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HOW TO MAKE A SEWING MACHINE MOTOR WITHOUT CASTINGS.

By CECIL P. POOLE.

THE accompanying drawings, together with the following instructions, will enable any mechanic of average ability to build a highly efficient motor that will operate the heaviest of family sewing machines with a consumption of electrical energy only a trifle greater than that required to maintain an incandescent lamp. All the materials entering into the construction of the motor may be procured in almost any town or small city, and the total cost of the machine, excepting, of course, the labor, should not exceed five dollars.

The first operation is that of making the magnet, which consists of a bar of ordinary wrought iron, $1\frac{1}{2}$ inches square and $19\frac{1}{2}$ inches long, bent (while red hot) into a U, as shown by Fig. 1. After bending the iron into shape, cut out two concavities in the limbs, as indicated by the dotted lines, to a circle of $4\frac{1}{4}$ inches diameter. The center of the circle of which the concave surfaces form arcs must be $5\frac{1}{2}$ inches from the short part of the U, known as the magnet yoke, and exactly midway between the magnet limbs, so that an equal amount will be cut out of each limb. This cutting can be done by any blacksmith, as it does not need to be precise in the matter of the surfaces of the concavities, the only object being to remove the bulk of metal that is to be cut away in order to form the armature chamber.

Next smooth up the sides of the magnet on the flat of an emery wheel, rounding off the corners so that a face view of the ends of the limbs will be as shown by Fig. 2; the faces, *f, f*, should also be smoothed off with the emery wheel, as these form the base of the machine. Then bolt the magnet to the face-plate of the lathe so that the center of the circle, *a*, to which the magnet limbs were cut away coincides with the lathe centers, and bore out the armature chamber to $4\frac{1}{2}$ inches in diameter, leaving the magnet as shown by Fig. 3; the curved surfaces forming the armature chamber are known as pole-faces. If the sides of the magnet (by "sides" are meant the part facing the reader in Figs. 1, 3 and 5 and the corresponding part on the other side of the magnet) were not ground to a true parallel on the emery wheel, and it is highly probable that they were not, it is advisable to take a slight cut over the whole side exposed while the magnet is on the face-plate so as to have it perfectly plane, and also take a cut over the opposite side to insure parallelism.

The journal yokes and boxes come next. There will

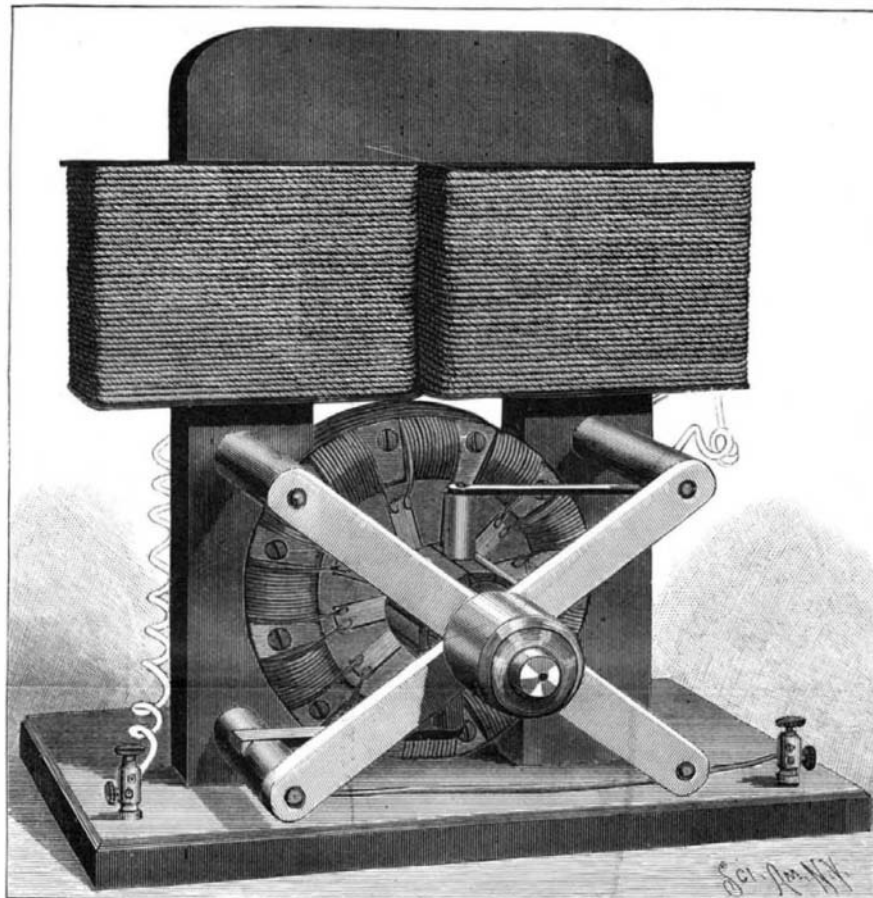
be two bearings and yokes, one for each side of the machine. Fig. 4 shows the parts necessary for one yoke and bearing; *y, y* are brass strips $6\frac{3}{8}$ inches long, 1 inch wide, and $\frac{1}{8}$ inch thick, with rounded ends; *b* is the box, made of a piece of round brass rod 1 inch in diameter and 2 inches long over all, one end being turned down to $\frac{3}{4}$ inch diameter for a distance of $\frac{3}{8}$

strips, *y, y*, have each a $\frac{3}{4}$ -inch hole drilled exactly in the center, several nicks being filed in the edges of these holes. Before putting the yoke together, tin the edges of these central holes and tin the small end of the box, *b*; then mount the strips on the end of the box so they will be at right angles with each other and so that the hole in the side of the box comes between two of the legs formed by the strips, and solder the whole at the center. Be sure to fill the nicks in the edges of the holes with solder.

When both yokes have been assembled, turn up a block of wood $1\frac{1}{2}$ inches thick to fit closely the armature chamber in the magnet limbs without spreading the latter. This block should have a $\frac{3}{8}$ -inch hole in the center, and it will be better to drill the hole first, mount the block on a $\frac{3}{8}$ -inch mandrel and turn it up true with the central hole. Put this block in the armature chamber with its $\frac{3}{8}$ -inch mandrel in the central hole, thread one yoke on one end of the mandrel and the other on the other end, turning the legs of each yoke to the position shown by Fig. 5. Clamp the whole together securely and drill four $\frac{1}{4}$ -inch holes, *h, h, h, h*, through the magnet limbs and both yokes; punch-mark one yoke and the face of the magnet limb on which it rests, so that in reassembling the machine the various parts will come back to the original position in which they were drilled; then take off the clamps and take off the yokes, remove the yokes and wooden block and anneal the magnet by heating it to a bright red and allowing the fire to die out with the iron covered up in the coals.

For mounting the yokes permanently on the magnet, four steel machine screws and eight distance pieces will be required. The screws are $\frac{1}{4}$ inch in diameter and $6\frac{1}{4}$ inches long under the head, and the head should be slotted. The distance pieces to hold the yokes away from the magnet are made from round brass rod 1 inch in diameter; two of them are $1\frac{1}{8}$ inches long, two are $1\frac{3}{8}$ inches long, two are $2\frac{1}{8}$ inches long, and the remaining two are $2\frac{3}{8}$ inches long. Fig. 6 shows one yoke mounted, with its distance pieces, *z, z, z, z*, and *s, s, s, s*, represent the thread ends of the screws. The yokes should be carefully fitted or trouble may result from non-alignment of the bearings.

The armature structure comes next. From some dealer in armature stampings procure one hundred rings of charcoal iron 4 inches in diameter outside and 3 inches in diameter inside. These rings must not be over $\frac{1}{8}$ inch thick and preferably about $\frac{1}{4}$ inch thick. Not all of the one hundred will be needed, but many will be spoiled in drilling. From a dealer in electrical supplies procure two rings of vulcanized fiber the



SEWING MACHINE MOTOR MADE BY AN AMATEUR.

inch, a $\frac{3}{8}$ -inch hole being drilled through the center and a $\frac{1}{2}$ -inch hole being drilled in one side far enough to let the point of the drill through into the bore of the box; *c* is the oil reservoir, consisting of a piece of brass tubing 1 inch long, $\frac{5}{8}$ inch in diameter outside and $\frac{3}{8}$ inch diameter inside, with one end permanently stopped by a plug soldered in and the other end threaded for a distance of $\frac{1}{8}$ inch. The hole in the side of the box, *b*, is threaded to match the thread on the end of the tube, *c*, which is packed with lamp wick, filled with oil, and screwed in the box when the machine is completed and ready to run. The yoke

is shown in Fig. 4, and the yokes are shown in position in Fig. 5.

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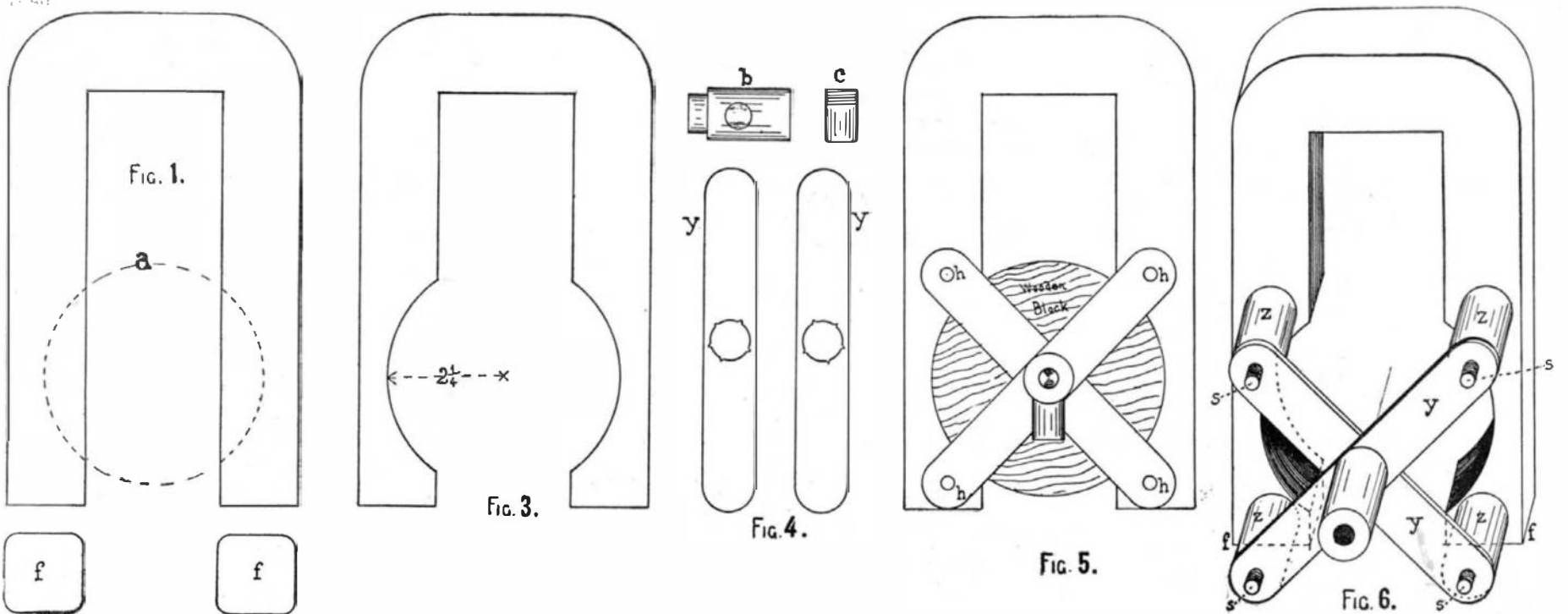


FIG. 2.

FIELD MAGNET.

FIG. 3.

FIELD MAGNET READY FOR ARMATURE.

FIG. 4.

PARTS OF YOKE.

FIG. 5.

PLACING YOKES IN POSITION.

FIG. 6.

MAGNET WITH YOKES.

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same diameter outside and inside as the iron rings, and $\frac{1}{4}$ inch thick. On the face of one ring space off twelve equidistant points on a circle scribed around the center of the ring's face midway between edges, as shown by Fig. 7, in which the points are indicated by $e, e, g, e, e, g, e, e, g, e, e, g$, those marked g being 90 degrees apart. Take two brass disks 4 inches in diameter, $\frac{1}{4}$ inch thick, with a $\frac{1}{2}$ -inch boss $1\frac{1}{2}$ inches in diameter on one side, as shown by Fig. 8, which may be obtained from any model-making establishment, and drill through the center a $\frac{3}{8}$ -inch hole, indicated by dotted line in the sketch. Clamp on the smooth

block, down to the brass disk, and follow with the iron rings, putting on last the fiber ring that has been drilled and then threading on the mandrel the brass disk that was also drilled with the fiber disk. Turn the disk so that the holes near its edge agree with those in the fiber ring under it and compress the whole arrangement with clamps. If there are so many iron disks that the fiber ring cannot be drawn down over the end of the wooden centering block, take off enough to let this be done, as it is imperative that all the rings and disks should be accurately centered with each other. Then drill $\frac{1}{4}$ -inch holes through

ment, and drill through both rings a $\frac{1}{8}$ -inch hole at each point marked e , leaving each ring as shown by Fig. 9.

Next cut out of hard wood twenty-four trapezoidal blocks (Fig. 10) $\frac{3}{8}$ inch thick, $\frac{3}{8}$ inch wide at one end, $\frac{1}{8}$ inch wide at the other, and $\frac{1}{2}$ inch long. In the center of sixteen of these drill a $\frac{1}{8}$ -inch hole; in the center of the other eight drill a $\frac{1}{4}$ -inch hole. Pin the sixteen trapezoids having small holes to the faces of the two fiber rings, putting the pins through from the back through the $\frac{1}{8}$ -inch holes in the rings; the pins, which must be of brass, should be a tight driving fit so that the trapezoids will not tend to slip off, and the faces of the latter should be coated with shellac varnish to prevent their turning on the pins.

The tie-bolts, mentioned above, are of brass, $\frac{1}{8}$ inch in diameter and $3\frac{1}{2}$ inches long, threaded at each end for a distance of $\frac{1}{8}$ inch. They must be insulated where they pass through the core by wrapping paper on them, gluing each layer and putting on enough to make the insulated portion fit snugly in the $\frac{1}{4}$ -inch holes drilled through the rings. Cut a strip of manila paper $2\frac{1}{2}$ inches wide, and wrap it tightly on the bolt, leaving an equal length of uncovered metal at each end. When the right thickness of insulation is obtained, drill two $\frac{1}{8}$ -inch holes in the bolt, exactly $2\frac{1}{8}$ inches from center to center, and equal distances from each end (this distance, if the bolt has been accurately cut to the length specified, will, of course, be $\frac{3}{8}$ inch). Two nuts must be also provided for each bolt, and two steel pins which are driving fits in the $\frac{1}{8}$ -inch holes, and slightly tapered. One of these tie-rods, without its nuts and pins, is shown by Fig. 11.

Then assemble the armature core on its wooden centering block, using enough iron disks to make the iron part measure $1\frac{1}{2}$ inches in thickness when compressed and being careful to have those of the $\frac{1}{4}$ -inch holes that were marked on the fiber pieces come in line with the hole through which the wire holding the iron disks together was run. Leave off the brass disks for the present. Through each $\frac{1}{4}$ -inch hole put a tie-rod, clamping the structure until the steel pins can be put in the holes in the tie-rods; enough iron disks should be put in to prevent any looseness when the clamps are removed. Fig. 12 shows the complete structure. After the tie-rods are pinned in place the remaining trapezoids are put on over the ends of the rods; a little groove will have to be cut in the back of the trapezoid to accommodate the steel pin in the end of the tie-rod.

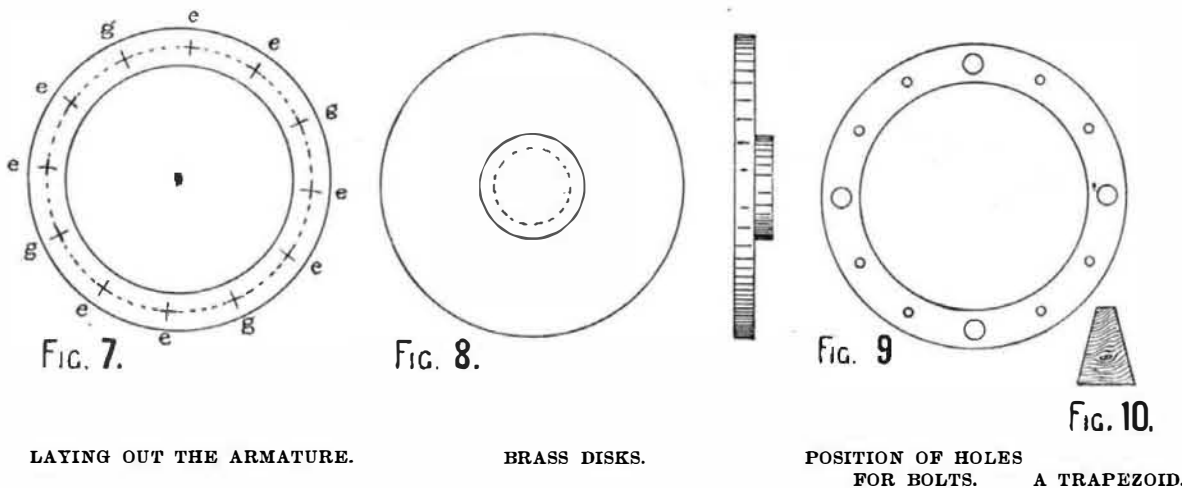
The commutator comes next, and while it would be advisable to buy a complete commutator, a very serviceable one can be made with proper care in following out the instructions given. If the builder prefers to buy the commutator, the dimensions accompanying the order must be these: Diameter of brush surface, 1 inch; length along the shaft, $1\frac{1}{2}$ inches; number of segments, 12. If the commutator is to be built along with the rest of the machine, proceed as follows:

Take a piece of brass tubing 1 inch in diameter outside, with a wall about $\frac{1}{8}$ inch thick, and measuring $2\frac{1}{2}$ inches long. Slit it at twelve equidistant points for a distance of $1\frac{1}{4}$ inches from one end, as shown by Fig. 13, and insert the unslitted portion in a hole in a block of wood that just fits the tubing; the block should be 1 inch thick and nailed to a bench or other support. Then bend outwardly the narrow strips made by slitting the tubing until it looks like Fig. 14; the wings should be brought to a right angle with the body of the tubing not slitted, and hammered out flat. Number the "wings" by means of punch marks, from one up to twelve, and then carry the slits along the length of the uncut portion of the tube, cutting it up into twelve pieces like Fig. 15. Next turn up two rings of vulcanized fiber 2 inches in diameter outside, 1 inch in diameter inside and $\frac{1}{4}$ inch thick, and fit around the circumference of each twelve steel screws, $\frac{1}{2}$ inch in diameter and $\frac{3}{4}$ inch long over all, without heads, as shown by Fig. 16, the screw-holes being carried clear through so that the point of the screw may emerge on the inside of the ring. Cut thirty-six strips of oil paper (the kind used with copying books to protect the leaves from moisture) $\frac{1}{4}$ inch thick, $\frac{1}{4}$ inch wide, and $1\frac{1}{2}$ inches long. Assemble the pieces of the commutator in numerical order within the two fiber rings, one ring at the wing end and one at the other end of the tubular part, put three slips of oil paper between each pair of neighboring pieces of tube, and draw the segments toward the center by means of the little screws until the oil paper slips are clamped so tightly between the brass segments that they cannot be pulled out with the fingers. In order to have the commutator come together and form an approximately true circle, a saw blade $\frac{1}{8}$ inch thick should be used in cutting the segments out of the tube. Then by judicious setting up on the screws the surface can be brought sufficiently near to a true circle as to require no truing up in the lathe. The protruding edges of the oil-paper slips can be cut off even with the brass with a sharp knife.

The core of the commutator may be made of wood; mount a block on a $\frac{5}{8}$ -inch mandrel and turn it up to the exact diameter of the interior of the commutator; then taper it slightly so that it will pass through the commutator before binding, and drive it home as tight as possible without straining the fiber rings that hold the segments. Cut off the block $\frac{1}{8}$ inch beyond the wing end of the commutator and flush with the other end. The complete commutator is shown by Fig. 17.

The next piece of machine work is the shaft, shown by Fig. 18. It is turned up from a piece of $\frac{3}{8}$ -inch bar steel $10\frac{1}{2}$ inches long. The dimensions are as follows: A, $\frac{3}{8}$ inch diameter, $2\frac{1}{8}$ inches long; B, $\frac{5}{8}$ inch diameter, $1\frac{1}{2}$ inches long; C, $\frac{3}{4}$ inch diameter, $3\frac{3}{4}$ inches long; D, $\frac{3}{8}$ inch diameter, $3\frac{3}{4}$ inches long. Last in the list of machine work on the motor proper are the brush holders, one of which is shown by Fig. 19, the drawing showing two views. The holder is a piece of brass tubing, $\frac{1}{2}$ inch internal diameter and $1\frac{1}{2}$ inches long, mounted on a piece of strip brass $\frac{5}{8}$ inch wide and $\frac{3}{8}$ inch thick, the other end of which is bent into a loop, as shown, and provided with an insulating bushing, $\frac{1}{8}$ of $\frac{1}{8}$ -inch fiber. The internal diameter of the bushing is a trifle over an inch when the clamping screw is loose, and the diameter of the loop in the brass strip is, therefore, $1\frac{1}{8}$ inch maximum. This loop is intended to fit around one of the distance pieces, z , Fig. 6, from which it is insulated by the bushing, t .

The brush is a piece of round carbon, $\frac{1}{2}$ inch in diameter and 1 inch long; it should fit snugly within the tube forming the holder, and a spiral spring,

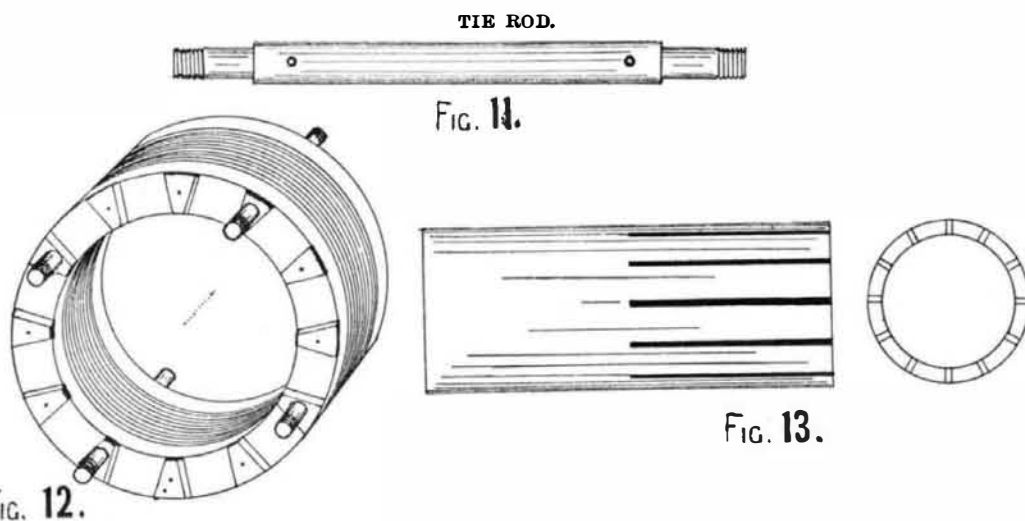


LAYING OUT THE ARMATURE.

BRASS DISKS.

POSITION OF HOLES FOR BOLTS.

A TRAPEZOID.



TIE ROD.

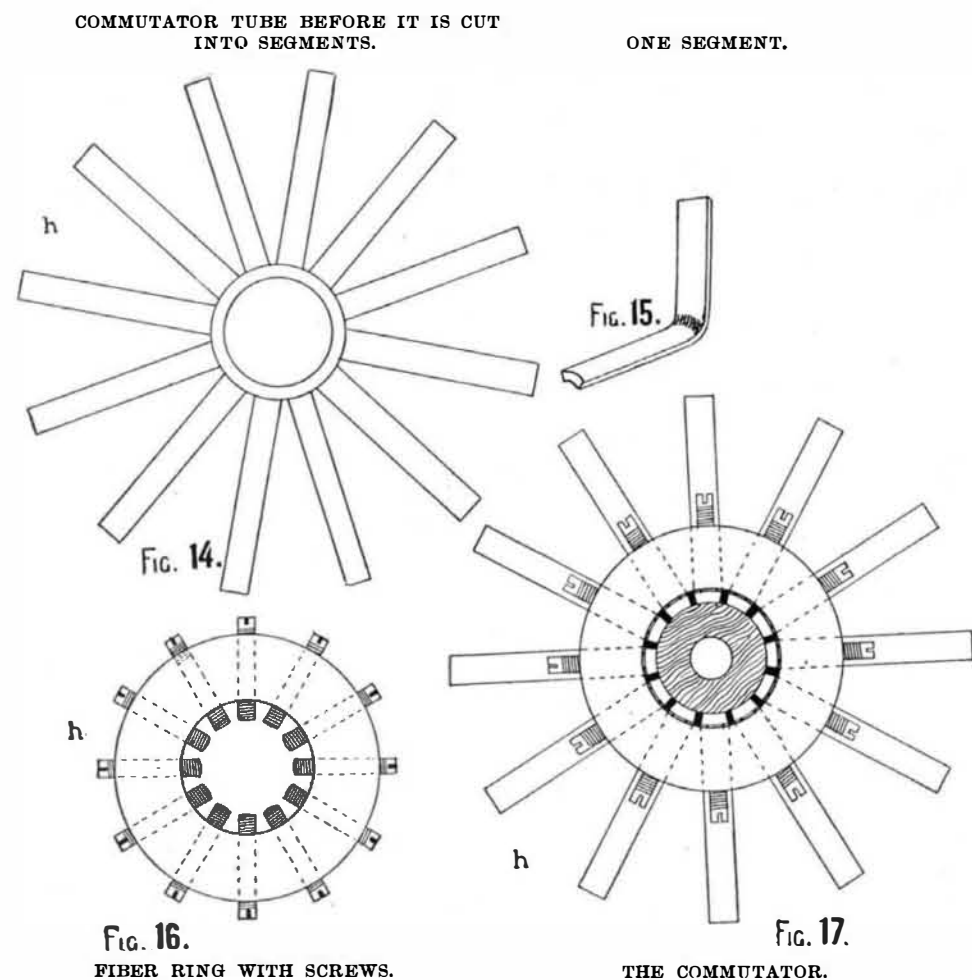
FIG. 11.

FIG. 12.

ARMATURE READY FOR WINDING.

THE SLITTED TUBE FOR COMMUTATOR.

FIG. 13.



COMMUTATOR TUBE BEFORE IT IS CUT INTO SEGMENTS.

ONE SEGMENT.

FIG. 16.

FIBER RING WITH SCREWS.

FIG. 17.

THE COMMUTATOR.

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side of one of these disks the fiber ring that has been scribed, letting the marked face come uppermost, and drill four $\frac{1}{4}$ -inch holes at the points marked g, g, g, g , on the face of the ring, through both the ring and the brass disk. Next mount on a $\frac{3}{4}$ -inch mandrel a block of wood $2\frac{1}{4}$ inches thick and large enough to permit turning it down to a roller 3 inches in diameter; instead of turning it to measurement, however, make it fit snugly into the interior of the iron and fiber rings. When this block is turned to size, thread on one end of the mandrel the brass disk that has only a central hole, next put the unmarked fiber disk on the wooden

block, down to the brass disk, and follow with the iron rings, putting on last the fiber ring that has been drilled and then threading on the mandrel the brass disk that was also drilled with the fiber disk. Turn the disk so that the holes near its edge agree with those in the fiber ring under it and compress the whole arrangement with clamps. If there are so many iron disks that the fiber ring cannot be drawn down over the end of the wooden centering block, take off enough to let this be done, as it is imperative that all the rings and disks should be accurately centered with each other. Then drill $\frac{1}{4}$ -inch holes through

the whole mass, entering the drill in the holes already bored in the top brass disk and fiber ring. These four $\frac{1}{4}$ -inch holes are for tie-bolts to hold the armature core together. When the drilling is finished, punch-mark each brass disk and fiber ring near one of the $\frac{1}{4}$ -inch holes (the same one in each case, of course), remove the clamps and the brass and fiber pieces, run a wire through the hole in the iron rings corresponding to the one marked on the fibers and disks and tie them loosely together until time to assemble the core. Then clamp the two fiber rings together, with the marked holes in align-

$\frac{3}{8}$ inch in diameter, made of No. 16 brass wire, must be provided to force the brush outwardly on to the commutator. One brush holder is attached to the lower left-hand distance-piece, *z*, and the other to the upper right-hand piece, the tubular part of the holder setting vertically, between the magnet poles, with its inner end not more than $\frac{1}{8}$ inch from the surface of the commutator. Electrical connection is made with the brush arm by means of a piece of flexible cord, such as is used in hanging incandescent lamps, one end of the cord being soldered to a copper washer, which is clamped under the head of the screw on the brush arm.

in Fig. 21, and wind into the wiring space between this trapezoid and its right-hand neighbor a coil the full width of the space, which should take 26 turns in width, putting five layers in, or 130 turns, to each coil. When the first coil is done twist to the final end the beginning end of the wire which is to wind the next coil, and proceed with that one in the same way. Care must be observed to put exactly the same number of turns in each coil and to twist the ending of each coil to the beginning of its neighbor on the right. When the armature is wound, put on the brass disks that were left off when the core was assembled, threading

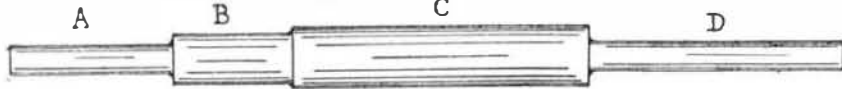
other similar piece of board to the one marked, and at the corners of the scribed square drill $\frac{1}{4}$ -inch holes through both boards; in the center of the square drill a $\frac{1}{2}$ -inch hole. Then make a mandrel of $\frac{1}{2}$ -inch round iron, the central part being full diameter and $2\frac{1}{2}$ inches long, and the ends being turned down to pass through the central hole in the board. Mount the boards on the ends of the mandrel and run $\frac{1}{4}$ -inch iron rods through the corner holes, forming a sort of reel, as shown by Fig. 23. Jam the boards against the shoulders of the mandrel by means of lathe dogs on the outer ends of the latter, and drive a nail in the face of each board so that the dog will drive the board without slip. The dogs must be so adjusted, of course, as to drive both boards in their proper angular positions, maintaining the parallelism between the $\frac{1}{4}$ -inch rods and the mandrel that is necessary to form a perfect coil.

Mount this winding frame in the lathe and wind a coil on it of No. 21 double cotton-covered magnet wire, putting as many turns as possible (it should take sixty-six) between the faces of the wooden blocks and making the coil twenty-seven layers deep. The starting end may be secured to the projecting end of one of the $\frac{1}{4}$ -inch rods to give the necessary tension to the first layer of wire, and at least a foot of the starting end should be left free. When the coil is finished, tie it at each of the four corners with strong linen thread, bending the final end sharply backward over one of these corner threads to keep the top layer snug; take the winding frame apart and varnish the coil all over with shellac, setting it aside to dry while the second coil is wound. This is exactly like the one already wound.

Then take the journal yokes and their bolts and distance pieces off the magnet and wrap the magnet limbs with muslin from $\frac{1}{2}$ inch above the bolt holes up to the bend, putting two layers on each limb and varnishing it on the outside of each layer. When this is dry, turn the magnet upside down, thread on each limb a fiber washer $\frac{3}{4}$ inches square and $\frac{1}{8}$ inch thick, the hole in the washer fitting the magnet limb snugly; varnish the faces of the washers now uppermost and slip the coils on the limbs down on the washers while the varnish is wet, so that the latter will stick to the coils. In putting on the coils, see that the beginning end of each coil goes on first, so that when the machine is set right side up the final end of each coil will be nearest the armature. Follow each coil with another fiber washer like those first put on the magnet, and then reassemble the journal yokes and distance pieces on the magnet, this time putting in the armature as you go along and also putting on the brushholders and brushes. The holders should be so adjusted that the ends of the brush tubes are $\frac{1}{8}$ to $\frac{1}{4}$ inch away from the surface of the commutator.

THE SHAFT.

Fig. 18.



BRUSH HOLDERS.

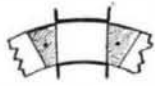


Fig. 20.

SECTION PREPARED FOR WINDING.

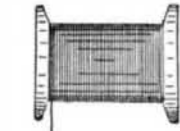


Fig. 21.

BEGINNING THE WINDING.

This cord is known as No. 18 cotton-covered lamp-cord, and may be procured from any dealer. It should be untwisted and one length used on each brush holder; the cord need not be more than 6 inches long.

We are now ready to wind the magnet and armature cores. The armature core must first be covered all around the outside surface with muslin; cut a strip 2 inches wide and 25 inches long and, after varnishing the periphery of the core with shellac, wind on this muslin strip, being sure that it is tightly wound. If it is pulled tight, it will make two layers; when the strip has been carried once around, varnish the surface of what is on the core, and then wind on the other layer of muslin. Then varnish the whole outside surface. Cut out 24 strips of oil paper, each $1\frac{1}{8}$ inches

the tie-rods through the holes near the edges of the disks, and putting the boss on each disk outside; clamp the disks hard against the wooden trapezoids by means of nuts on the tie-rods. The holes in the disks must be bushed with little pieces of fiber tubing and a fiber washer must go under each nut, in order to insulate the tie-rods from the disks; otherwise the armature would run destructively hot.

Insert the shaft in the center of the structure, letting that part marked *B* in Fig. 18 come on the side, where the ends of the armature winding are, and pin the brass disks to the shaft through the bosses. The commutator goes on the part of the shaft just referred to, and it should be a driving fit, so as to obviate pinning or keying it to the shaft. Then connect up the ends

THE WINDING.

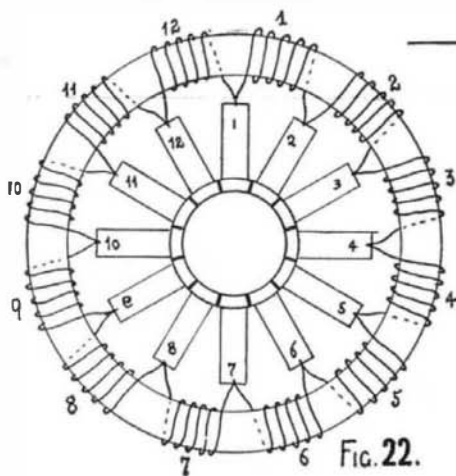


Fig. 22.

REGULATOR—FRONT VIEW.

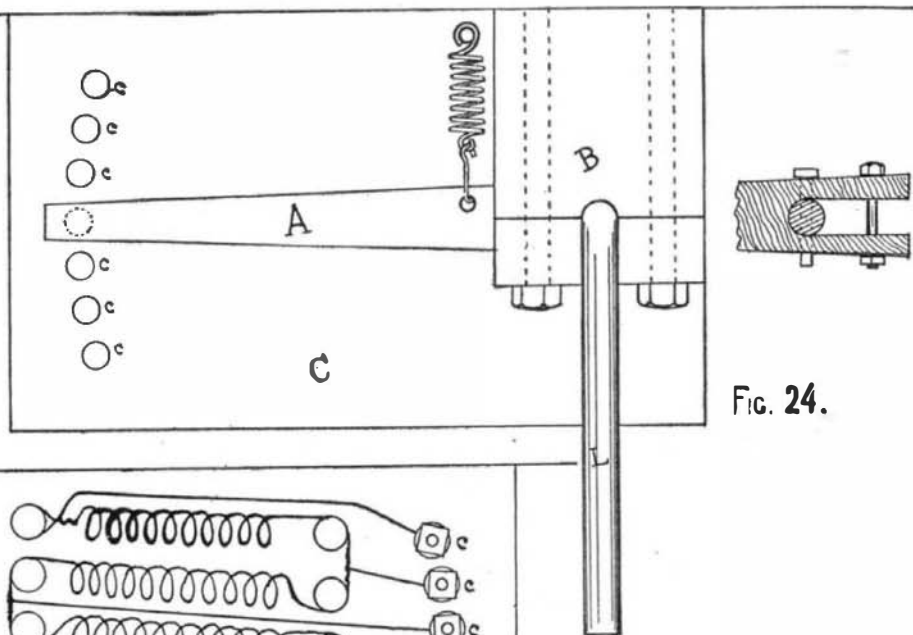


Fig. 24.

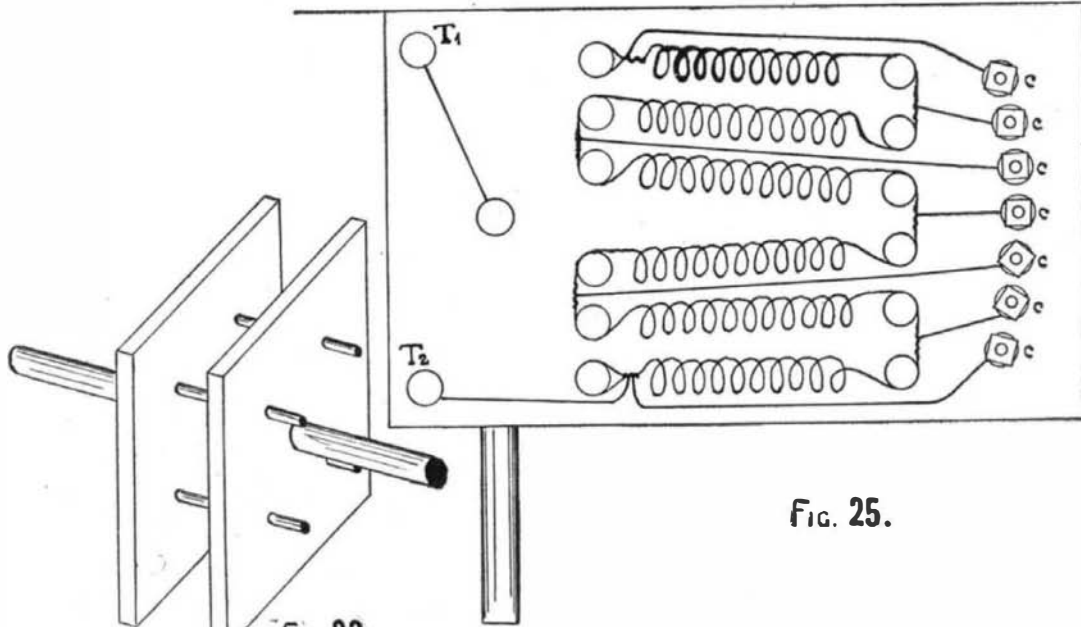


Fig. 25.

REEL FOR WINDING FIELD MAGNET COILS.

REGULATOR—BACK VIEW.

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wide and 2 inches long, and bend up the edges, making the crease $\frac{1}{4}$ inch from each edge, so as to form shallow troughs the width of which will be the same as the space between the trapezoids on the ends of the core; apply two of the troughs to the inside and outside circles of the core, as shown in Fig. 20, and tie them in place with No. 40 or No. 50 sewing cotton, one strand at each side of the trough. Then wind on an old cotton-spool 68 feet of No. 26 double cotton-covered magnet wire, hook the outer end around one trapezoid, as

of the armature coils to the lugs of the commutator, leading each end straight out, parallel with the shaft, to the nearest lug. If the ends were twisted together in accordance with the directions, the result will be as shown diagrammatically by Fig. 22.

Prepare for winding the magnet coils by making a winding bobbin as follows: On a piece of board an inch thick and 4 inches square lay out a square measuring $1\frac{1}{2}$ inches on a side, the scribed square being symmetrical with the edges of the board; clamp an-

The free ends of the magnet coils nearest the armature are connected to the brushes by means of flexible lamp cord, as described in the instructions for making the brush holders, the end of the flexible cord being soldered to the end of the magnet wire close up to the coil. The upper ends of the magnet coils go to the terminal block, which is a block of wood, $1\frac{1}{2}$ inches square and 4 inches long, bolted on the top of the magnet yoke, and carrying two binding posts, which form the terminals of the machine. The motor is bolted to the

table of the sewing machine, with one leg right on the edge of the table and in such position that the pulley of the motor, which must go on the end of the shaft away from the commutator, is in line with the belt pulley of the machine. The motor pulley should be one-half the diameter of the pulley on the sewing machine, and be of the same width and depth of groove.

The regulator is shown by Figs. 24 and 25, the former being the front view and the latter the back. Referring to Fig. 24, *A* is a wooden arm, $9\frac{1}{2}$ inches long, $\frac{1}{2}$ inch thick, and tapering from $\frac{1}{2}$ inch to $1\frac{1}{4}$ inches in width. The narrow end is faced with a thin strip of copper to make contact with the buttons, *c*, which are simple brass bolts with flat heads; the wide end of the wooden arm is split to straddle the shaft, to which it is pinned as well as clamped. *L* is the lever controlling the arm, *A*; it is made of $\frac{1}{2}$ -inch round iron rod, bent to form a right angle; the lever portion is 6 inches long; the length of the horizontal portion on which the lever, *A*, is mounted is the same as the width of the sewing machine table on which the motor is to be used. The back end of the shaft is journaled in the base board, *C*, and the front part in a wooden bearing, *B*, which is bolted to the under side of the sewing machine table between the narrow drawer and the pan. The base board, *C*, is 6 inches wide (vertically) and $10\frac{1}{2}$ inches long. It is fastened to the under side of the machine table, flush with the back edge. The lever, *L*, is to be moved by the right knee of the machine operator.

The arm, *A*, is normally held in its highest position by the coil spring shown, in which position the current is cut off the motor entirely. The contact buttons, *c*, are $\frac{1}{2}$ inch in diameter; the bolts of which they are the heads are $\frac{3}{8}$ inch in diameter and long enough to protrude $\frac{1}{2}$ inch on the reverse side of the base board. This side is shown by Fig. 25. The resistance coils consist of German silver wire, No. 20 B. and S. gauge, wound into coils on a $\frac{5}{8}$ -inch rod (the rod being removed, of course, when the coil is formed). The piece of wire forming the upper coil should be 100 feet long; the next coils contain 90, 80, 70, 60, and 50 feet of wire, respectively, in the order named. The binding posts, *T*₁ and *T*₂, are connected as shown, the connection between *T*₁ and the iron shaft being made by means of flexible cord which will follow the movements of the shaft. On the front the shaft is connected to the copper facing at the small end of the arm, *A*, by means of No. 16 copper wire. All the connections on the back are made with No. 16 copper wire, preferably but not necessarily insulated.

The back surface of the base board must be covered with a sheet of asbestos over a thin sheet of fiber. The ends of the resistance coils are twisted together and soldered, and the connecting wires should be soldered on at the same time. The coils are held on ordinary porcelain knobs, fastened to the board by wood screws. The connecting wires should be bent into loops where they connect with the bolts, *c*, and a copper washer should go under each nut and on top of the loop of the connecting wire.

The connections between the motor and the regulator and the source of current supply are as follows: From *T*₁ to one binding post on the motor, from *T*₂ to one side of the supply circuit, and from the other binding post on the motor to the other side of the supply circuit.

The motor above described will run satisfactorily on any direct-current incandescent lamp circuit of 100 to 120 volts pressure. If it is desired to build the machine for use in connection with a battery, the windings will have to be changed as follows: Armature coils, No. 13 wire, 8 turns wide and 1 deep, each coil; field magnet coils, No. 8 wire, 5 layers deep, 18 turns per layer, each coil; regulator, No. 13 wire, the coils having one-tenth the number of feet specified above.

The battery to run such a motor must give 8 volts and from 10 to 20 amperes, according to the load on the motor; consequently four cells will be required.

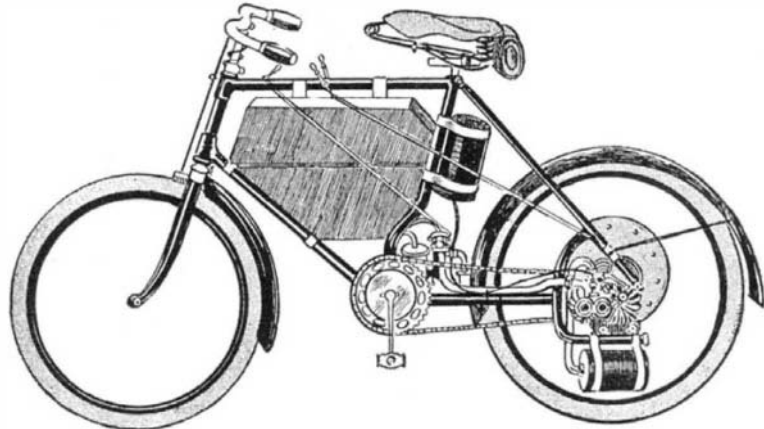
Should the reader desire to build a standard shunt-wound motor of $\frac{1}{4}$ horse power instead of the series-wound type specified, the same frame may be used,

the only variation being in the manner of winding. In order to wind the machine as a $\frac{1}{4}$ horse power motor, to work on a 110 volt circuit, the armature coils must consist of No. 27 wire, double cotton-covered, each coil being 9 layers deep and 28 turns in width—252 turns, total, per coil. The magnet coils will consist of No. 25 wire wound to a depth of 39 layers, with as many turns lengthwise as can be got in the space of $2\frac{1}{2}$ inches allotted for the coil length; with careful winding, 92 turns can be put in each layer, giving each magnet coil a total of 3,588 turns.

In order to change the design into a $\frac{1}{2}$ horse power motor, the magnet must be made of iron $2\frac{1}{2}$ inches square, instead of $1\frac{1}{2}$ inches, and the armature, shaft, journal-yoke bolts, etc., must be made exactly 1 inch longer, axially, than the above measurements specify. The windings will be No. 24 wire on the armature, each coil 5 layers deep and 21 turns wide; No. 22 wire on the magnet, each coil being 37 layers deep and 74 turns long (or as many as the $2\frac{1}{2}$ inch space will take). The number of armature coils and all other data not specified in this paragraph will remain precisely as in the original instructions above.

PEUGEOT GASOLINE BICYCLE.

We figure herewith, from *Le Monde Illustré*, a bicycle constructed by the Peugeot establishment in Paris,



PEUGEOT GASOLINE MOTOR.

and exhibited at the recent Salon du Cycle et de l'Automobile at the Champ-de-Mars. This machine is provided with a De Dion motor, which is placed directly in the axis of the driving wheel—an arrangement that ought to give the apparatus stability and allow of no loss of power.

GAS ENGINES AND LIGHTHOUSES.

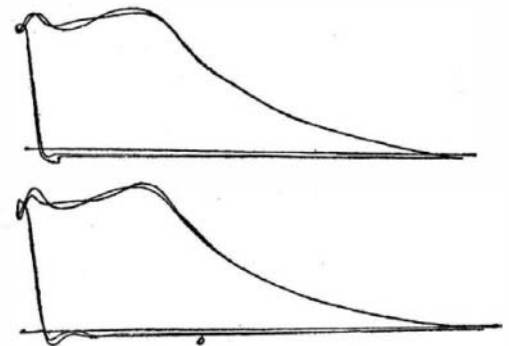
We illustrate herewith one of a set of three gas engines and air compressors which Messrs. Crossley Brothers, Limited, of Manchester, have supplied to the Commissioners of Irish Lights for working the fog signaling apparatus in the lighthouse at Mew Island, near Donaghadee, at the south side of the entrance to Belfast Lough.

As will be seen from the woodcut, the compressor cylinder faces that of the gas engine, and both pistons are coupled to the same crank pin. This arrangement makes a well-balanced job, and the strains are easily taken up. In such an important matter as fog signaling it is essential that the risk of breakdowns during work shall be eliminated as far as possible. Direct driving is therefore preferable; and to suit the gas engine it is necessary that high-speeded compressors should be employed.

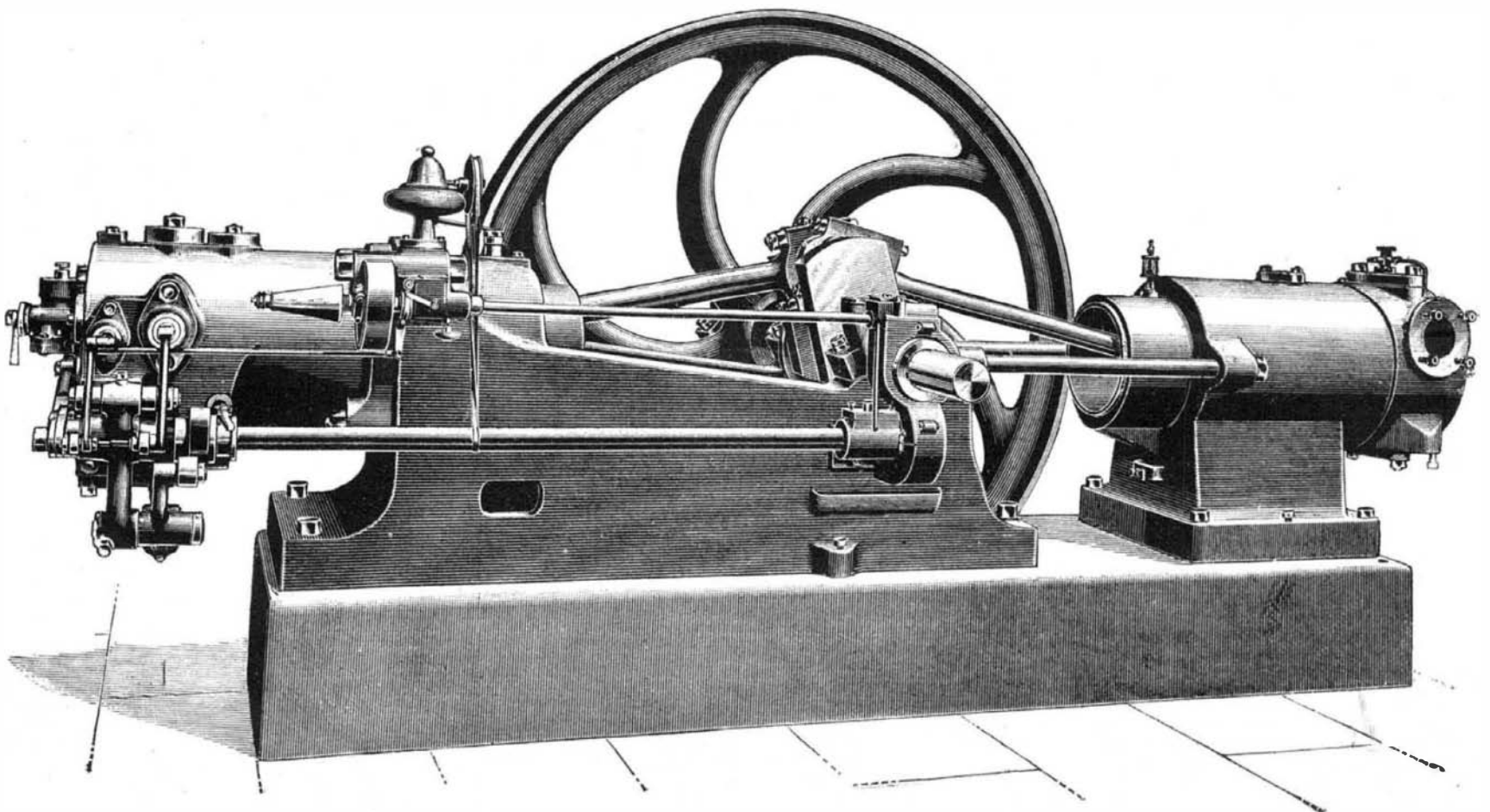
The gas engines are of 14 nominal horse power, and run at 170 revolutions a minute, and are capable of indicating 42 horse power as a maximum. The com-

pressor cylinders are 14 inches diameter by 21 inches stroke, and are single acting. Each compressor is capable of delivering 280 cubic feet of free air per minute and afterward compressing it to 25 pounds per square inch. The fly wheel is 7 feet diameter by $8\frac{3}{4}$ inches wide, and an outer bearing is provided to support the overhang of the wheel. Each engine and compressor is mounted on the same cast iron foundation, and they are held together by strong wrought iron stays. The compressor cylinder is water-jacketed, and the suction and delivery valves are made under Atkinson's patent, and are particularly suited for high speed compressors.

The valves consist of a number of flat rings placed one inside the other concentrically, and seated over narrow angular passages in the valve seatings. The air passes both the inner and outer edges of the valves, which, although they have a very small lift—in this instance $\frac{1}{8}$ inch—give a very large area. The suction and delivery valves are both alike, and are placed one over the other on the same central spindle which holds them together, the under side of the delivery valve being provided with guides and stops for the suction valves. To show the action of these valves we give a copy of indicator diagrams taken at 170 revolutions per minute. The diagrams show the small resistance during the suction stroke; that the compressor is quite filled at the end of this stroke; and also the promptness with which the suction valves close, thus insuring



indicator string and the looseness of the indicator gear. The prompt closing of the delivery valves is also shown, together with the small clearance space and the early recommencement of the suction. The compressors are also fitted with Atkinson's patent



COMBINED GAS ENGINE AND AIR COMPRESSOR.