after the end cover is fixed in position in the main casing.

The flywheel, Fig. 39, is made with a brass boss on to which a lead outer part is cast. To enable the lead to grip or key to the brass boss, ridges are cut into the brass. The boss is turned and bored, but no holes are drilled and tapped for the securing screws at this stage, for they would only get filled with lead (Fig. 40). The mould is a standard nut bored out to cast the flywheel oversize and so leave a machining allowance. The steel base of the mould is a separate piece, turned to suit the shape of the profile on the flywheel. The brass boss is placed on a spigot in the mould and the molten lead poured in. For melting the lead I use a small pie baking tin which fits nicely on

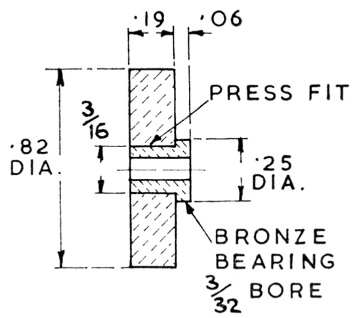



FIG. 38 END COVER.

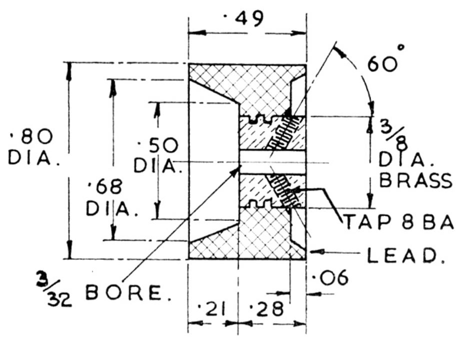



FIG. 39 FLYWHEEL

the gas ring. One edge of the tin is bent so as to form a lip for pouring easily. The lead, and bits from old printing blocks, is cut into small pieces to melt more quickly. After casting, the brass boss is drilled and tapped for the set-screws. A piece of wood cut to the required angle (Fig. 41) serves to hold the flywheel for this operation.

Due to the softness of the lead, machining the flywheel presents a few problems. To remove the bulk of the surplus metal I found a split ring chuck, as at Fig. 42, very helpful. Holding the flywheel in the ordinary 3-jaw chuck is not advised as the jaws dig into the flywheel. To finish to size it is necessary to hold the flywheel on a piece of shaft, as at Fig. 43 and secure by the setscrews. A small flat filed on to the shaft to receive the setscrew makes a more positive drive. Care and patience are required when turning, for the metal comes off very easily, but do not be tempted to take heavy cuts. It is also advisable to support the shaft at the outer end as shown in Fig. 43. When finished, put the flywheel on to the armature shaft and check the distance from the commutator over the flywheel.

## BUILDING YOUR OWN MOTOR

With the magnet and the pole pieces already secured to the body casing, assembly of the motor details may now be completed. Put the thrust washers on to the commutator end of the armature shaft and, after slightly oiling, slide the shaft into the casing. Looking down the hole for the brush gear, check the position of the commutator. Especially check that there is no excess of solder to the wires on the commutator, and that the thrust washers will in fact take the thrust before the wires can contact the edge of the magnet. The steel thrust washer at the flywheel end is now fitted and the end cover placed into position. A slight amount of side play is permissible and any adjustment required for free running is made by altering the width of the washer. Adjustment of the tightening pressure of the screws fixing the end cover may also be required to obtain the best position.

The brush gear may now be pressed into position and we are then ready for the exciting moment of the first run for the motor. It is always advisable to connect to a controller having an overload trip, just in case of trouble. It is sometimes difficult to see whether the motor shaft is turning and so I generally fit a spare flywheel to the shaft extension. After some initial adjustment as described, these motors have run well with very good response to the controller.

The motors in the foregoing notes have been built with specific locos in mind and are not expected to meet all applications. It is hoped, however, that in describing my methods and experience of building them, that sufficient information has been given to enable the reader to adapt the ideas presented to meet his own requirements. If, as a result of this article, a better understanding of motors is achieved, then my main objective will have been fulfilled.

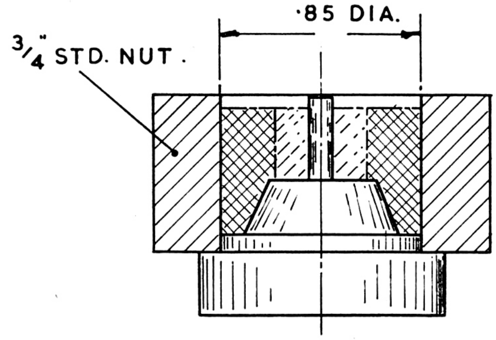



FIG.40 MOULD FOR CASTING FLYWHEEL.

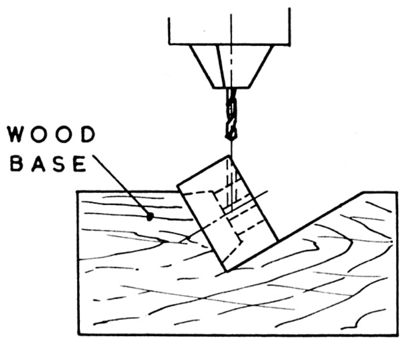



FIG.41 DRILLING FOR SETSCREW.

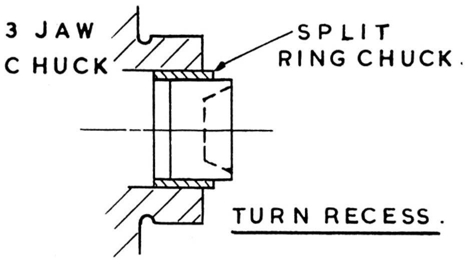



FIG. 42

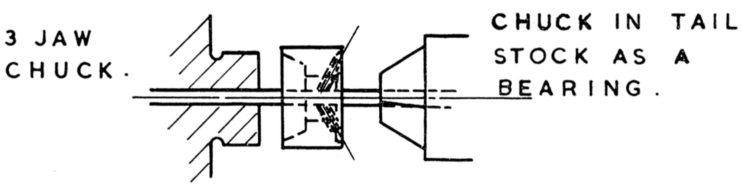



FIG.43 FINISH TURN FLYWHEEL.

## L.M.S. (N.C.C.) NARROW GAUGE COACHES

*Continued from page 609*

and numerals in yellow) for the body, and black for platform ironwork and underframes. In less austere days transfer lettering would have been used, and narrow gauge coaches bore the Midland coat-of-arms before grouping. Other similar vehicles included Nos 307, 316, 317, 319 and 320 (thirds). Nos 329 and 330 were composites, while No 312 was officially styled a " saloon " (as distinct from tramcar) with 22 third class seats. There was even an eight-wheeled brake van to match, open platforms and all. This was No 333. Few particulars of any of the foregoing have survived (most were scrapped when the Ballymena-Larne passenger service closed in 1933) and photographic evidence would be very welcome.

Any attempt at an accurate working model of this type of carriage means overcoming the problem of having fixed hornplates while allowing the truck frames enough play to negotiate reasonably sharp curves. Depending on the scale-gauge relationship, there might be enough clearance to allow the use of a conventional, but inside-framed, bogie behind a fixed frame with dummy axleboxes. This I leave with the experts, for No 306 would make a model full of character.