GILBERT

REG. U.S. PAT. OFF.

FUN WITH YOUR MOTOR

FOREWORD

Hello Boys! The many things it is possible to do with an electric motor, the stunts that can be performed have always interested me very much. Of course I realize that almost every boy knows how to connect up a motor so that it will operate construction toy models, etc., but it has always seemed to me that there were any number of very interesting stunts a motor could be made to do that were unknown to the average boy.

In this book I have shown you a number of the best tricks that I have learned in years of experimenting and I think you will agree with me after reading about them, that an electric motor is a great deal more fascinating and useful than many people give it credit for.

Sincerely yours,

A. C. Gilbert

Part I

HOW YOUR MOTOR RUNS

Of course, almost every one knows that an Electric Motor runs when current is introduced, but not many folks know of the wonderfully interesting things that are possible with a little ingenuity. It is to give you a better idea of the great number of things you can do and the fun you can have with an electric motor that this book has been written.

The experiments are all easy to perform and clearly illustrated. We have used one of the powerful Gilbert Toy Motors in making our illustrations, as this particular motor is very well adapted to stunts of this kind. Try some of them and see for yourself the immense amount of fun you can have.

(1) HOW TO MAKE A GALVANOSCOPE: A galvanoscope is a simple little piece of apparatus for detecting the presence of an electric current in a wire circuit. To make it, take a strip of cardboard 1 inch wide and 4 inches long and form it into a rectangle, as shown at A in Fig. 1.

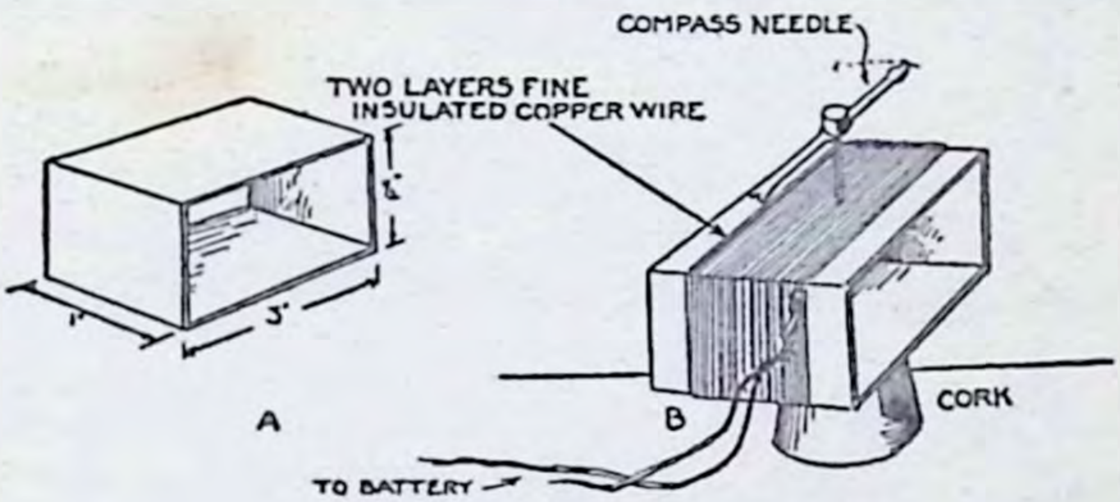


Fig. 1

Now wind on it two layers of twelve turns each of cotton-covered magnet wire and twist the ends together to hold the wire in place. Stick a sewing needle in a cork, the sharp end up, and force the cardboard on it. Then set a compass needle on top of it as at B. This completes your current tester, or galvanoscope, as it is called, and it is ready for use.

(2) HOW TO MAKE MAGNETISM OUT OF ELECTRICITY: To make magnetism out of electricity, connect one end of a loop of wire to one of the binding posts of a dry cell or a battery, as shown in Fig. 2,

and hold the loop of wire over your compass and parallel with its needle. Now touch the other end of the wire loop to the other binding post, when the compass needle will swing at right angles to it. This is the fundamental basis on which all electric motors work.

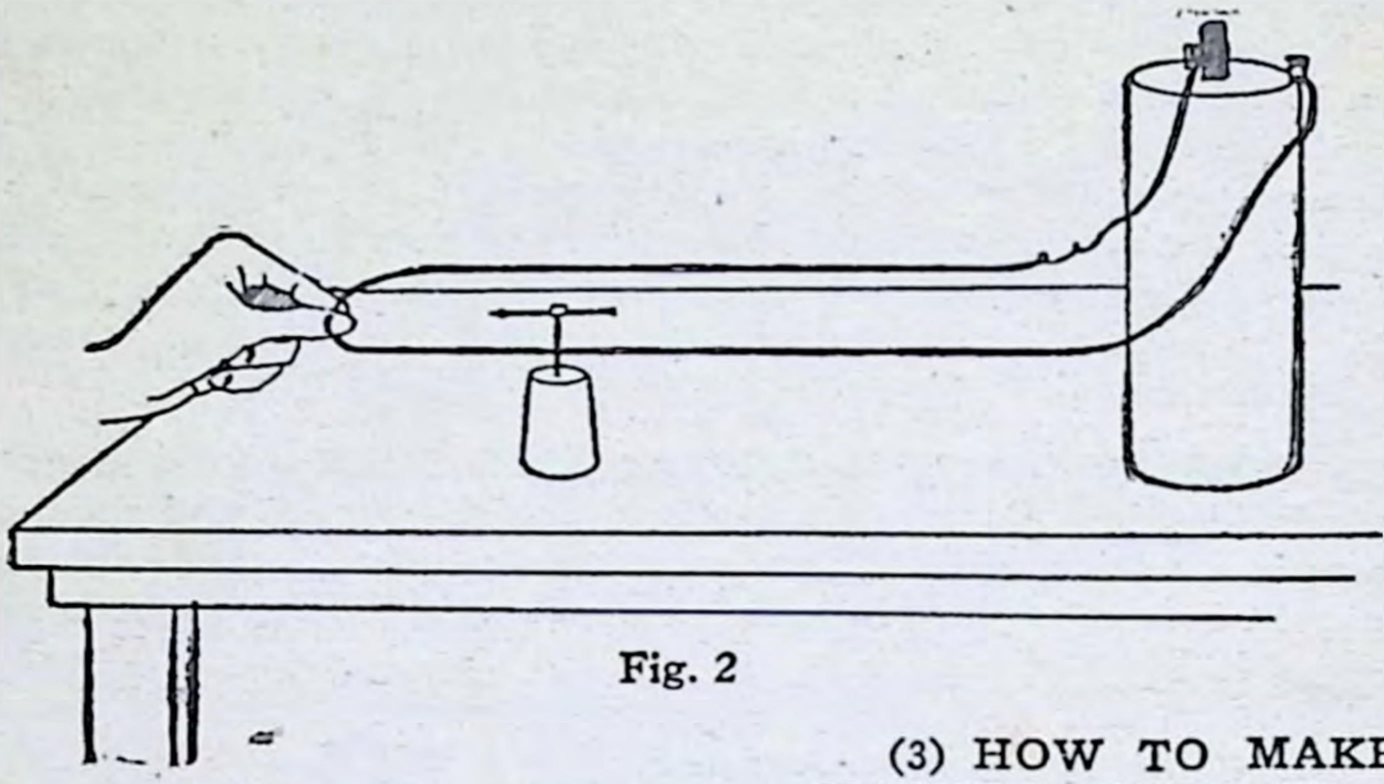


Fig. 2

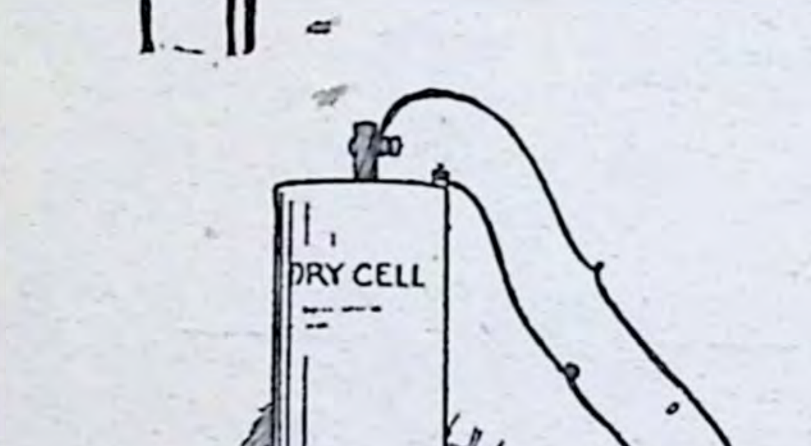


Fig. 3

(3) **HOW TO MAKE A MAGNET OUT OF AN IRON NAIL:** Wind a couple of layers of cotton-covered magnet wire on a nail and connect the ends of the wire with the binding posts of a dry cell as shown in Fig. 3. You will now find that the piece of iron has become a magnet. The instant, however, that you break the circuit it loses its magnetism. As the magnet is made by an electric current, it is called an electromagnet, and the field magnet of a motor as well as the armature works on this principle.

(4) **A ONE MOSQUITO-POWER ELECTRIC MOTOR:** Lay the electromagnet described in the above experiment close to your compass

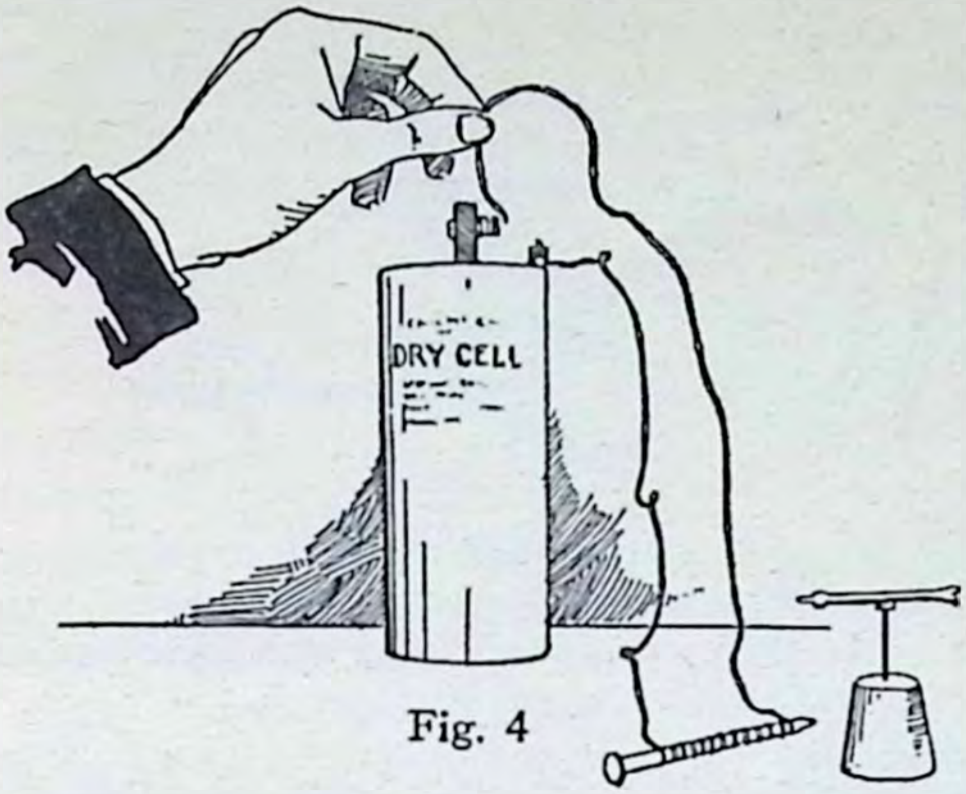


Fig. 4

as shown in Fig. 4, and connect one of the ends of the magnet coil with a dry cell. Now quickly touch the other wire of the coil with the other binding post of the dry cell and draw them apart, when the compass needle will spin. By touching the wires together and pulling them apart at the right instant, you can keep the needle spinning. Here, then, you have an electric motor, though it is on a mighty small scale.

(5) HOW TO TEST THE FIELD MAGNET: Connect the ends of a field magnet to the binding posts of a dry cell and then test it out with a soft iron wire, or nail, and you will find that it behaves just like a Horse-shoe Magnet, except that it is much stronger. Fig. 5 shows how the connections are made.

Fig. 5

(6) TELLING THE POLES OF YOUR FIELD MAGNET: When you energize the field magnet with an electric current, one of its poles is a north pole and the other one is a south pole. To tell which pole is north and which one is south, try them out with your compass needle. The north pole of the latter is the arrow point and the south pole the

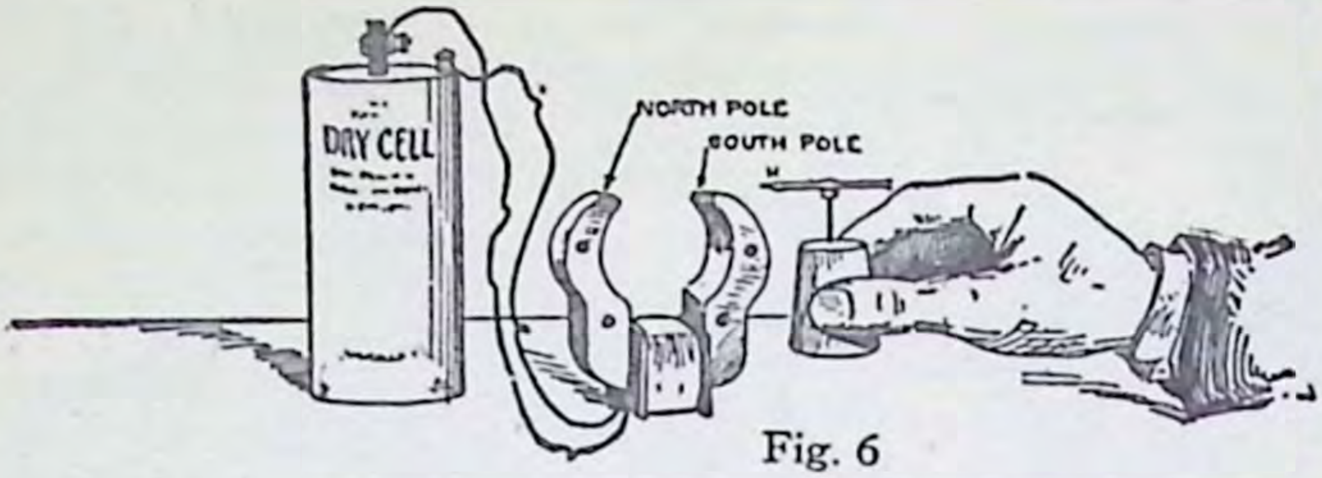


Fig. 6

"Tail" of the needle. Now when you place the north pole of your compass near the south pole of your field magnet, they will attract each other (see Fig. 6); and when you place the north pole of your compass against the north pole of the field magnet, they will repel each other.

(7) HOW TO CHANGE THE POLES OF YOUR FIELD MAGNET: You can make either pole of your field magnet the north pole and the opposite the south pole, that is, you can reverse the polarity, as it is called, by simply changing about the connections of the ends of the field coil with the terminals of the dry cell. Before and after you change over the connections, test out the poles with your compass.

(8) TO TRY OUT THE LIFTING POWER OF YOUR FIELD MAGNET: Connect one end of the field coil with one of the binding posts of a dry cell, connect up the other end (Fig. 7) of the field coil to the other binding post of your dry cell. Now, hold the field magnet upside down, lay the pole pieces on a pile of small nails and see how many of them the magnet will lift up, as shown in Fig. 8.

Fig. 7

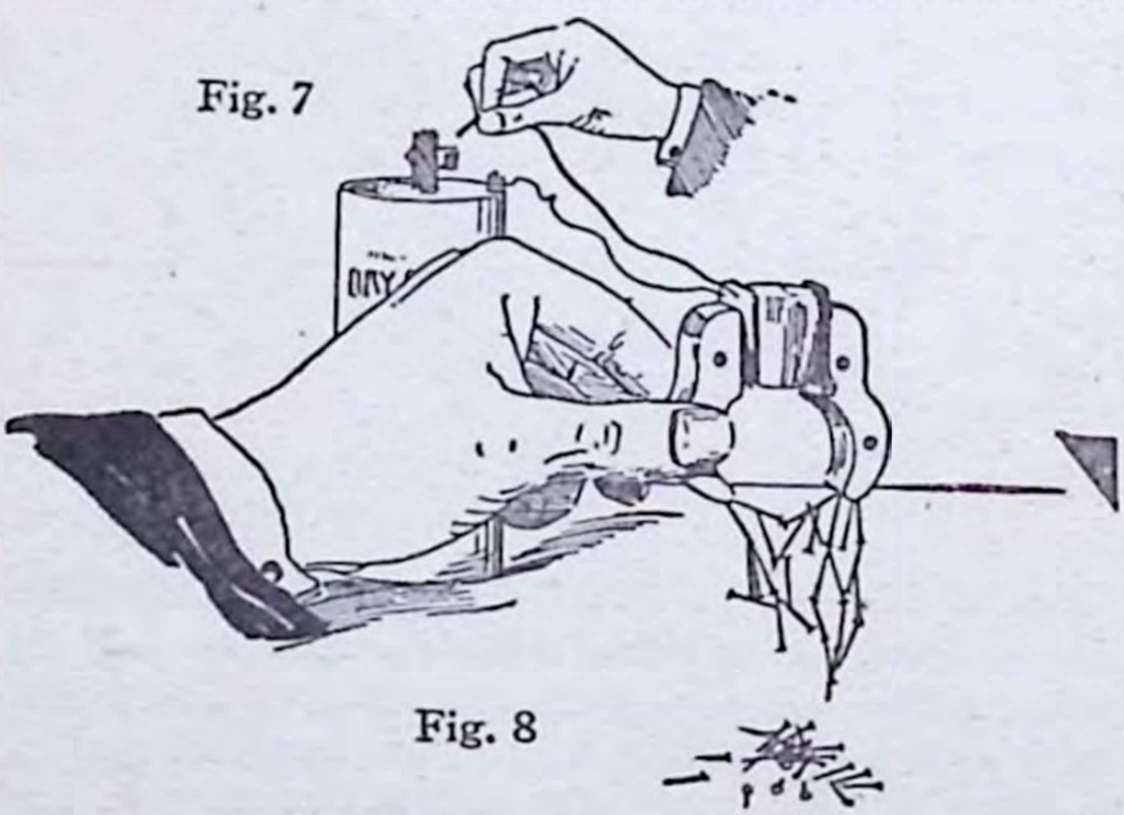


Fig. 8

(9) HOW TO TRACE THE MAGNETIC FIELD: Connect the coil of the field magnet to the dry cell, or battery, as shown in Fig. 9. Now lay the field magnet flat on a table, or other level surface, and on the poles of it lay a business card or a sheet of glass. Sprinkle some iron

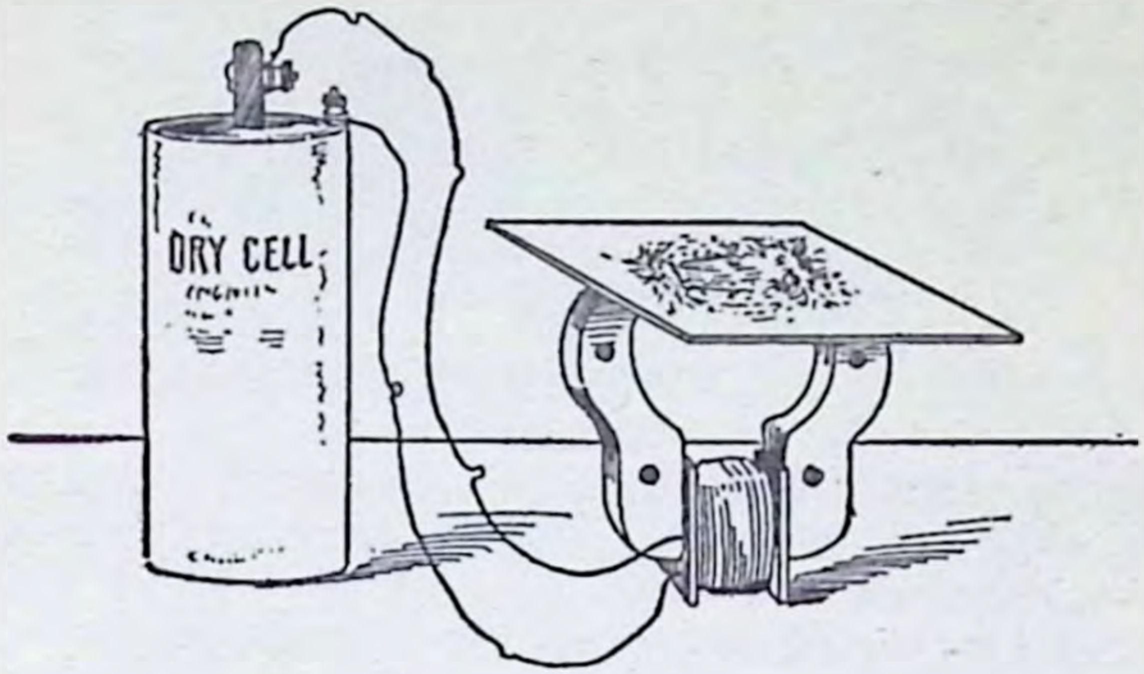


Fig. 9

filings over the card, or glass, when they will arrange themselves in curved lines between the poles, which shows how the magnetic lines of force flow from one pole to the other.

(10) WHAT "RESIDUAL MAGNETISM" MEANS: Iron, however soft, always retains a little of the magnetic force that has been impressed upon it and hence the field magnet is really a very weak magnet even though there is no current flowing through the field coil. To demonstrate this, hold the field magnet upside down and connect it to a dry cell, or battery. Now dip the pole pieces into a heap of iron filings and lift it up again, when, of course, the latter will cling to them. Cut off the current, and nearly but not all of the filings will drop. Since some of them still cling to the pole pieces, it proves that the magnet has not lost all of its magnetism.

(11) HOW TO MAGNETIZE THE BLADE OF YOUR KNIFE: Place the blade of your pocket knife, a piece of steel watch spring, or some needles between the poles of the field magnet and then energize the latter by closing the circuit, and you will find that any or all of these steel objects

will be permanently magnetized by what is called "induction," that is, the magnetic force acts through space without the magnet and the object being in actual contact with each other.

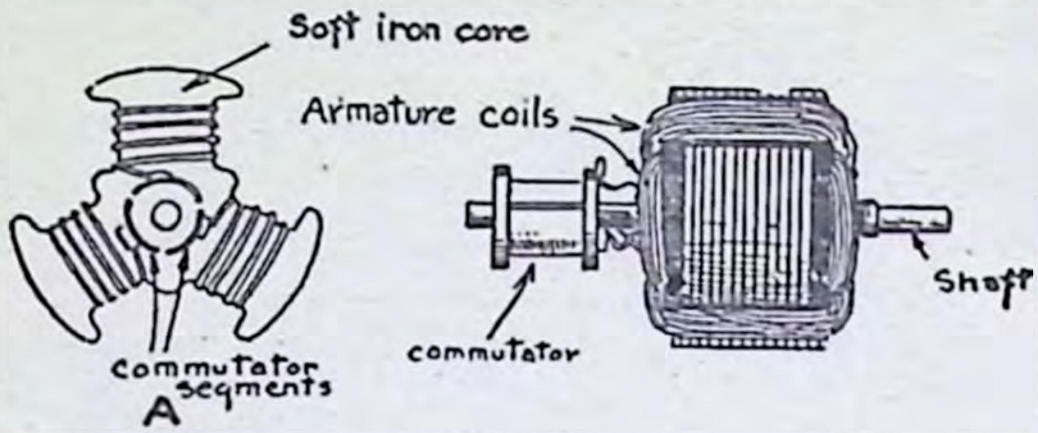


Fig. 10

(12) HOW THE ARMATURE OF A MOTOR IS MADE: The part of a motor that rotates is called the armature. It is formed by four distinct parts, and these are (1) the shaft; (2) the core, which is built up of 12 plates, or laminations, of soft iron; (3) the windings, or coils of insulated wire wound on the pole pieces of the core; and (4) the commutator, which is formed of three brass segments insulated from each other by means of hard fiber checks. The coils are connected to the segments of the commutator, as shown at A in Fig. 10, and the armature complete is shown at B.

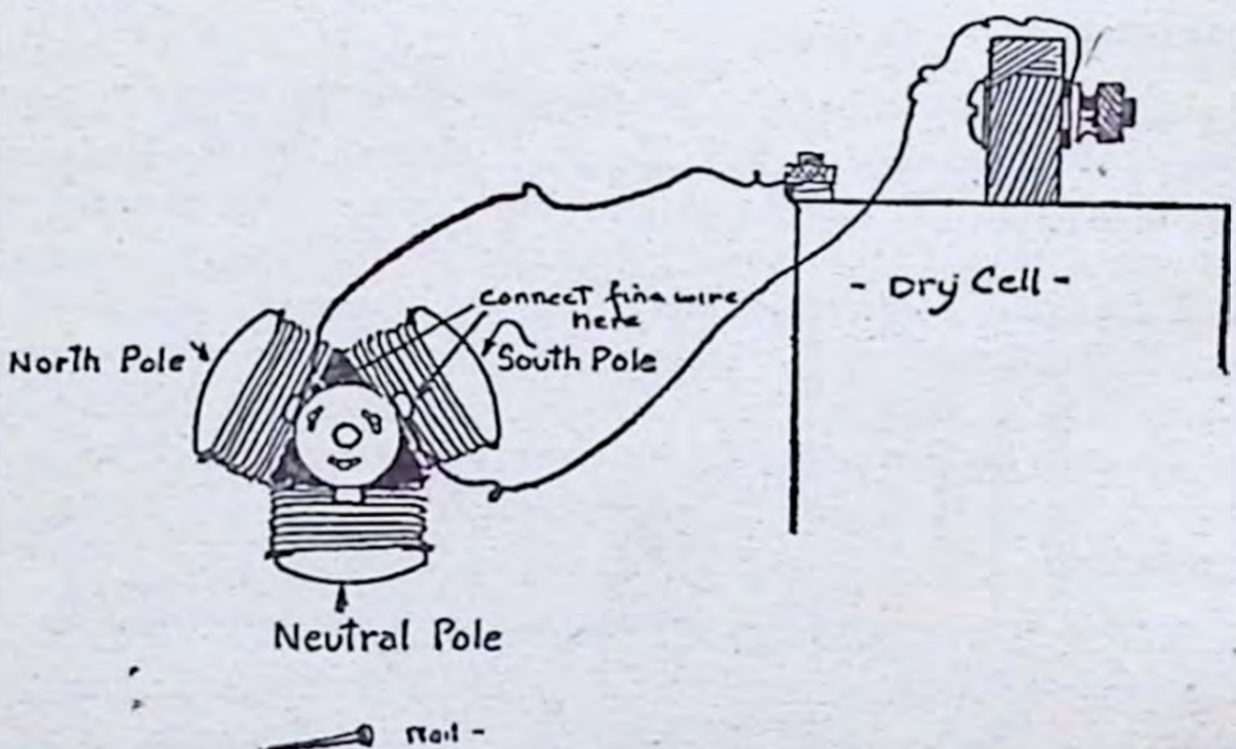


Fig. 11

(13) HOW TO TEST THE ARMATURE POLES FOR MAGNETISM: The core of the motor armature has three pole pieces and each one of these is wound with a separate coil of wire. Now, the thing to do is to find out how many and which poles are magnetized when the current is passed through the coils of wires. You can test them out by twisting a piece of very fine wire around each of the connections where the ends of the armature coils are soldered to the commutator, as shown in Fig. 11. Connect two of these wires at a time with a dry cell or a battery. Now lay a little nail on the table and hold the armature over it. Try the magnetic power of each pole and you will find that two of them are magnetized and that the third one is not.

(14) HOW TO TEST THE POLARITY OF THE ARMATURE POLES: Connect up the armature and a dry cell or battery, as explained in the above experiment, and bring the compass needle near each armature pole in turn, when you will find that one of them is a north pole, the next

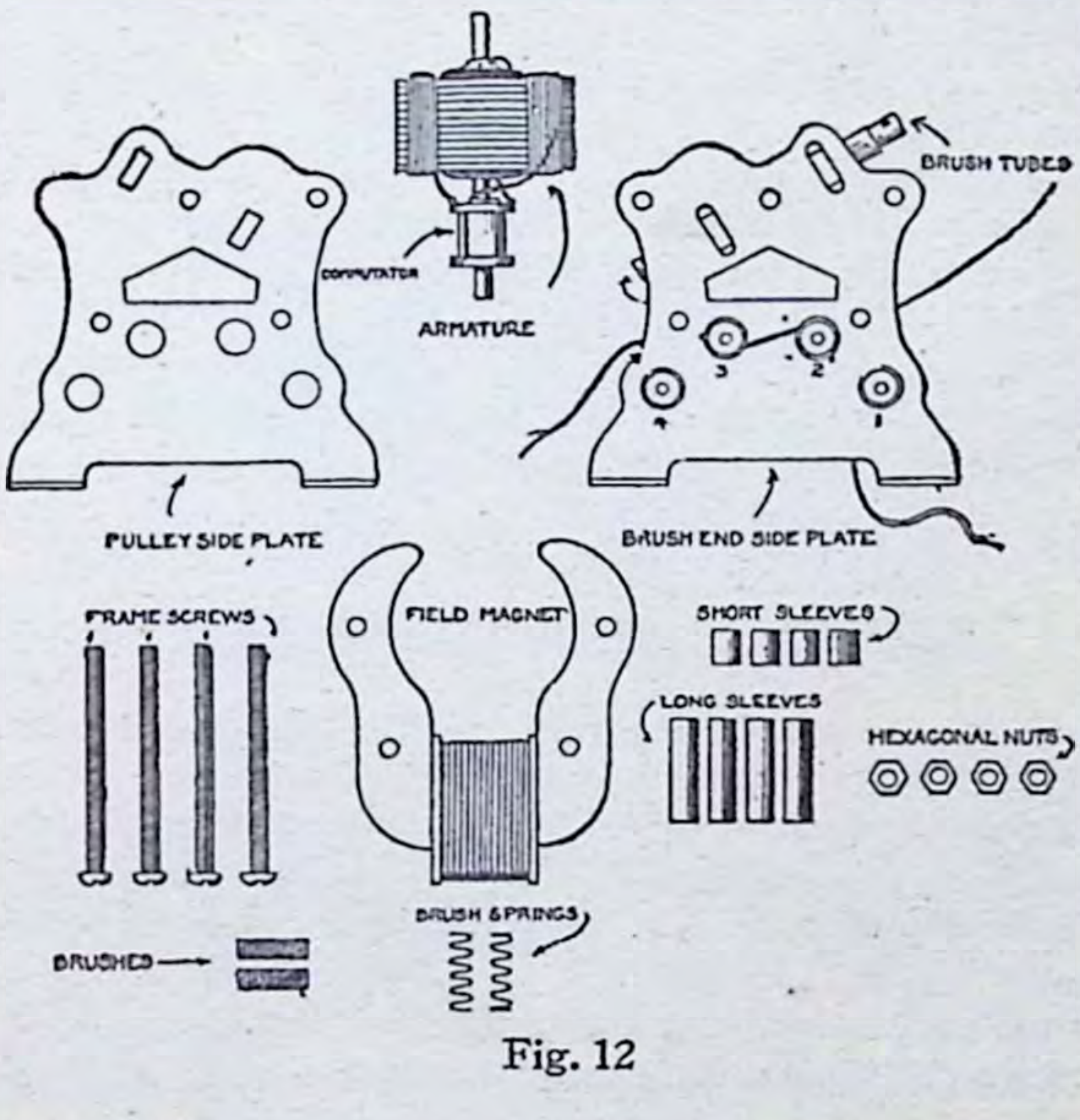


Fig. 12

one is a south pole, and the last one is a neutral pole; that is, it is not magnetized at all (see Fig. 11). Now when the armature rotates in the motor and the brushes make contact successively with the segments of the commutator, the current flowing through the coils is reversed every time the armature makes half a revolution. Hence, while the poles of the field magnet remain north and south all the time, the poles of the armature change from north to south and then to neutral successively.

(15) THE PARTS OF YOUR MOTOR: All of the parts of the motor are shown and named in Fig. 12. By referring to these parts, you will readily understand the instructions given below which tell you how to put your motor together.

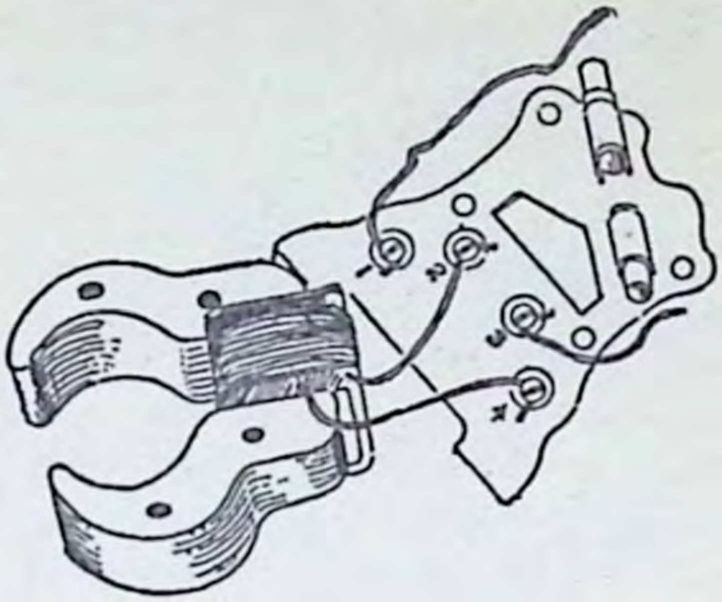
(16) HOW TO PUT YOUR MOTOR TOGETHER: The next four illustrations explain how to assemble the powerful Erector Motor. These illustrations are all so clear that it is hardly necessary to write any further instructions. I am quite sure you will have no difficulty in assembling this motor so that it operates and will run your models and toys which you build.

There is only one point that I want to caution you on particularly, and that is, be sure that the terminal screws are insulated from the motor side plates. The cross section (Fig. 14C) shows the proper method to obtain perfect insulation. Follow this very carefully. If these screws are not insulated thoroughly, you get a short circuit and the motor will not function. BE VERY, VERY CAREFUL THAT THIS IS TAKEN CARE OF.

Of course, models which can be made to run with motors are always more fun than stationary models. This little motor will drive a train, soda mixer, railway signals, and any number of things which you can think of yourself.

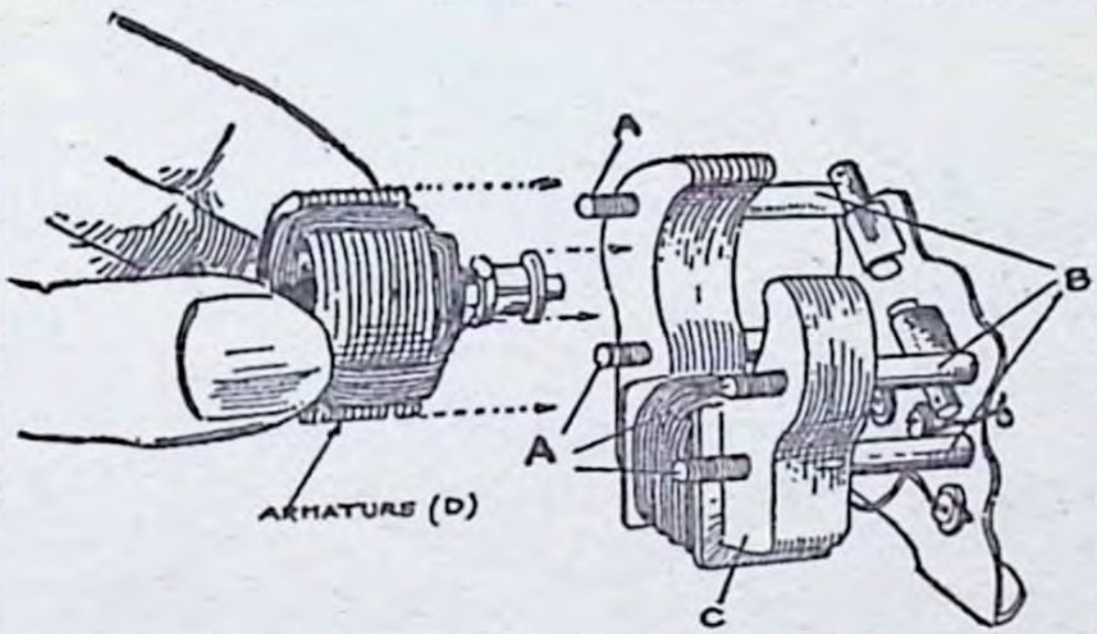
HOW TO ASSEMBLE MOTOR

You will find the names of the parts in Fig. 12. The brush end side plate and the field magnet are first connected by fastening the lower wire from the field winding to insulated binding screw No. 2, and the upper wire to insulated binding screw No. 4. Be sure to scrape the cotton covering from the wire ends and scrape the copper bright and shiny where it goes under the screw heads. All joints in electrical apparatus must be clean and tight or the current will not flow. In your part boxes you will find the frame screws (1⅝ inches long under the screw head) and four sleeves



HOW TO CONNECT FIELD
MAGNET TO THE BRUSH SIDE PLATE

Fig. 13



THE TWO BRASS AND TWO STEEL SCREWS "A" ARE INSERTED IN THE BRUSH SIDE PLATE. THE BRASS AND STEEL SLEEVES ARE PUT IN PLACE AS SHOWN AT "B." THEN SLIP THE FIELD MAGNET "C" OVER THE PROJECTING SCREWS. THE ARMATURE "D" IS INSERTED AS SHOWN ABOVE

Fig. 14A

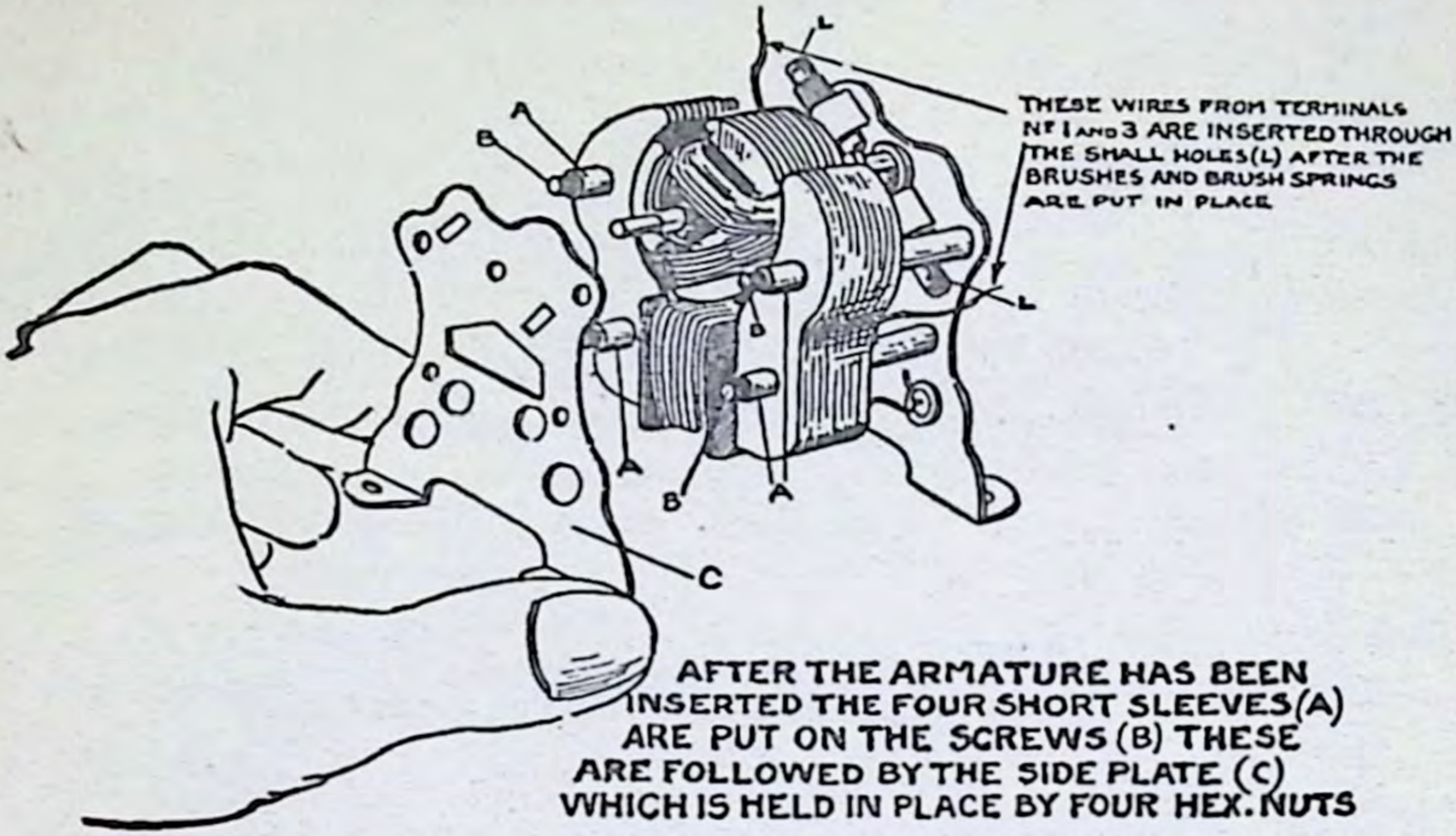


Fig. 14B

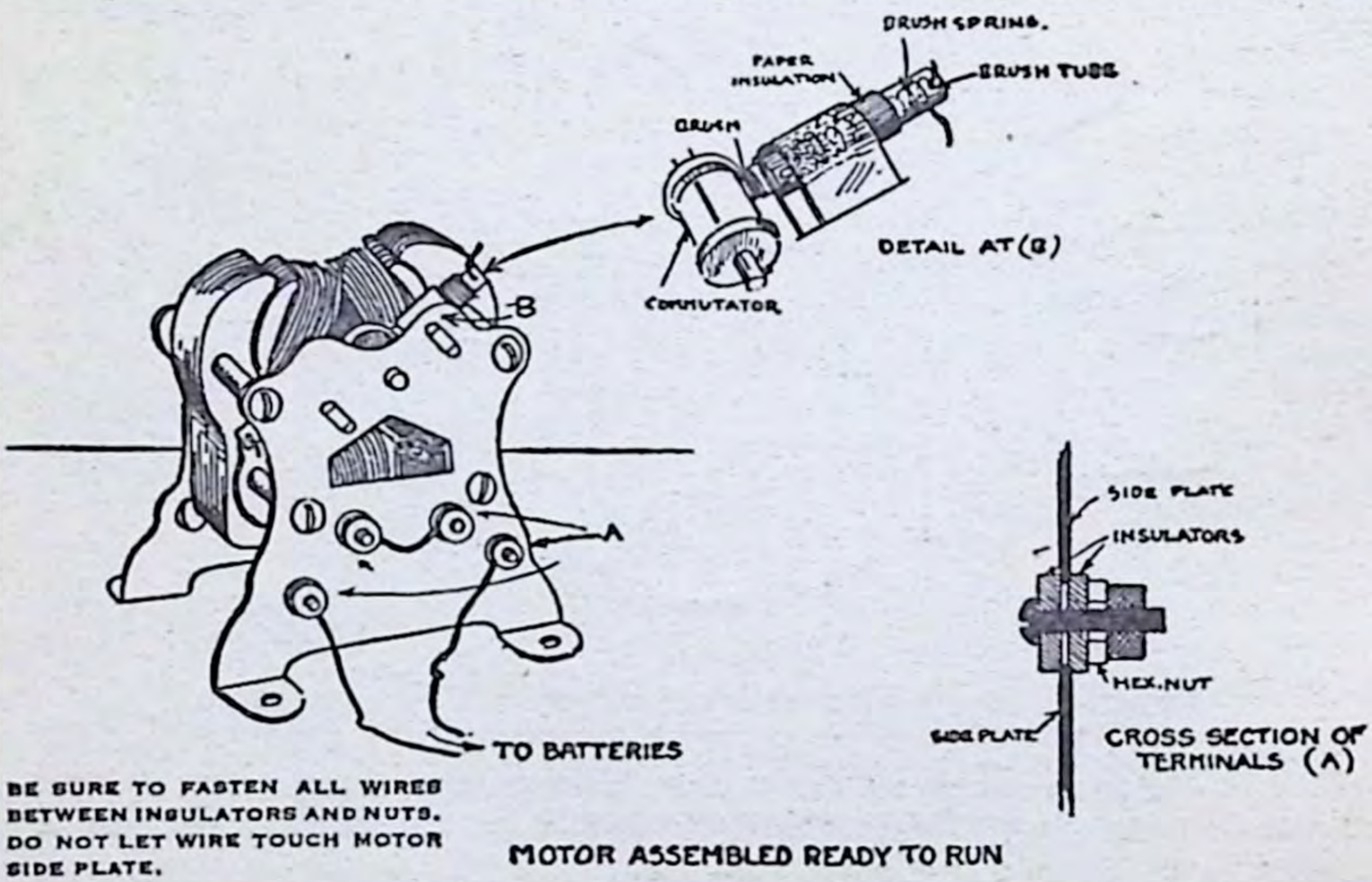


Fig. 14C

¾ inch long. Slip the screws through the brush side plate so that the heads will be on the same side as the brass binding nuts are. Put a ¾-inch sleeve over each screw. Put the brass screws and sleeves at the top. Next push the screw through the four holes in the magnet frame (having the magnet turned with the open end at the brush tube end of the side plate). Slip the armature in place by putting the winding through the circular hole in the field magnet and slipping the commutator end between the brush tubes with the shaft through the hole in the side plate. In the part box are four ¼-inch sleeves. Put these over the ends of the screws, then slip the pulley side plate over the screws and also over the armature shaft. The feet of the side plate should be turned out from the rest of the motor. Fasten the motor tightly together by screwing the four hexagonal nuts on the outside ends of the screws. Force the pulley on the end of the armature shaft which sticks out of the pulley side plate.

The copper brushes which will be found in the part box go in the brush tubes, one in each, and should slide in freely and rest against the commutator. The two little brass springs which will be found in the part box slide in the brush tubes next to the brushes and serve to keep these pushed in against the commutator.

Short wires should be connected from terminal screw No. 1 and terminal screw No. 3 to the brush tubes. The brush ends of these wires push through the two little holes in the outside end of the brush tube and hold the springs in place. Bend the end of the wire over so it will not slip out. This will hold the springs in. Connect a toy transformer (4 to 18 volts) or a set of four dry batteries (connected together from the outside post of the next) to terminals 1 and 4. Connect terminals 2 and 3 with a short piece of copper wire and your motor will run when the current is turned on.

(17) HOW THE MOTOR MOTES: By which I mean, how the motor works. Connect the binding posts 3 and 4 (see Fig. 15) with a battery. Now let's suppose that the current flows into the motor through the binding post 4, when it makes its way first through the coil of the field magnet and magnetizes it. Then it passes to the binding post 1, through the connecting wire to 2, and thence to the brush.

The commutator makes the current pass through the three coils of the armature and from these coils the current flows through the commutator segments to the other brush which is connected with the binding post 3, from which the current goes back to the battery. On its way through the armature, the current flows, by means of two segments of the com-

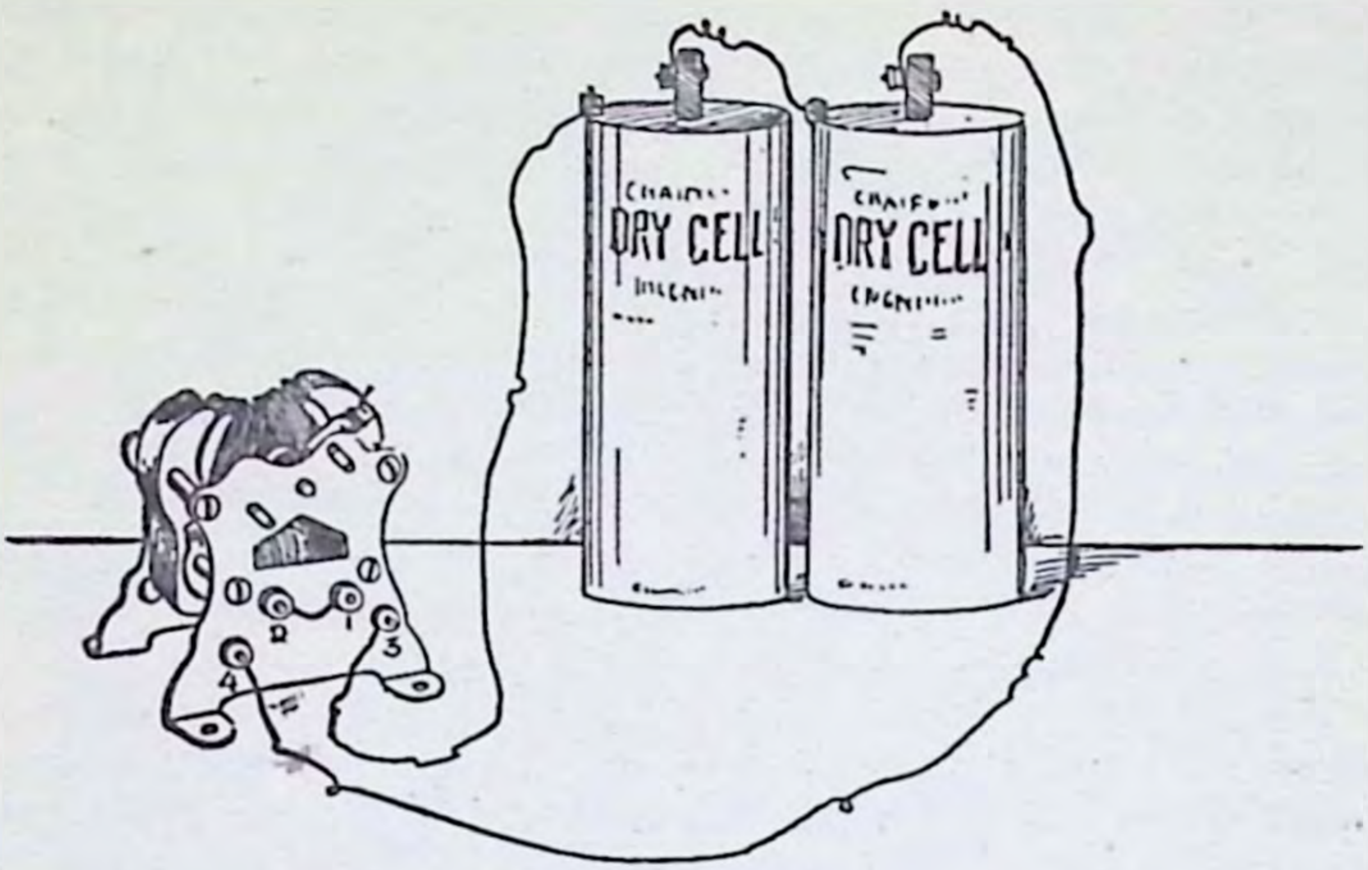


Fig. 15

mutator, to two coils of the armature at the same time; it goes into one coil by the outside end of the wire and into the next coil by the inside end. This is the reason that one of the armature poles is north and the next one is south as shown in Fig. 11.

Because two of the poles of the armature are unlike they are attracted by the poles of the field magnet and this pulls the armature around. At exactly the same moment that the poles are attracted to just opposite the ends of the field magnet, the commutator reverses the current, which causes the poles of the armature and the field magnet to repel each other and this pushes the armature around.

If you will look at your commutator closely as you turn the armature around, you will see that the brush moves across the slit between the segments at the same moment that the poles of the armature are just opposite the poles of the field magnet.

(18) ABOUT THE POWER OF YOUR MOTOR: The attraction and repulsion of the poles of the armature and the field magnet make the armature rotate and, hence, the power developed by the motor depends on the strength of the magnets. As these are electromagnets, their strength increases with the amount of the current which energizes them,

although a limit is soon reached because the core, as the iron part of the magnet is called, can be magnetized only to the point where they are saturated with magnetism. It is on the same principle that a sponge can be made to absorb a certain amount of water and no more.

(19) HOW TO MAKE THE ARMATURE RUN IN THE OPPOSITE DIRECTION: If you will turn back to Experiment 7, you will see that by changing the connections of the coil on the field magnet and the battery the polarity of the former will be reversed. But to reverse the direction of the rotation of the armature, you must reverse the direction of the current flowing into the field magnet or in the armature, but not in both. The easiest way to do this is by means of a reversing switch.

(20) HOW THE REVERSING SWITCH IS MADE: To make it easy to change about the connections of the battery and your motor and to make the change instantly, a reversing switch is used. The reversing

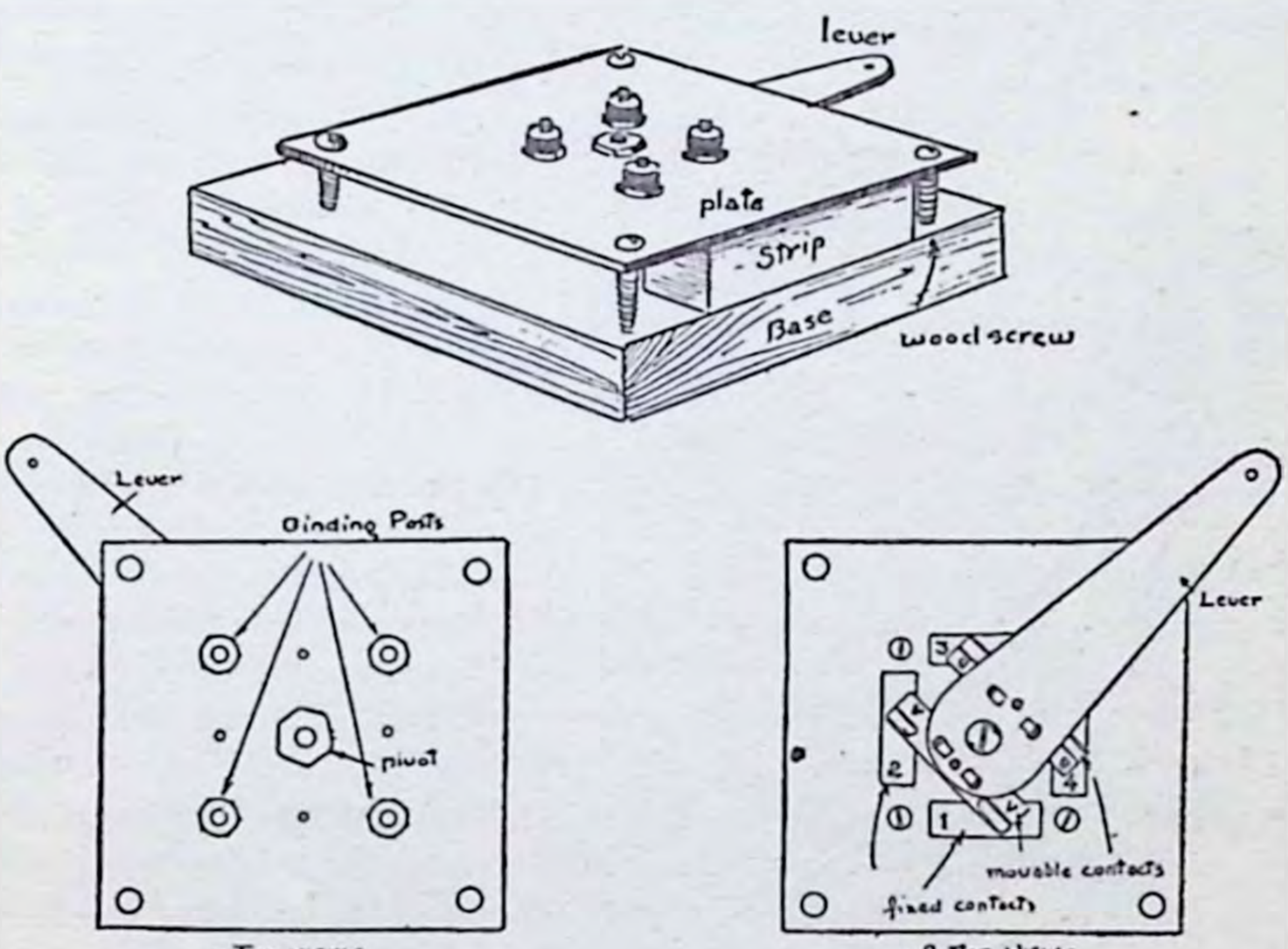


Fig. 16

switch for a Gilbert motor is formed of a sheet of hard fiber 2½ inches on the sides. Four binding posts are secured to the top of the piece of fiber as shown in the top view of Fig. 16, and these make contact with four fixed metal contact plates on the under side of the fiber as shown in the bottom view of Fig. 16. These fixed contact plates are numbered 1, 2, 3, and 4, respectively, in the diagrams.

Two movable ribbed brass contact bars, marked A and B in the diagram, are secured to a fiber lever, the large end of which is pivoted to the center of the sheet of fiber. To use the commutator, mount it on a wood base about ½ an inch thick and 3 inches on the side. To do this, cut out two strips of wood ½ an inch square and 1½ inches long, place these strips on the opposite edges of the switch, and screw the switch down to the block, all of which is shown in the perspective view in Fig. 16.

(21) HOW THE REVERSING SWITCH WORKS: Connect the reversing switch with the motor and battery as shown in Fig. 17, that is, connect the binding post of the motor marked 1 to the binding post of the reverse switch marked 1; connect the binding post of the motor marked 2 to the binding post 2 of the switch; connect the post 3 of the motor with the post of the switch marked 3; finally connect the post 4 with the zinc of the battery and the carbon of the battery with the binding post 4 of the switch. Now when the lever of the switch is in the position shown by the full line in Fig. 17, the armature will run in one direction, and when the lever of the switch is in the position shown by the broken line, the armature will run in the opposite direction. Finally

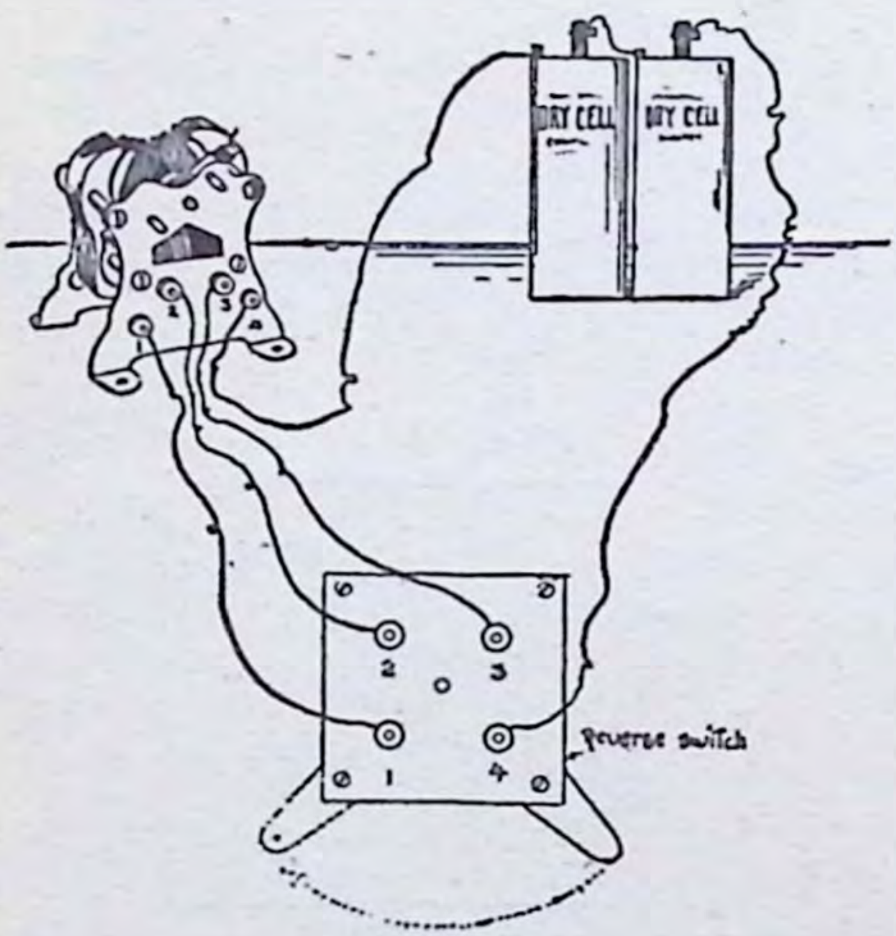


Fig. 17

when the switch lever is halfway between the binding posts 1 and 4, the circuit is, of course, open when no current can flow from the battery to the motor.

(22) HOW TO CHANGE THE SPEED OF YOUR MOTOR: To make your motor run at varying speeds, what you need to do is to connect a rheostat, as an adjustable, or variable resistance is called, in the circuit between the motor and the dry cell, or battery, as shown in

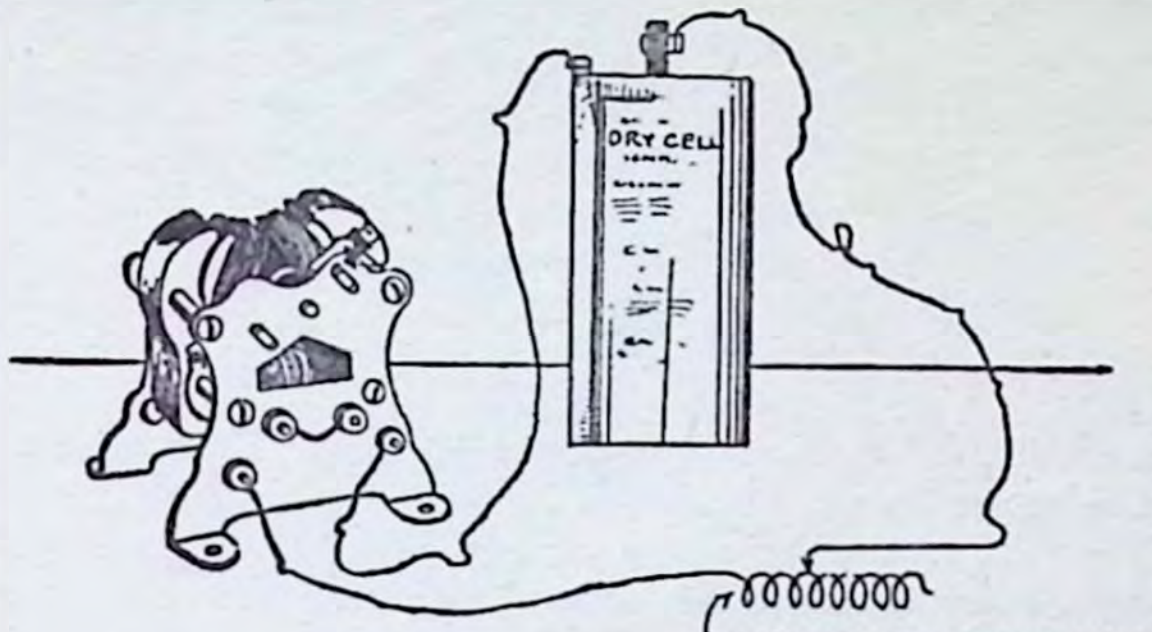


Fig. 18

Fig. 18. Now by cutting in or out more or less resistance by means of the rheostat, a smaller or a larger amount of current will flow through the circuit and your motor will run slower or faster accordingly.

(23) HOW TO MAKE A SIMPLE CARBON RHEOSTAT: Take the leads out of two pencils and be careful not to break them. Wrap and twist a piece of bare copper wire around one end of each and then glue them to a strip of wood as shown in Fig. 19. Connect these two wires to the battery and your motor and then slide another and shorter piece of lead from the ends to which the wires are attached toward the free ends, when the resistance will become greater and the speed of your motor will be less, as well as the power developed.

(24) HOW TO MAKE A WIRE RHEOSTAT: Drive ten brads or tacks in a pine board about 5 inches wide and 10 inches long and drive

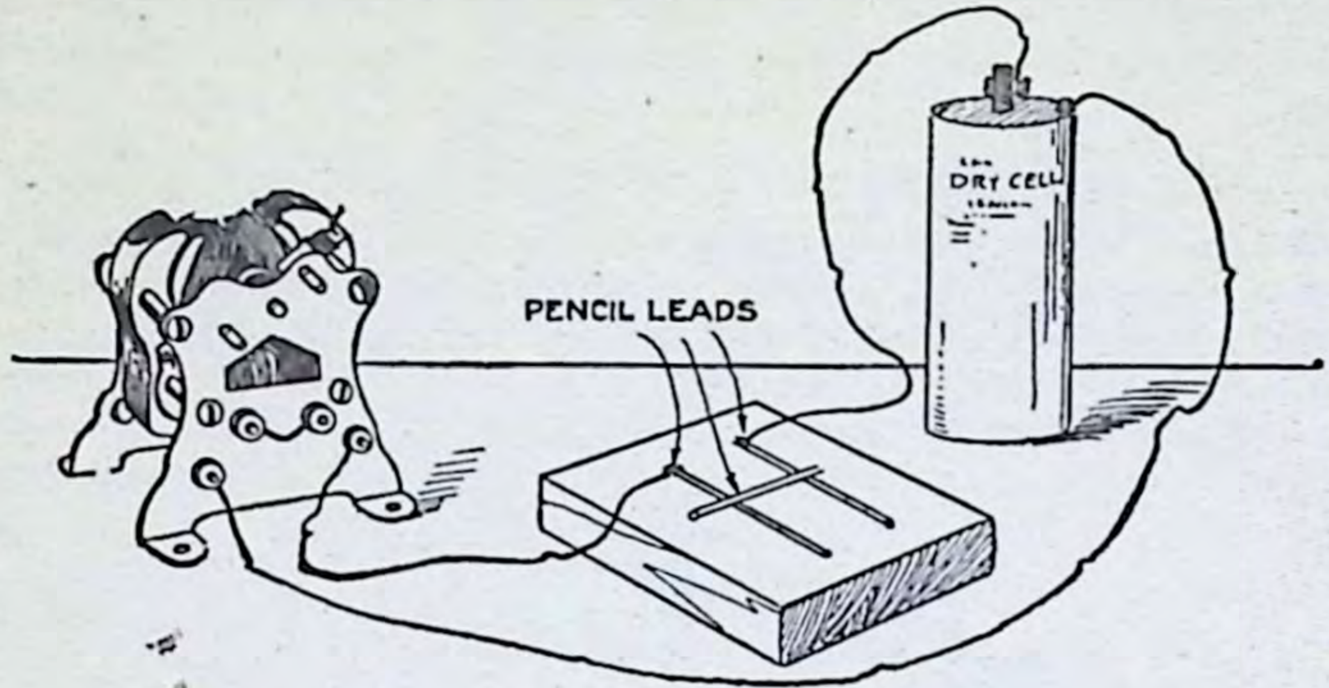


Fig. 19

them down until the heads project about ¼ inch. Now take a piece of No. 30 iron wire, or better, because it has a higher resistance, a piece of German silver wire of the same size, and twist one end around one of the end tacks, then carry it to the corresponding tack at the other end and so on until the last tack is reached, where you twist the other end of the wire

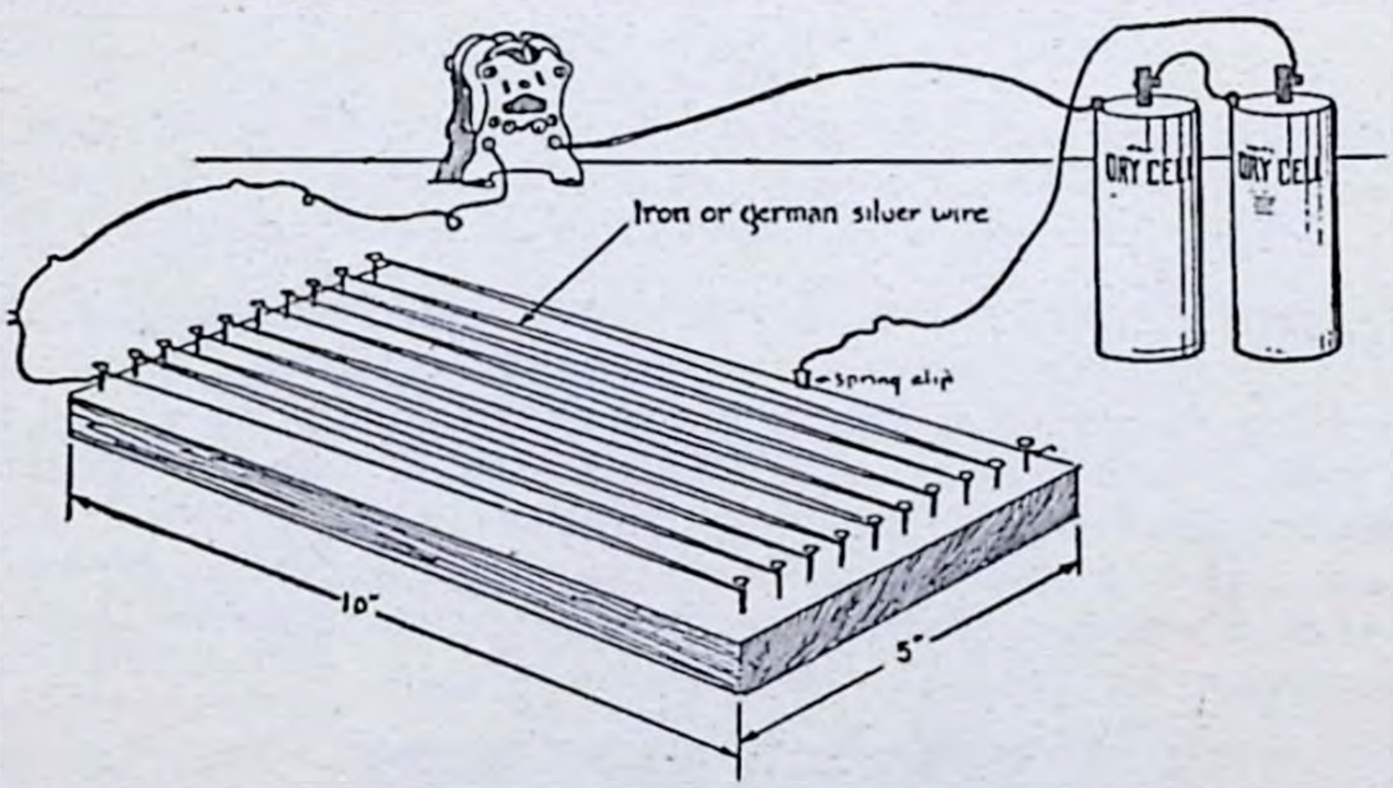


Fig. 20

fast. Fig. 20 shows how the rheostat is made. To vary the resistance, all you have to do is to clip the clip on to various parts of the wire.

(25) **HOW TO MAKE A WATER RHEOSTAT:** Take a couple of teaspoons and twist a piece of wire around one end of each and be sure it makes a good contact. Next cut a strip of cardboard 1 inch wide and 4 inches long and cut out two holes in it about 1 inch apart and just large enough to push the spoons through.

Now fill a tumbler two-thirds full of water, put a tablespoonful of salt in it, and stir it until it is thoroughly dissolved. Place the spoons in it

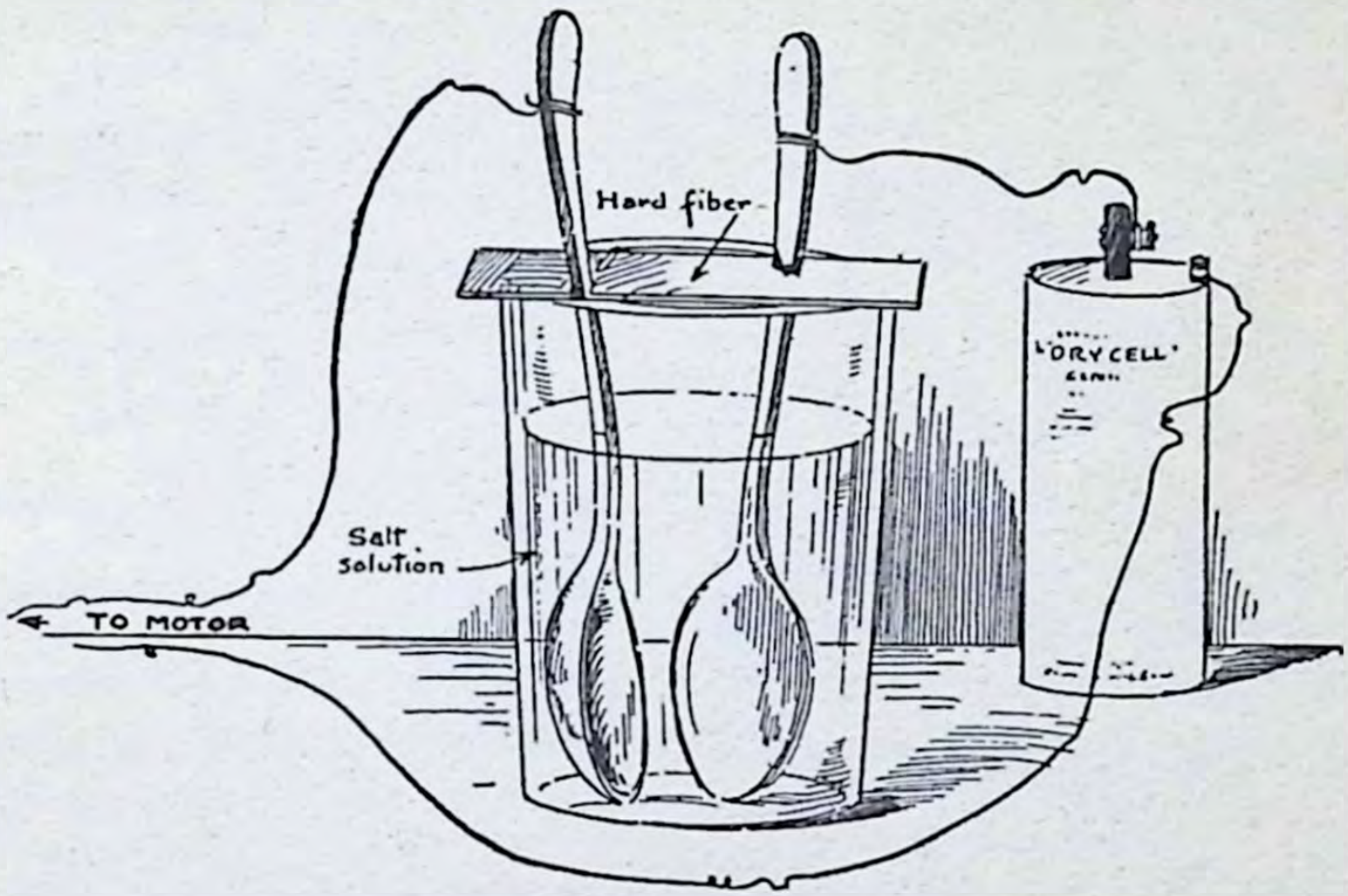


Fig. 21

as shown in Fig. 21 and connect one of the wires to the battery and the other wire to your motor and then connect the free binding posts of the battery and the motor together. By raising and lowering the spoons more or less, more current will flow through the rheostat from the battery to the motor.

(26) WHAT THE "LOAD ON A MOTOR" MEANS: When a horse is pulling an empty wagon it has no load (that's sure); but when it is pulling a wagon with something in it, it has a load (which is quite as certain). Just so with a motor; when it is not running any machine it has no load on it, but when you belt it to a machine and make it do work it then has a load on it. The extent of the load on it depends on the amount of power it has to develop in order to do the work.

Part II

SOME MYSTO EXPERIMENTS WITH YOUR MOTOR

(27) THE DISAPPEARING COLORS: Cut a disk out of pasteboard 3 inches in diameter. Divide it into three equal spaces, as shown in Fig. 22. Cut out and paste on three colors of tissue paper, namely,

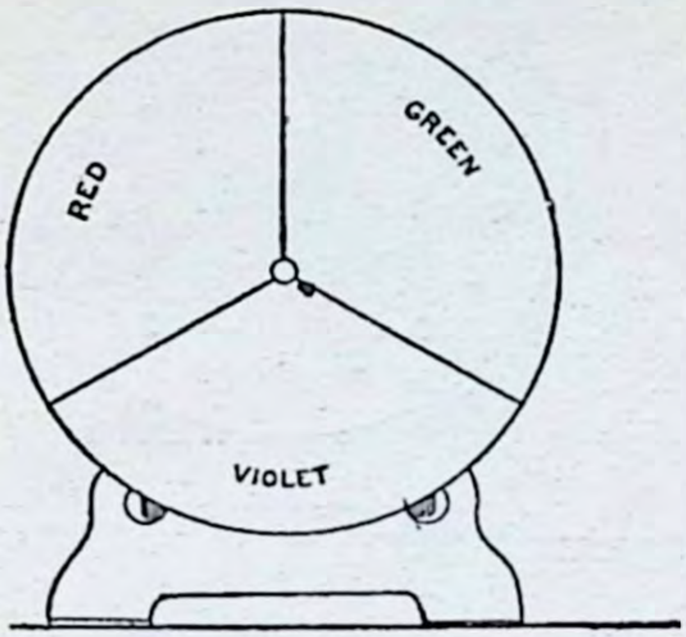


Fig. 22

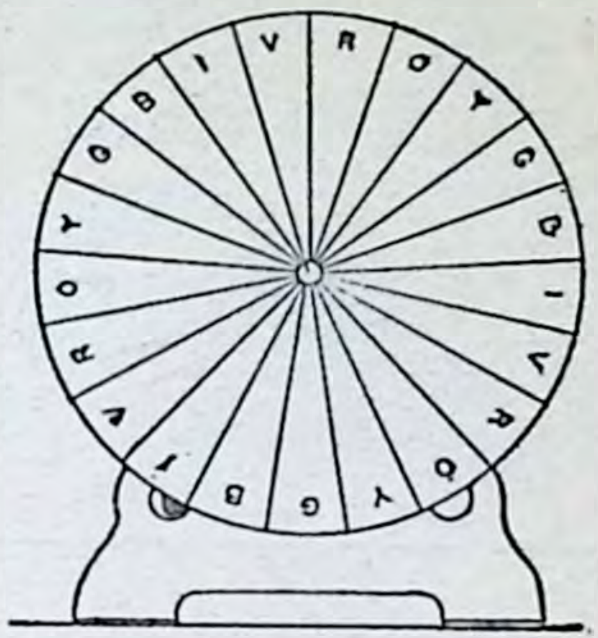


Fig. 23

red, green, and violet; then place the disk on the shaft of your motor and switch on the current. When the disk is rotating fast enough the colors will blend into one and you will not be able to see any of them.

HOW MANY COLORS MAKE WHITE: By dividing the disk into 21 spaces and pasting on red, orange, yellow, green, blue, indigo, and violet pieces of tissue paper, as shown in Fig. 23, and then rotating the disk with your motor, the many-colored surface will appear to be white. If the disk takes on a gray color when it is rotating, it is because the colors of the tissue paper are not of exactly the right shade.

(28) RED AND GREEN MAKE YELLOW: Cover half of the pasteboard disk with red paper and the other half with green paper, put it on the shaft of your motor, when these two colors will blend into yellow, since red and green make yellow.

(29) THE BUZZ SAW: Cut a saw-tooth edge on a cardboard disk 3 inches in diameter, as shown in Fig. 24. Mount the disk on the shaft of your motor and set it to rotating. Now hold the edge of a business card against the rapidly moving toothed wheel, when it will give out a

Fig. 24

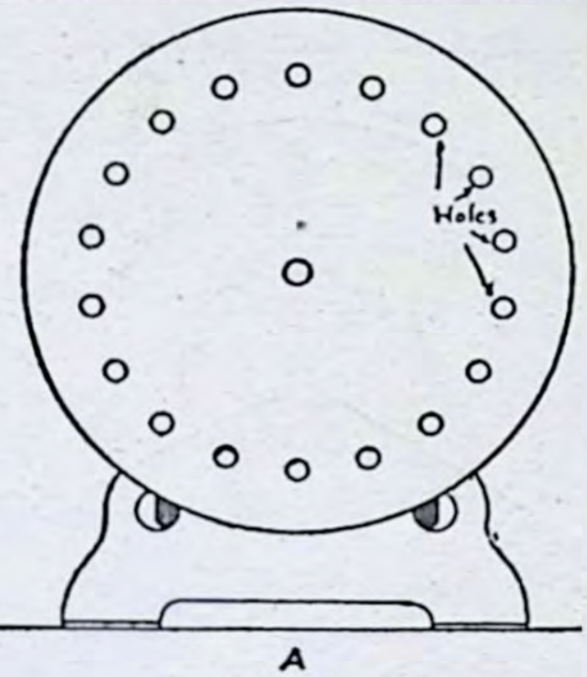


Fig. 25

musical note. By cutting out a number of disks and spacing the teeth differently, various musical notes will be provided. By spacing the teeth on a disk unevenly it will make a harsh sound — that is, a noise.

(30) THE SONG OF THE SIREN: (1) Punch a ring of evenly spaced holes around the edge of a disk 3 inches in diameter with a sharp-pointed nail and make a hole in the center of it, as shown at **A** in Fig. 25, and mount it on the shaft of your motor. Take a rubber tube ¼ inch in diameter and 1 foot long, make a mouthpiece of cardboard and fix the small end of it to one end of the tube. Now run your motor and then blow with the mouthpiece, when the disk will give forth a musical note. (2) Punch a ring of unevenly spaced holes around the edge of the disk, rotate it, and blow into the tube as before, when it will give forth a curious noise.

(31) THE SPINNING CHAIN: Fasten an endless chain by a string to the end of the shaft of your motor and hold the latter so that the chain hangs down. Now start up your motor, when the centrifugal force will make the chain spread out into a ring and whirl in a horizontal plane. This experiment illustrates the tendency of a body to rotate about its shortest diameter.

(32) THE ROLY-POLY EGG: Here is a trick with an egg that Columbus didn't know anything about. Take a fresh egg (and be sure it is fresh) and make a hole about ⅛ inch in diameter at both ends; this done, carefully blow out the contents and then fasten a thread to one

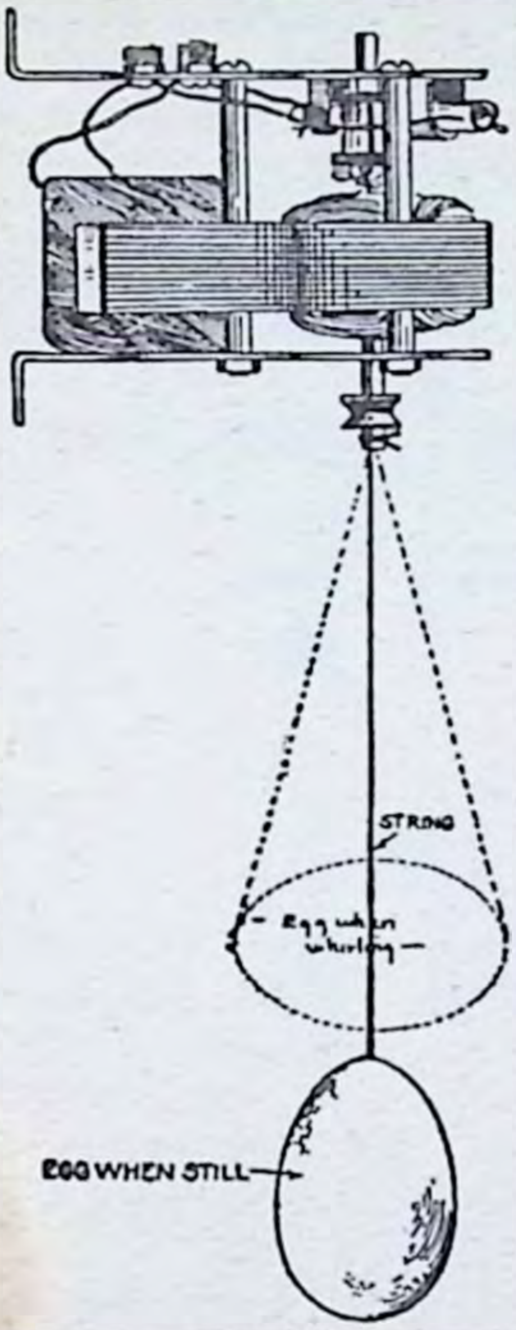


Fig. 26

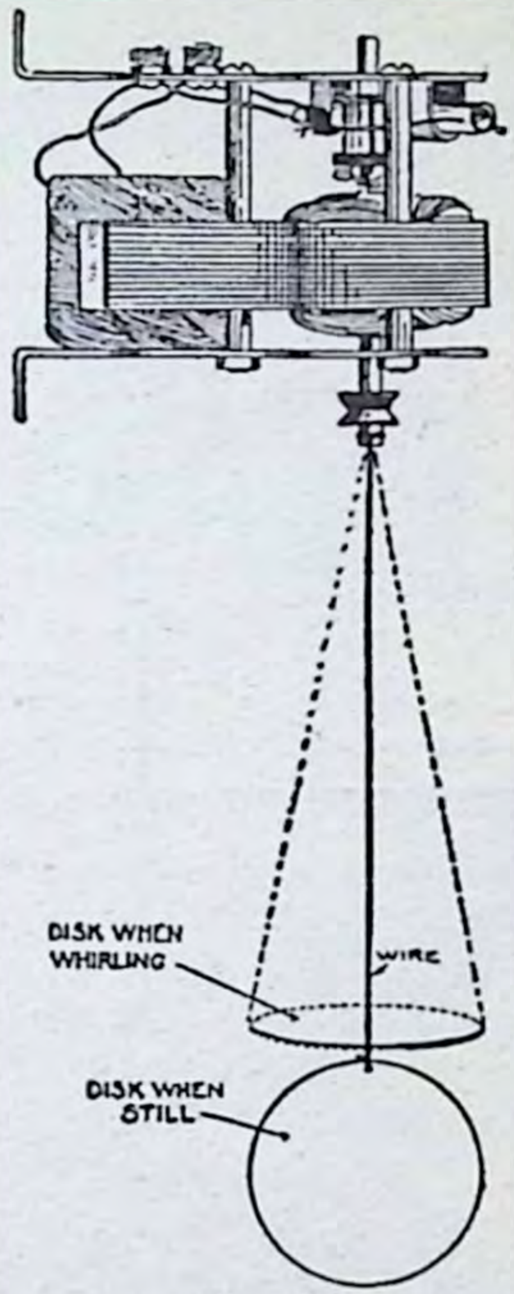


Fig. 27

end of the shell with a drop of sealing wax and tie the other end of the thread to the shaft of your motor. Hold the latter so that the shaft is vertical and slowly start up the motor, when the centrifugal force will make the egg whirl about its shortest diameter and so bring it to a horizontal position as shown in Fig. 26.

(33) THE WHIRLING DERVISH DISK: Tie a wire to the edge of a metal disk and tie the other end of it to the shaft. Hold your motor so that the shaft is vertical and switch on the current. When it gets up to speed the centrifugal force will make the disk rise to a horizontal plane as shown in Fig. 27.

(34) THE PAIL OF WATER THAT JACK CAN'T SPILL: Fix a piece of No. 24 copper wire around the top of a thimble to form a bail on it as shown in Fig. 28. Suspend the little bucket thus made by a string from the end of the shaft of your motor and hold the latter so that the

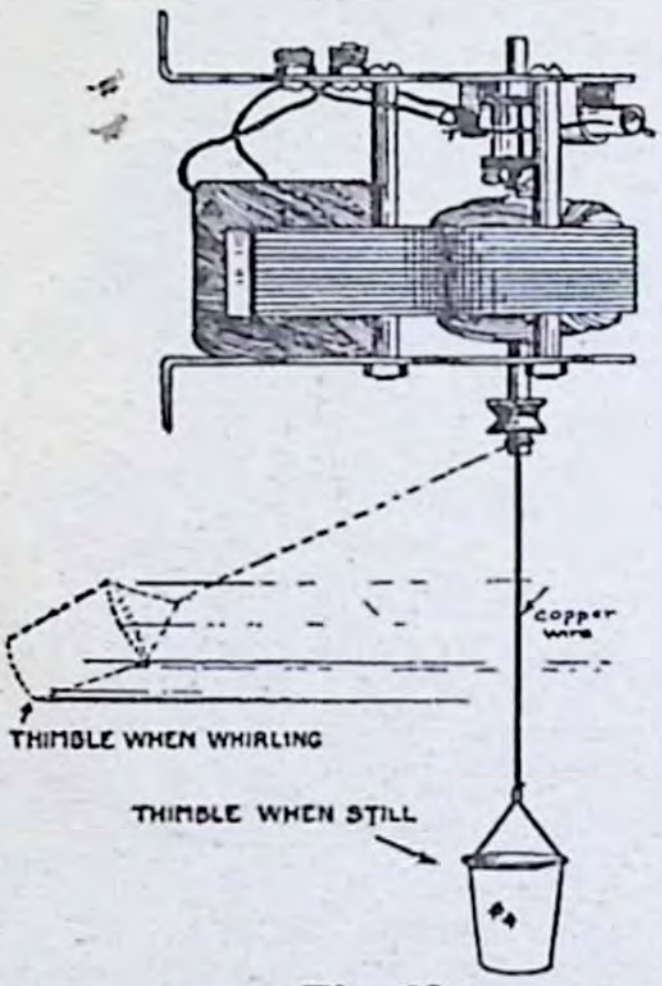


Fig. 28

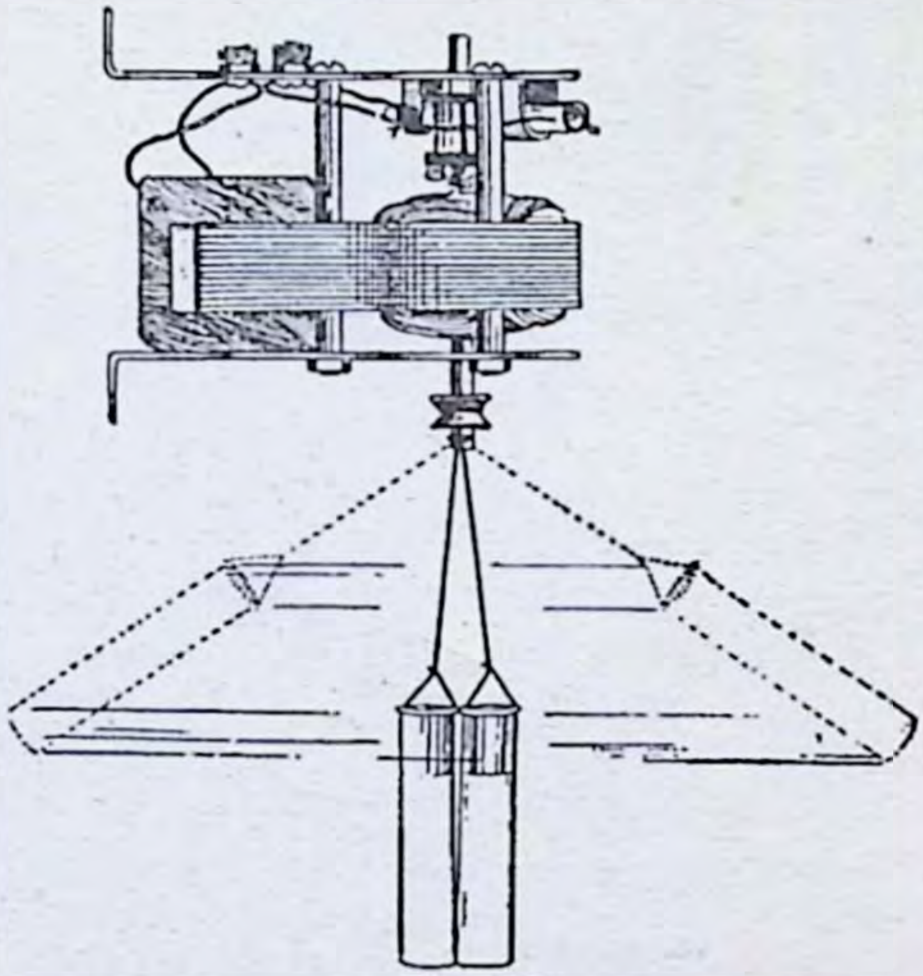


Fig. 29

shaft is vertical. Start up your motor and as it gathers speed the centrifugal force will throw the little bucket out and up until it will be revolving in a horizontal plane. The water, however, will not spill out as the centrifugal force holds it in.

(35) HOW TO SEPARATE CREAM FROM MILK: Fill two of the smallest pill bottles you can get about half full of fresh milk (not skimmed). Tie a strong thread around the neck of each bottle and tie the

other ends to the end of your motor shaft. Hold the motor with the shaft in a vertical position, as in Fig. 29, and start it up. As the speed increases the little bottles will fly farther and farther apart, and the cream, which is heavier than the milk, will be thrown to bottom ends of the bottles. This kind of an apparatus is called a centrifugal separator.

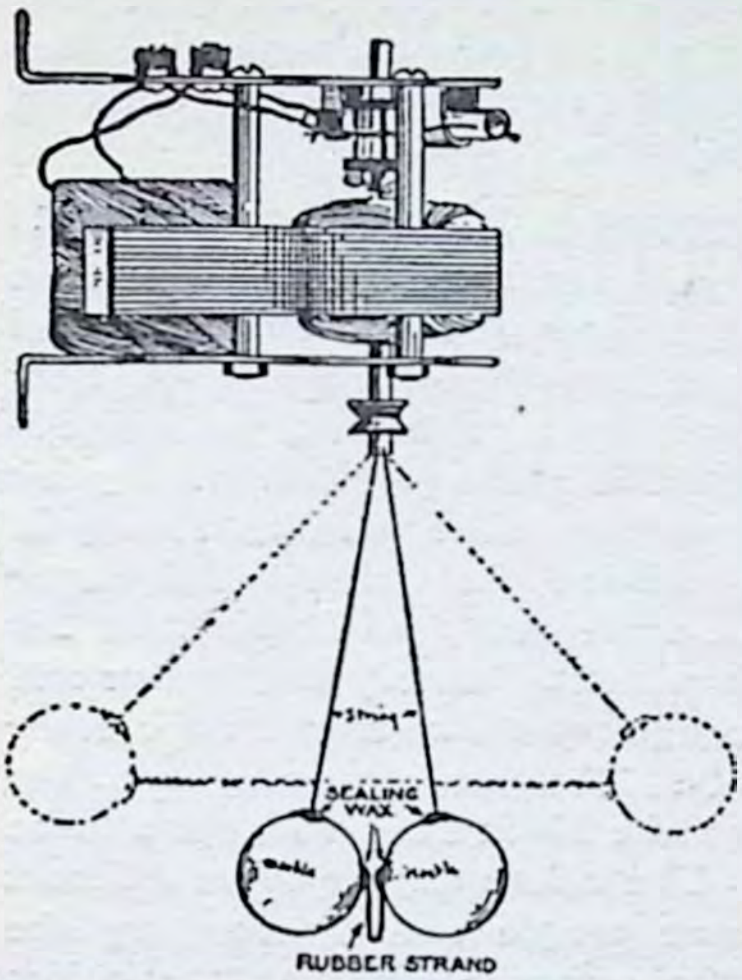


Fig. 30

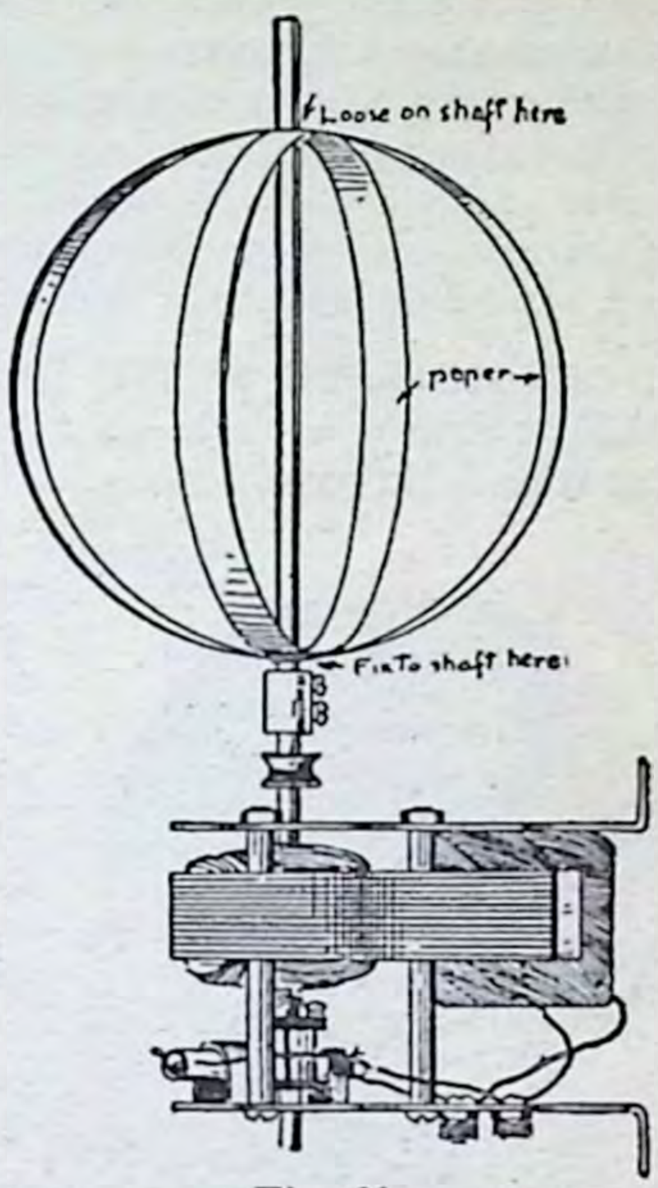


Fig. 31

(36) HOW A STEAM ENGINE GOVERNOR WORKS: Stick the ends of two strings to two marbles with a bit of sealing wax and then fasten the ends of a thin rubber band, which you have cut in two, to the marbles with sealing wax, as shown in Fig. 30. Tie the free ends of the strings to the end of the motor shaft and start up your motor. When the motor is not running, the marbles will, of course, hang down, but when they begin to rotate they will rise against the action of the rubber strand.

(37) WHY THE POLES OF THE EARTH ARE FLAT: First connect the extension shaft to the shaft of your motor by means of a coupling. Next make two hoops 3 inches in diameter of cardboard that is just stiff enough to hold the shape. Glue the hoops together at the bottom only and at right angles to each other. Make a ¼-inch hole through them at the top where they cross and a hole just large enough at the bottom where they cross so that when you push the hoops down on the shafting they will revolve with it, as shown in Fig. 31.

The tops of the hoops must slide freely on the shaft. Now start your motor and when the speed is high enough the hoops will begin to flatten at the ends. This experiment shows how the earth when it was spinning in a semi-fluid state was flattened at the poles.

(38) HOW TO MAKE BLACK LINES APPEAR TO BE COLORED: Draw a circle on a piece of pasteboard 3 inches in diameter. Cut it out and paste a piece of black paper over half of it and a piece of white paper over the other half of it. Now draw a series of arcs, that is, parts of circles, with India ink (a jet-black writing ink will do) on the white part, as shown in Fig. 32. Mount the disk on the motor shaft, put a rheostat (see Experiment 24) in circuit with the battery and motor and cut in enough resistance to make the latter run slowly. Throw a strong light on the disk when the black lines will seem to be colored. The colors appear to be different to different people and by rotating the disk in the opposite direction the colors will apparently change. This is known as Benham's color effect.

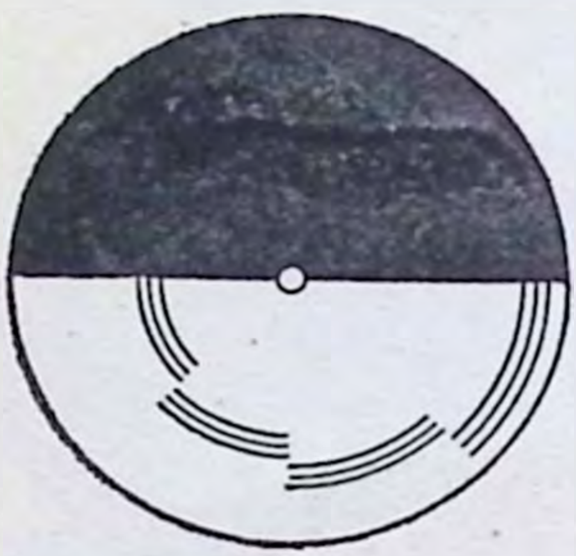


Fig. 32

(39) THREE GOOD OPTICAL ILLUSIONS: Cut out three disks of cardboard 2 inches in diameter and with 3-inch handles to them as shown at A, B, and C in Fig. 33, and punch a small hole in the center of each one. Now screw the shaft coupling to the shaft of your motor and screw a wire crank in the other end of the shaft coupling as at D.

Now slip one of the disks on the end of the crank, hold the handle between your thumb and forefinger loosely and run your motor very slowly when it will give the disk a rinsing motion. The circles on the first disk will seem to turn in the direction that the motor shaft is rotating. The internal teeth on the second disk will apparently turn in the opposite direction to that in which the shaft is rotating, while the spirals on the third disk will appear to turn first one way and then the other.

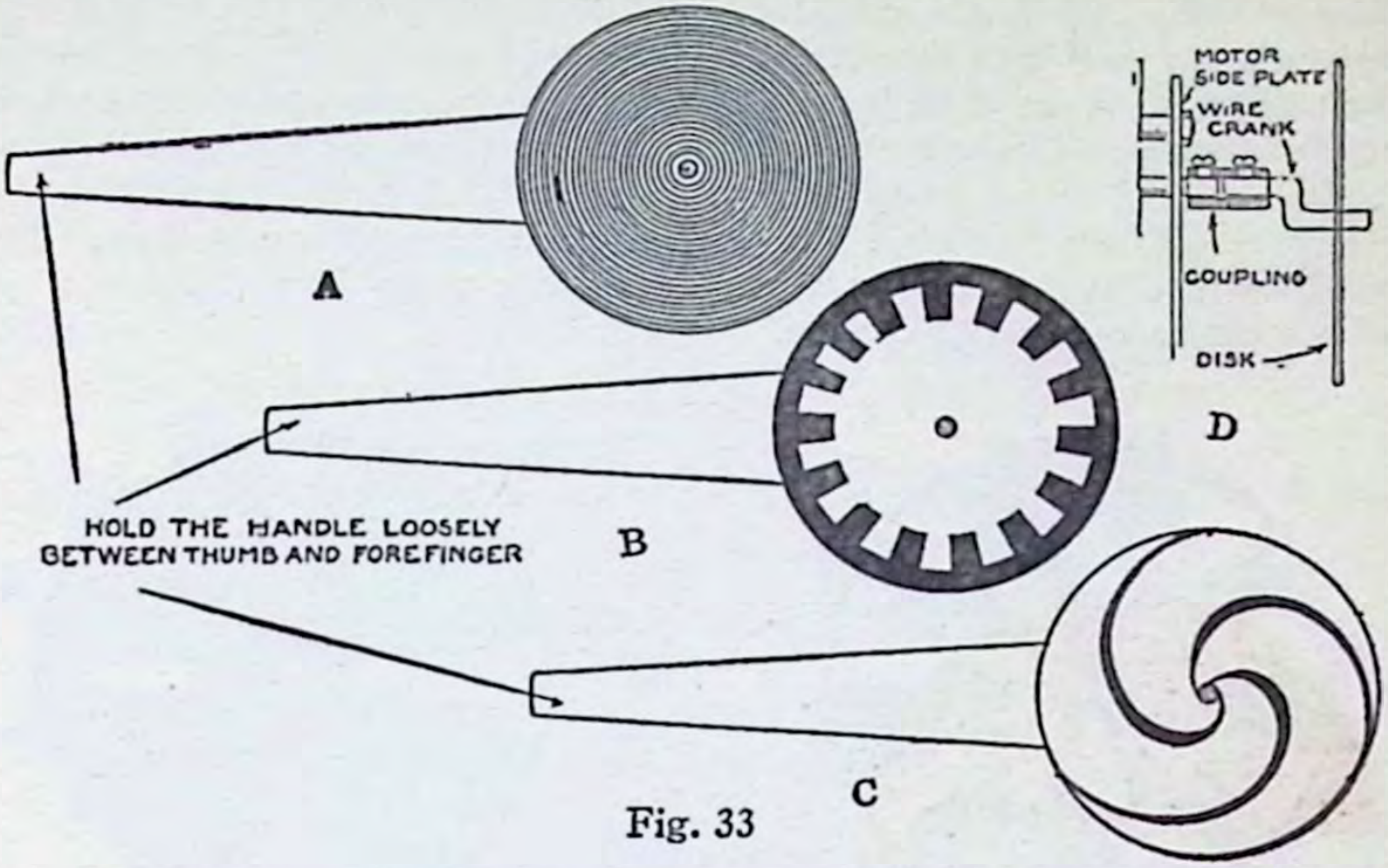


Fig. 33

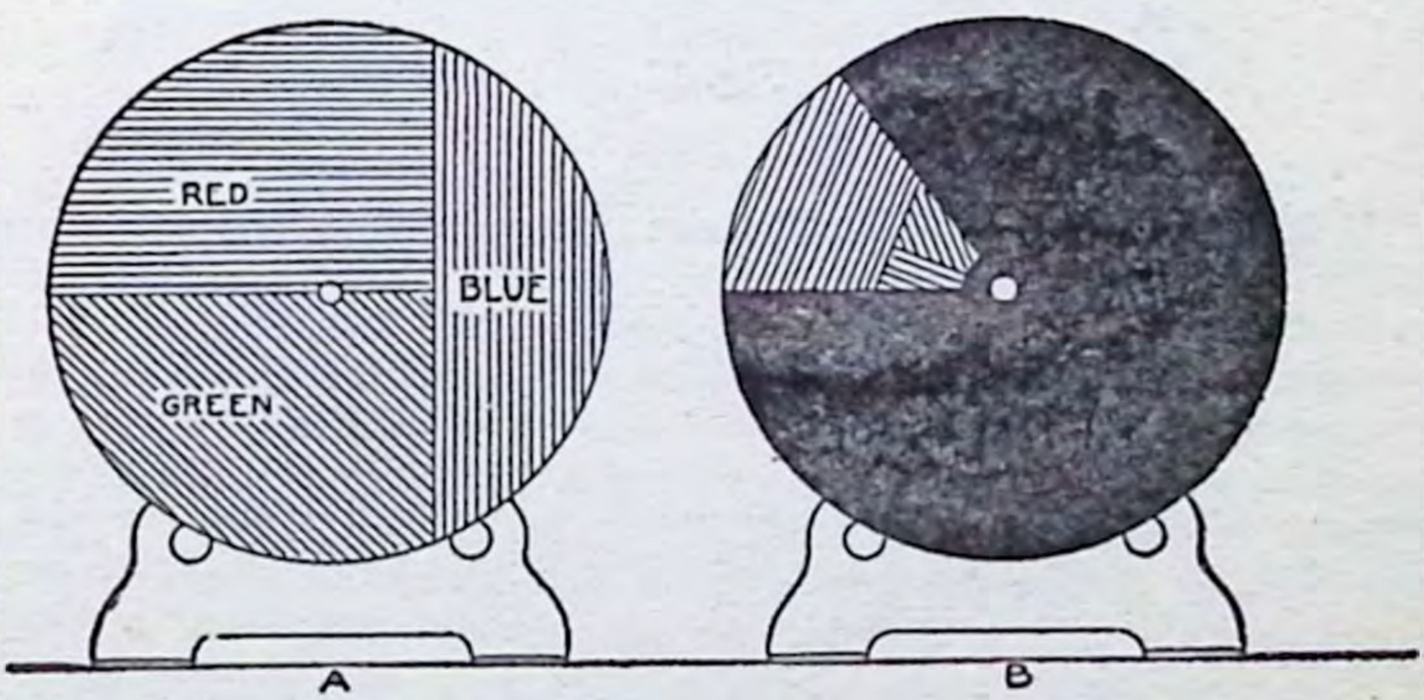
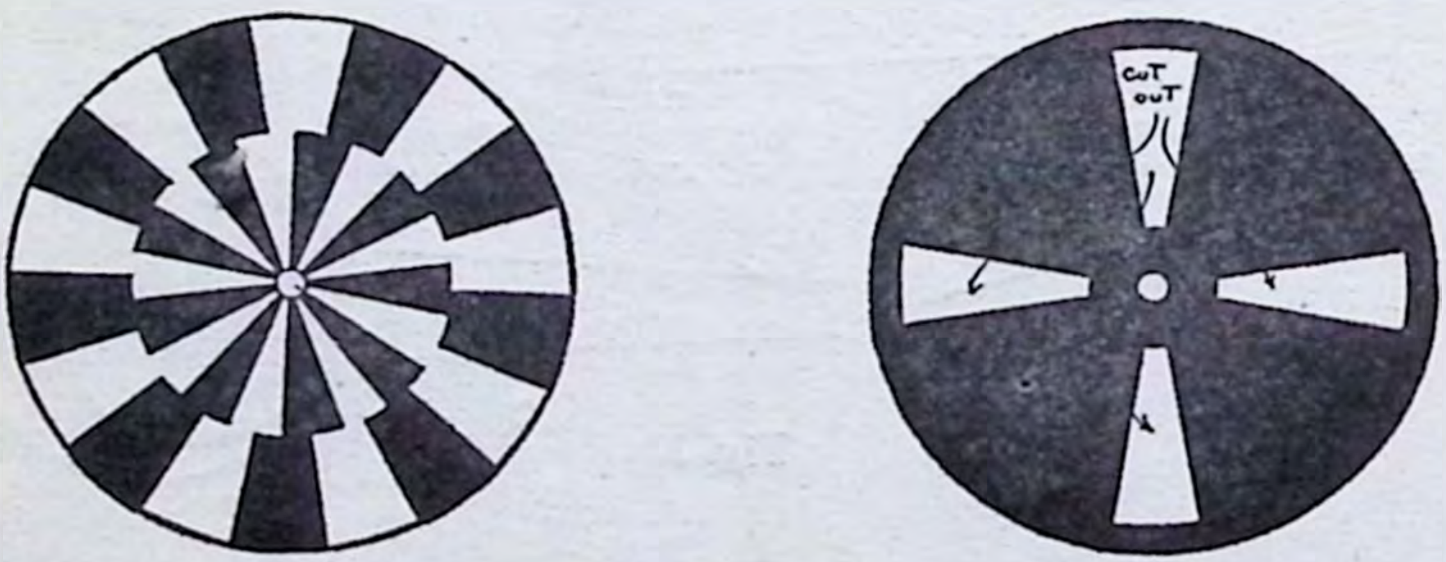


Fig. 34

(40) THE CHAMELEON COLORS: Cut out two disks of pasteboard 3 inches in diameter and on one of them paste three pieces of differently colored tissue paper as shown at A in Fig. 34. Paste a piece of black tissue paper on the other disk and cut a section out of it as at **B.** Now punch a hole in the center of each disk and mount the colored one on the motor shaft so that it will fit tight and mount the sector disk on the shaft so that it will be loose. Now start up your motor and then look at the color disk through the sector disk. On changing the speed of the latter, by touching its edge with your finger, it changes its position with reference to the color disk when you see the different colors in turn. The persistency of vision makes these colors run together and form rings whose colors constantly change.



A B

Fig. 35

(41) THE JAG-O-SCOPE: Cut out two pasteboard disks 3 inches in diameter and divide one of them into two sets of radial bars each as shown at A in Fig. 35. Put in the radial bars with India ink, or any other jet-black ink. Next cut four radial slots in the other disk, as shown at B, then punch a hole in each disk and mount the color disk A on the motor shaft so that it will not slip and make the hole in the slotted disk B just large enough so that it will fit tight on the shaft. Start up your motor and then change the speed of your radial bar disk by pressing your finger against the edge of it and at the same time look through the slotted disk. By changing the speed of the radial disks, one set of the bars will seem to be standing still while the other set seems to rotate; the two sets of bars will seem to be turning in opposite directions and, again, the bars will take on a curved form.

(42) THE PHANTOM VASES: Screw the coupling of your motor on the shaft and set the motor on end so that the shaft is vertical and

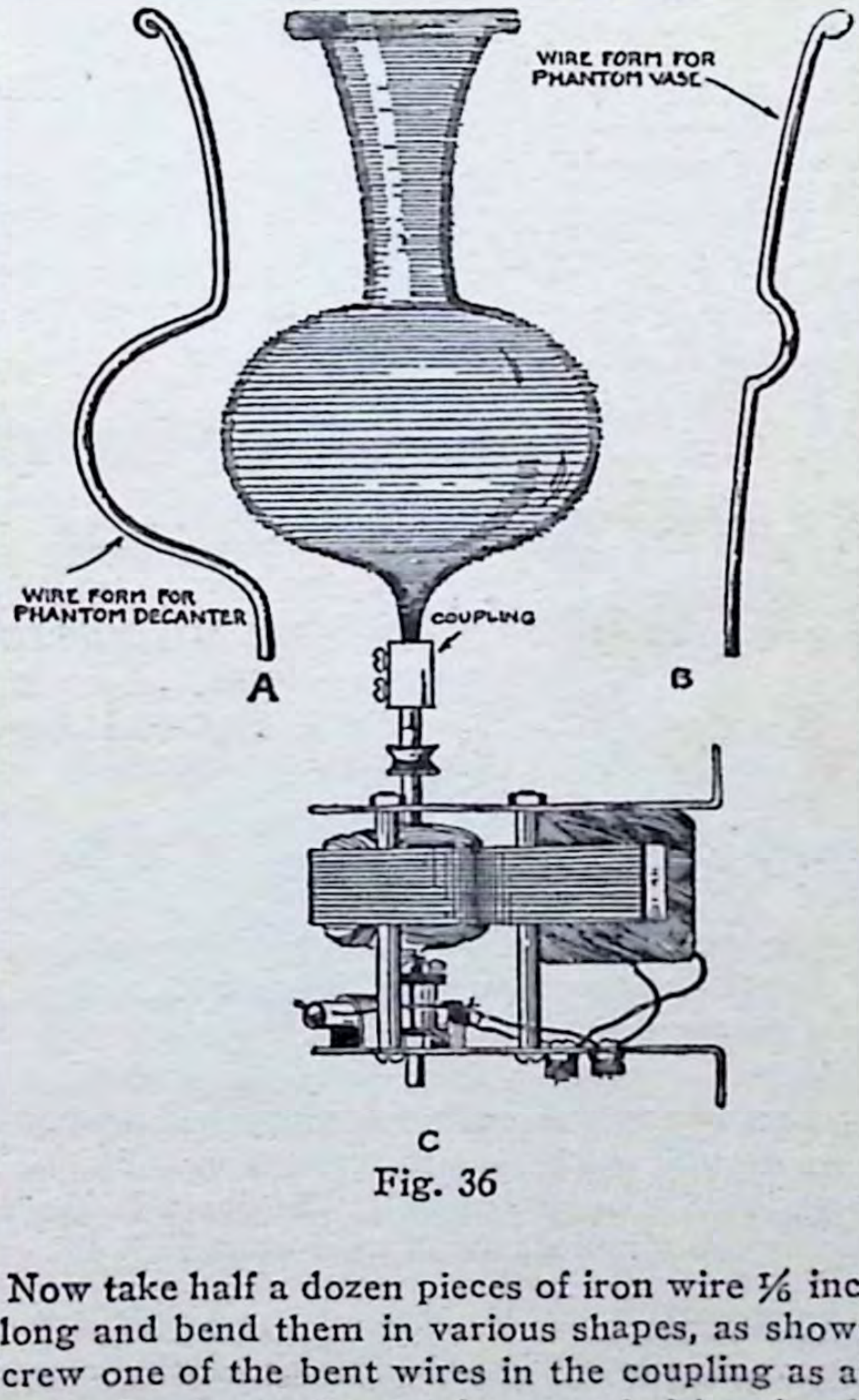


Fig. 36

pointing up. Now take half a dozen pieces of iron wire ⅙ inch in diameter and 3 inches long and bend them in various shapes, as shown at A and B in Fig. 36. Screw one of the bent wires in the coupling as at C, and start up your motor slowly; due to the persistency of vision, it will take on the shape of a vase, but it will be very phantom-like indeed.

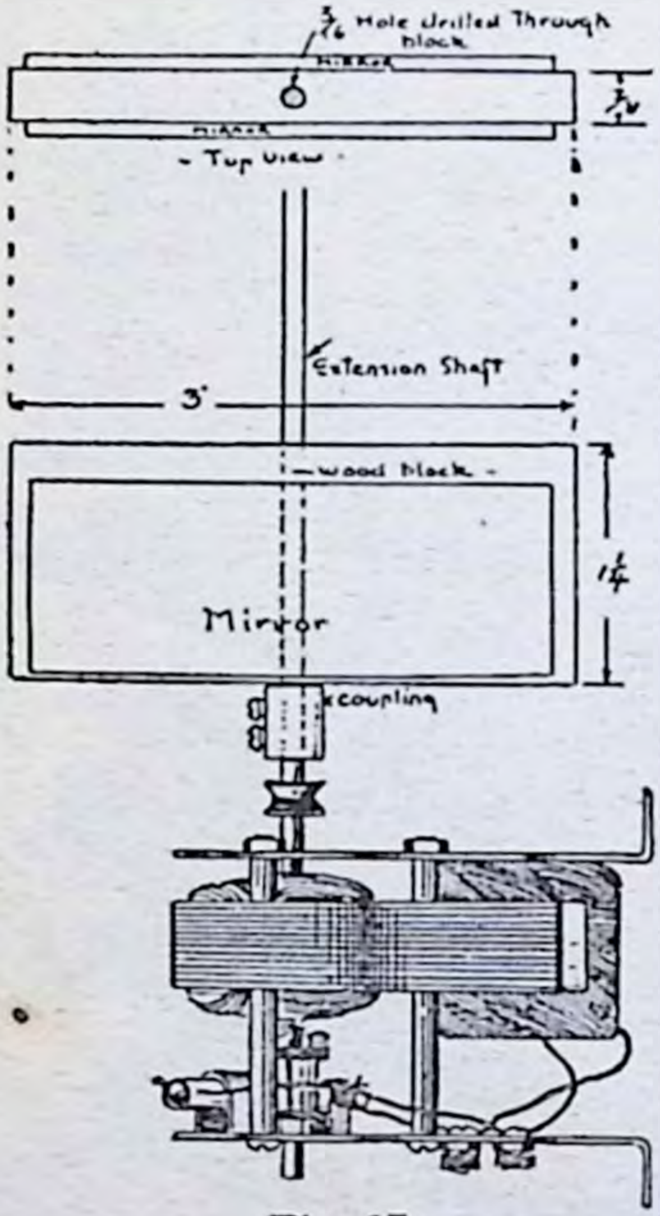


Fig. 37

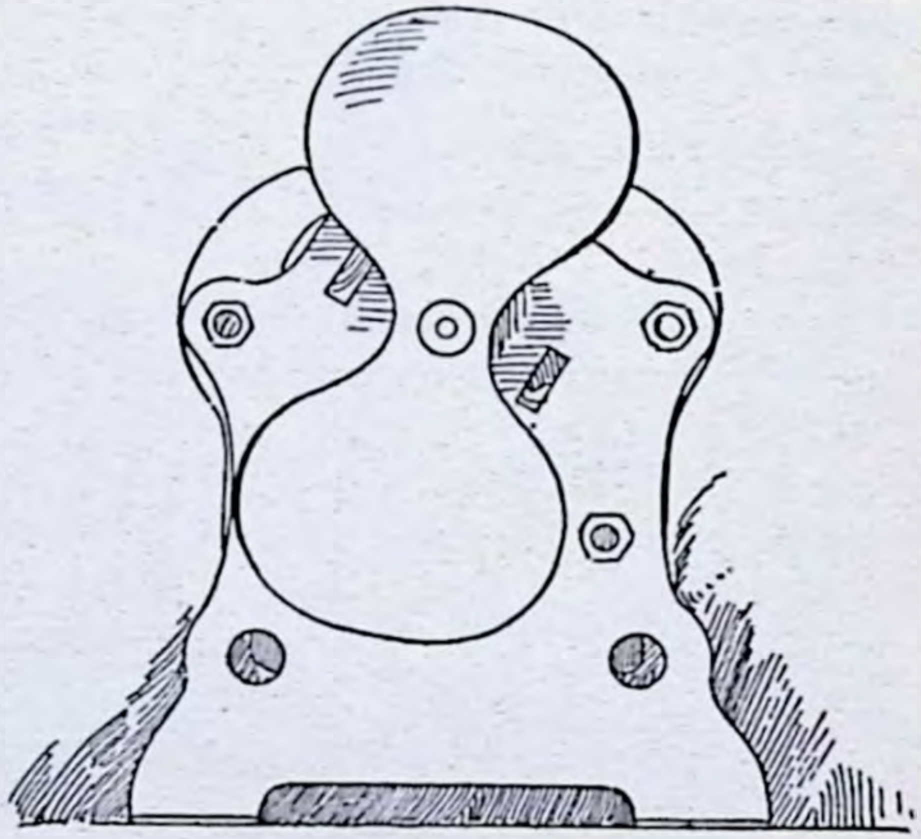


Fig. 38

(43) THE VIBRATING FLAMES: Cut out a piece of wood ⅜ inch thick, 1 inch wide, and 2½ inches long, and drill a $\frac{3}{16}$-inch hole through the center of it, as shown in Fig. 37. Now fasten mirrors to each side of the block with gummed paper and then mount it on the shaft of your motor. Next set the motor on its side with the shaft in a vertical position and place a lighted candle a foot in front of it and in a line with the mirror.

Take a rubber tube ½ inch in diameter and 6 inches long, make a mouthpiece of cardboard, and fix the small end of it to one end of the tube. Now run your motor slowly and then talk into the mouthpiece, when you will see separate images of the vibrations of the flame in the rotating mirror that are set up by the sound waves of your voice.

(44) AN ELECTRIC FAN: Screw a two-bladed fan on the shaft of your motor, as shown in Fig. 38. Switch on the current and be cool. Be sure to get the fan on the right way or it will blow the air toward the motor instead of away from the motor.

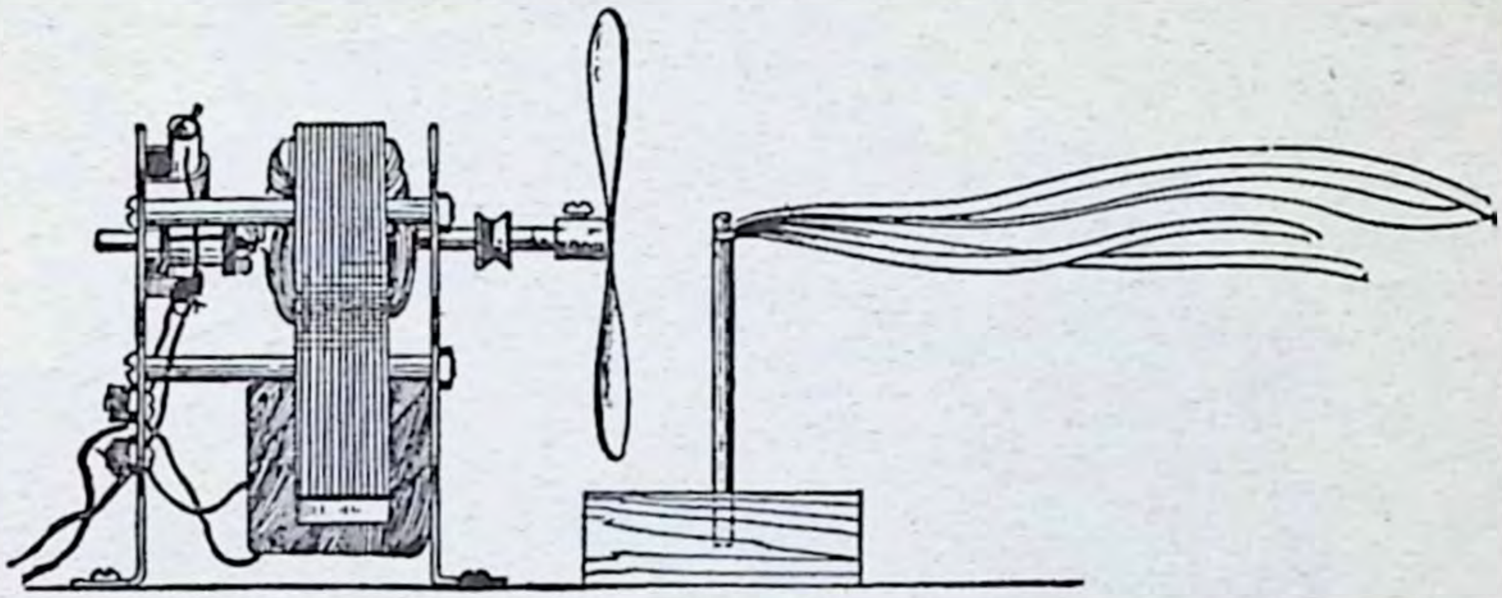


Fig. 39

(45) THE BREEZY RIBBONS: Mount a wire in a wood block, as shown in Fig. 39, and fasten three or four tissue-paper ribbons about 5 inches long to it. Set it in front of the fan and start the motor running, when the breeze set up will blow the ribbons straight out and keep them floating in the air.

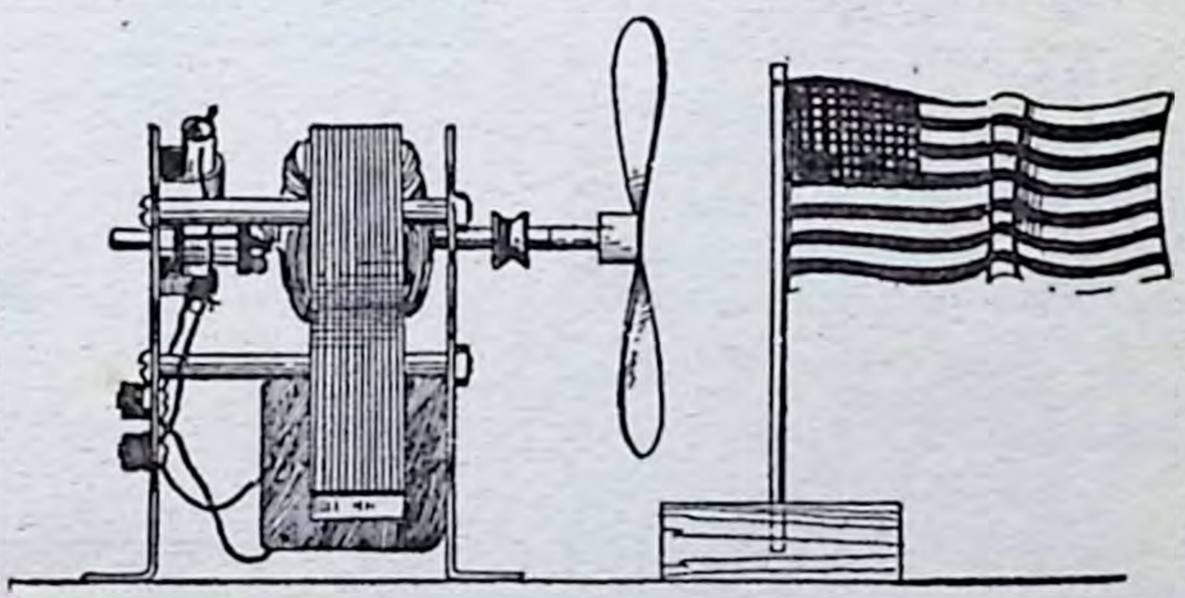


Fig. 40

(46) OLD GLORY UNFURLED: Get a little silk flag about ⅜ inch wide and 1½ inches long and glue it to a match; then glue the match to a block of wood or other support and set it so that the match will be directly in a line with the center of the fan, as shown in Fig. 40. Start your motor, when the breeze will make the flag wave gloriously—and long may it wave!

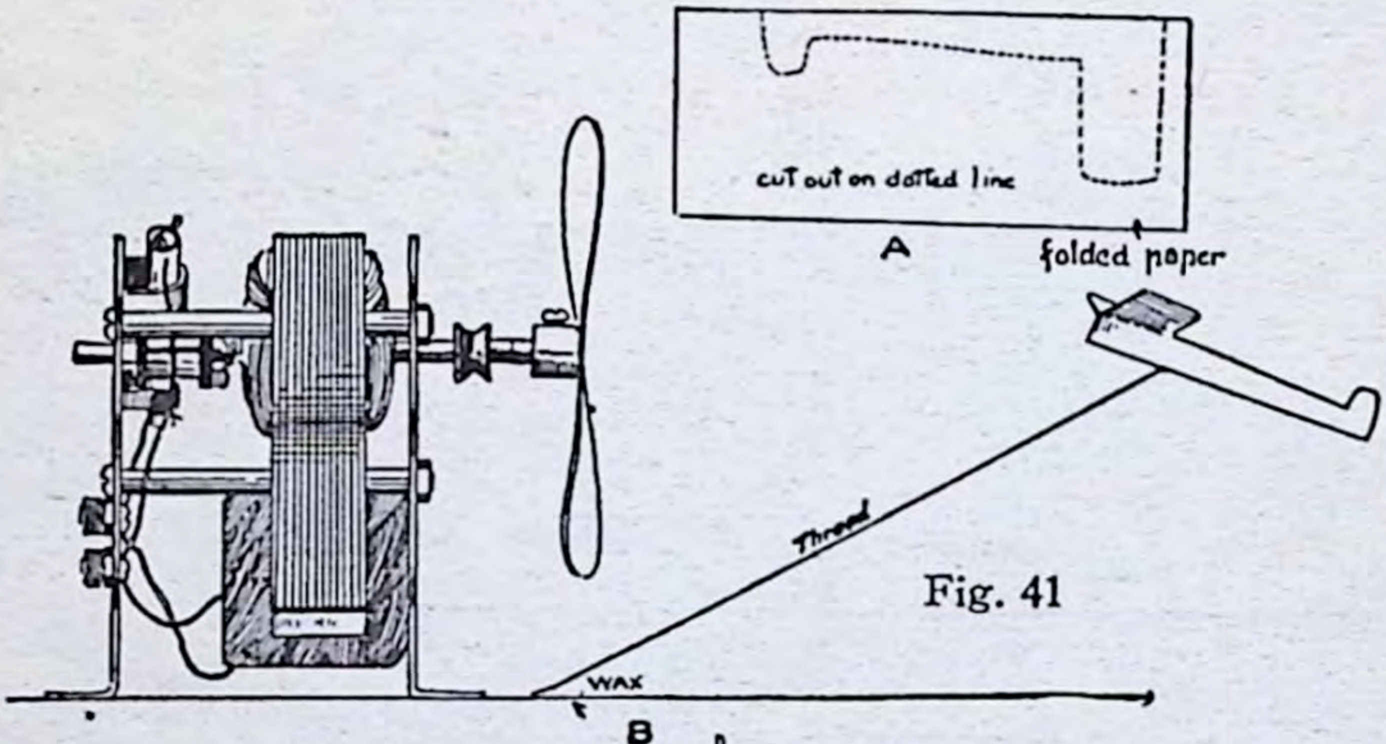


Fig. 41

(47) THE FLYING AIRPLANE: Make an airplane 1½ inches long by folding over a piece of thin paper, cutting it out as shown at A in Fig. 41, pasting together the folded part, and spreading out the wings. Tie one end of a silk thread about 5 inches long to the airplane and fix the other end to the table, with a bit of wax, close to the fan and in a line with the center of it when it will soar away —without getting anywhere.

(48) AN ELECTRIC STIR-A-BOUT: Couple an extension shaft to the shaft of your motor and screw the fan on the end of it, as shown in Fig. 42. You now have a stirrer with which you can stir up a drink or a beater with which you can beat up an egg.

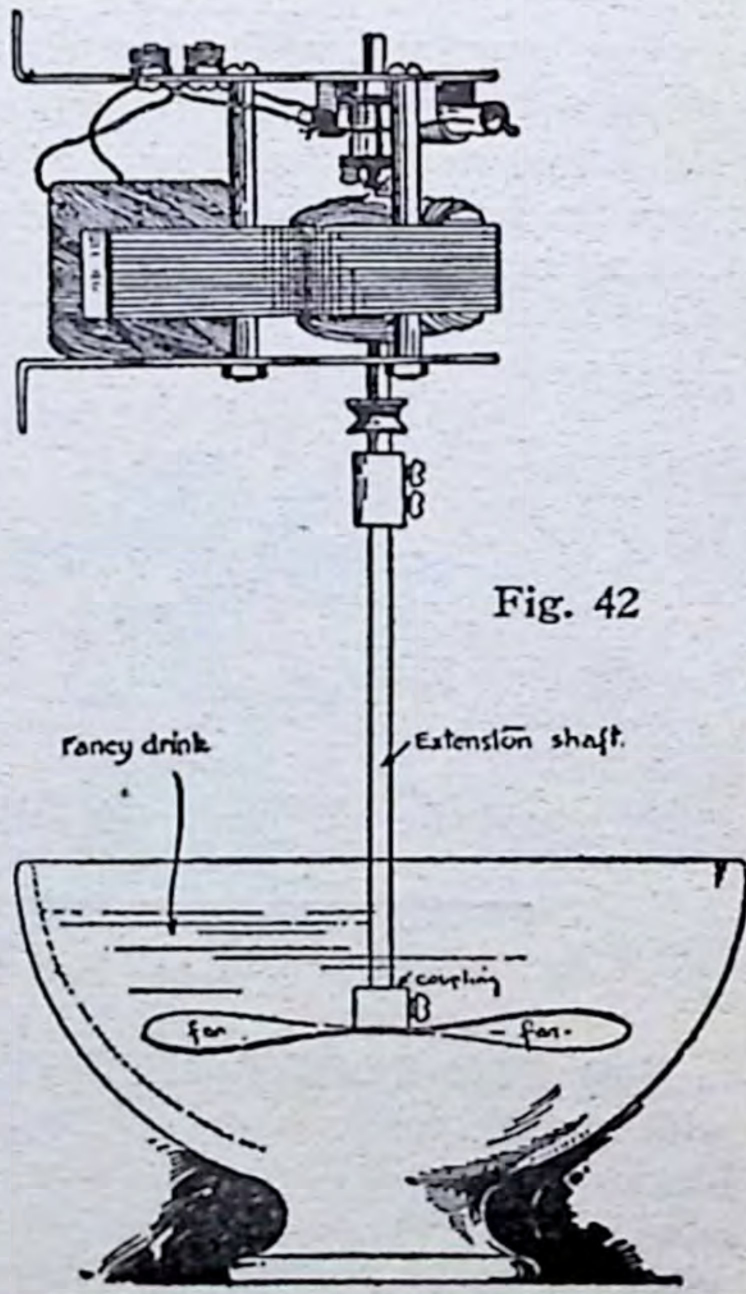


Fig. 42

(49) AN ELECTRIC GRINDING WHEEL: Make a paper wheel ⅜ inch thick and 2 inches in diameter (see Experiment 51) and make a hole in the center of it so that it will fit on the motor shaft tight. Now get a strip of fine emery paper ⅜ inch wide and 6½ inches long and glue

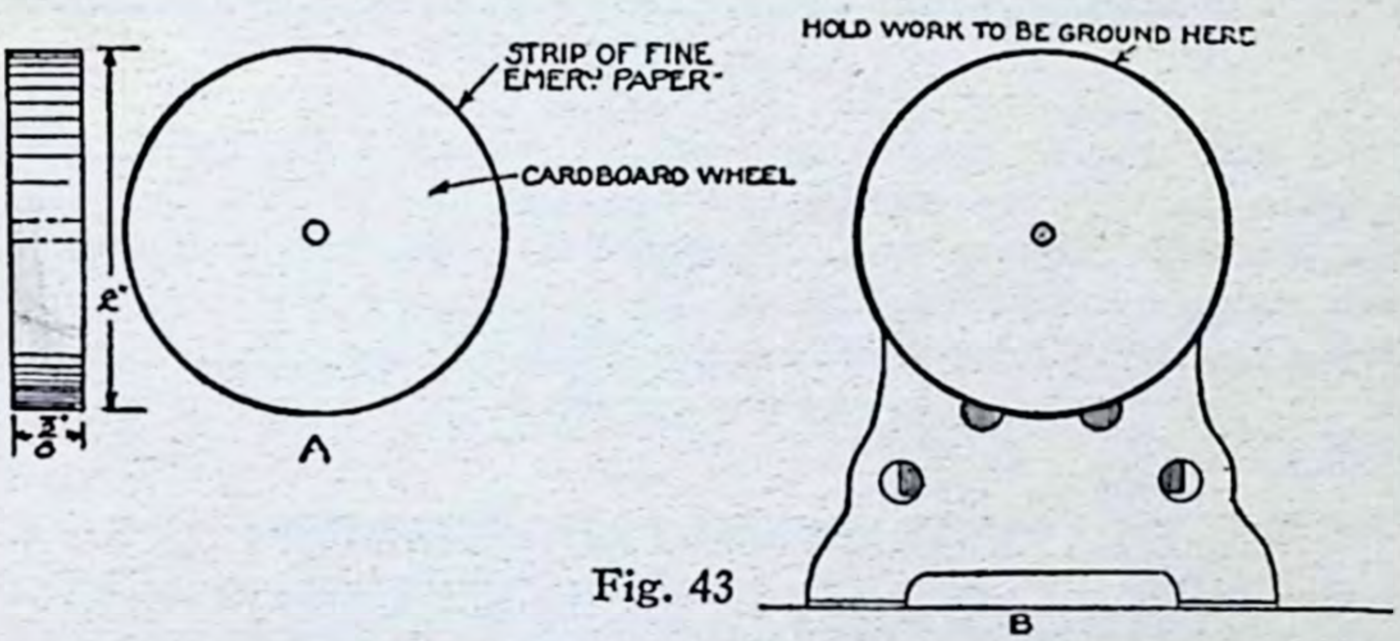


Fig. 43

it securely to the surface of the wheel. Mount the wheel on the shaft and start up the motor, when you can grind the blade of your knife, a pair of scissors or the like. (See Fig. 43.)

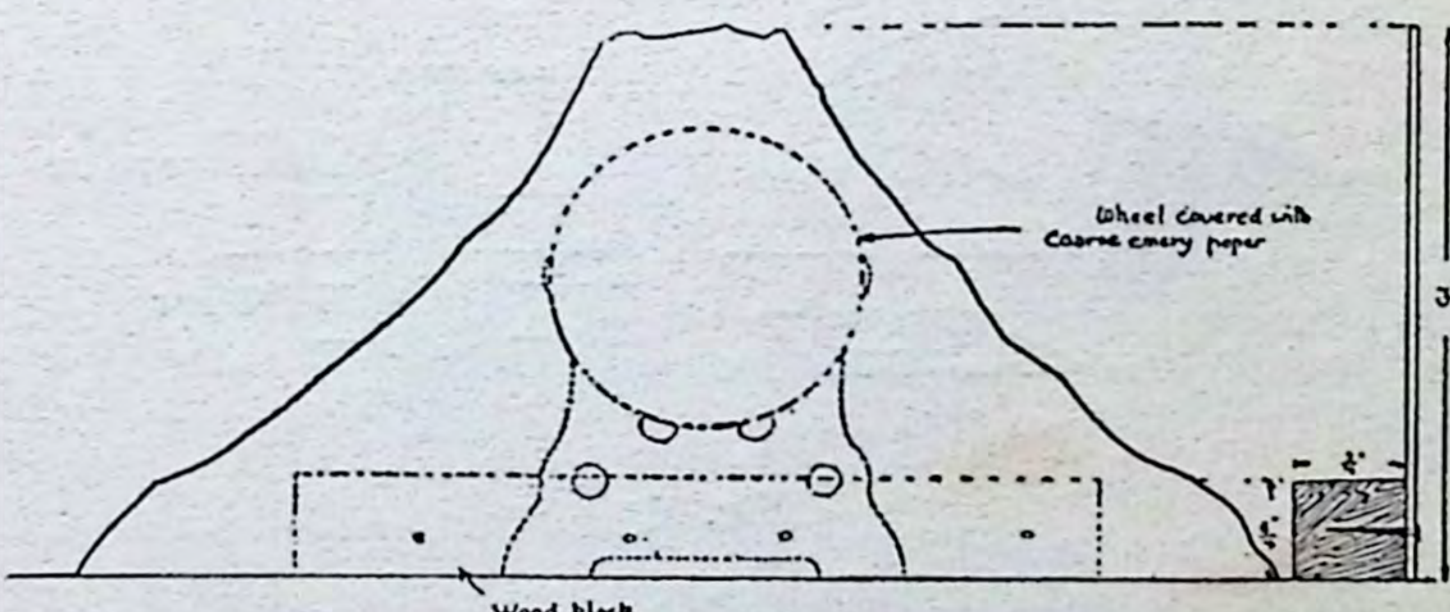


Fig. 44

(50) MOUNT VESUVIUS IN ERUPTION: Make the wheel as in the above experiment, but cover the rim of it with coarse emery paper and mount it on the motor shaft. Now draw a picture of Mount Vesuvius on a sheet of cardboard, cut it out and stand it up in part of your motor, as in Fig. 44. Press a nail against the rotating emery wheel, when it will send out myriads of sparks. If you will make this experiment in a dark room it will look as if Mount Vesuvius were in eruption again.

Part III

HOW TO MAKE WHEELS, PULLEYS, GEARS, SHAFTS, AND BELTS

You will have to use wheels, pulleys, gears, shafts, and belts when you make the toys and models that are described in Part IV. As your motor is small and runs at a high speed, in order to get enough power from it to drive your toys and models, you must belt the pulley of it to a pulley of a larger diameter. The latter, of course, runs much more slowly than the former and in this way you can get enough power to do the work you require of it.

(51) HOW TO MAKE WHEELS AND PULLEYS: (1) For wheels and pulleys you can often use spools to good advantage. By cutting spools in two a pair of serviceable wheels are made that will run on a track. (2) A pulley is a wheel that has a plain rim or a grooved rim and which drives another pulley or is driven by another pulley.

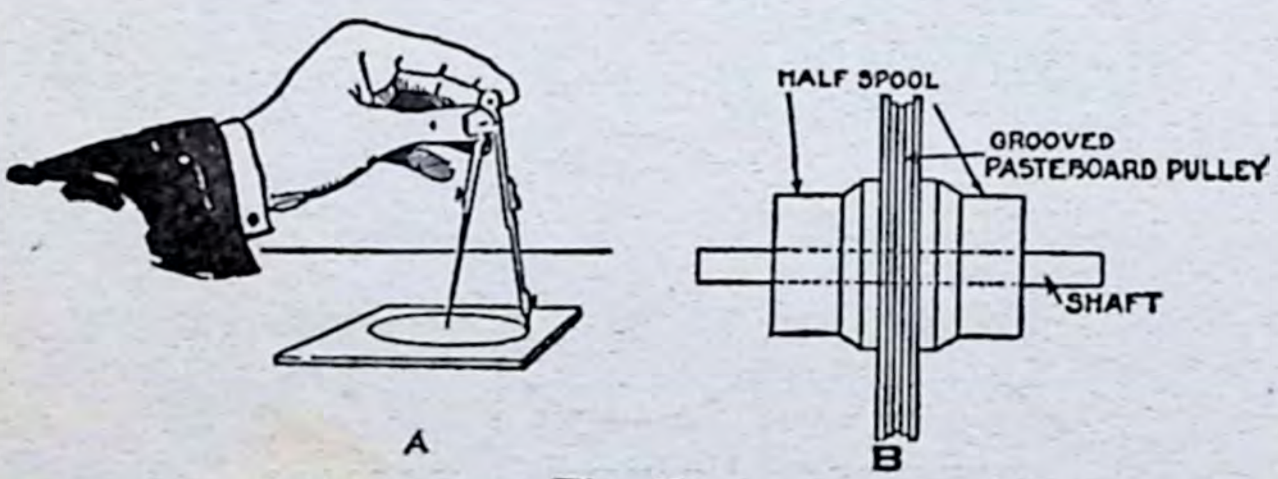


Fig. 45

If you want to make a pulley that is larger or smaller than a spool, you can do so by drawing a dozen circles on a piece of thick pasteboard with a pair of compasses (see Fig. 45), cutting the disks out with a pair of shears and then gluing them. When you have them all glued together put a flat-iron on the pile and let them dry under this weight overnight. In this way you can make pulleys with plain faces or grooved faces. You can make paper pulleys stronger by backing them up on each side with the half of a spool, as shown at B.

(52) **HOW TO MAKE GEARS:** Gears are wheels with teeth cut in their faces so that they mesh, as shown at A in Fig. 46. You can make gears that will increase or reduce the speed of your motor by using a spool

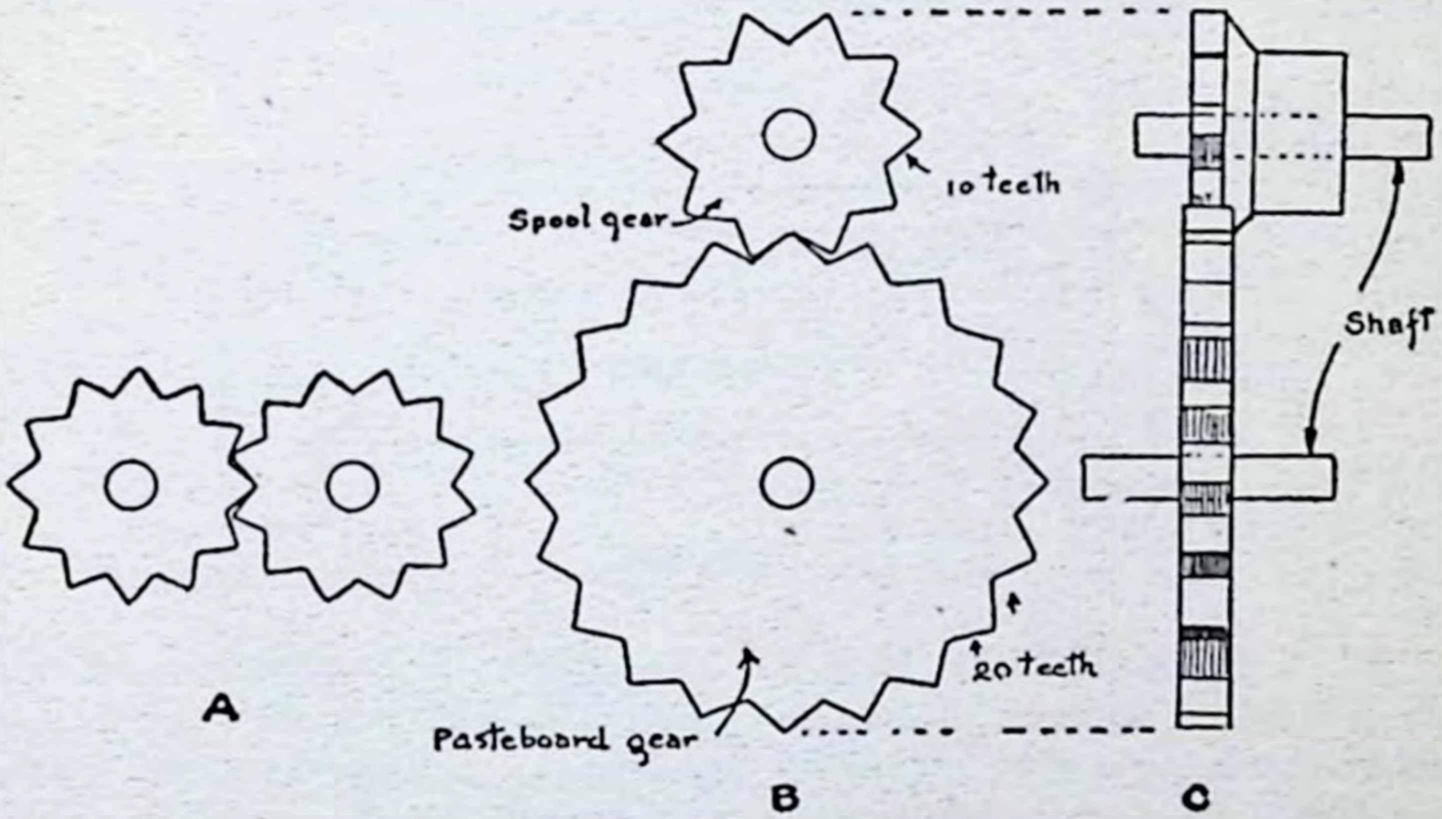


Fig. 46

for one of the gears and making the other and larger gear out of pasteboard, as B and C. To make one gear run twice as fast as another one that is meshing with it, you must have twice as many teeth on the large gear as there are on the small one.

(53) **HOW TO MAKE SHAFTING:** In making models that need shafting belted to your motor outfit, you can use round rods of wood, or dowels, as they are called, and these you can get at any carpenter shop or lumber yard. The best size to use for making toys and models is about ¼ inch in diameter, as this will just go in the hole of the spools and allows the latter to turn on it. Or you can glue or nail a spool on the dowel, when they will turn together.

(54) **HOW TO MAKE BEARINGS:** There are two ways to make bearings for the shafts, but screw eyes are used in either case. In the first way, screw eyes are used that are just large enough to slip over the

shaft, as shown at A in Fig. 47. Where it is possible, however, it is better practice to drive a brass-headed upholsterer's nail into the end of the shaft, as shown at B. This kind of a bearing is very easy running and does not use up the power in overcoming friction as the first kind does. You can buy the nails and the screw eyes at any hardware store.

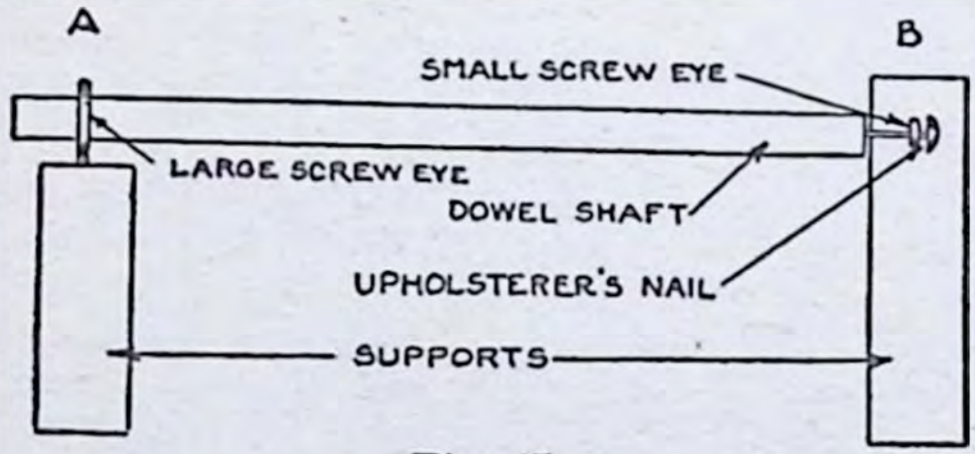


Fig. 47

(55) THE KIND OF BELTS TO USE: To transmit power from one pulley to another, a belt is used. For driving models use either rubber bands or cotton string for your belts. Rubber-band belts are the best where the distance between the pulleys is short and a string pulley is best where the distance between the pulleys is more than three or four inches.

Part IV

HOW TO MAKE ELECTRIC-MOTOR-DRIVEN TOYS AND MODELS

To connect your motor with either a battery or a transformer and watch the armature spin away at the rate of a thousand revolutions a minute is highly pleasing. To make the experiments described in Part II is wonderfully entertaining, but for real downright fun you can't beat running toys and models that you have made with your own hands.

The ones which follow are crackerjacks. A little more difficult, it is true, than some of those illustrated in the first part of the book, but worth every bit of the time they take you to prepare — in the fun they give you.

By being able to do stunts of this kind with an electric motor you can make your friends' eyes sparkle in wonder at your ability. You can surprise them with your knowledge of electric motors and what can be done with them. Don't let a chance like this go by. Make the most of it. Try every one of these great experiments and then work out other stunts yourself, basing them on the motor principles you learn from these. There's no limit to the things you can do if you only try.

(56) HOW TO MAKE AN ELECTRIC TRACTOR: To make this tractor saw out a wood base ½ inch thick, 3 inches wide, and 9 inches long. Next make two drive wheels, one of them grooved, of pasteboard ¼ inch thick and 2 inches in diameter (see Experiment 51) and make a ¼-inch hole in the center of each one. Cut off a piece of dowel 3¾ inches long for the axle, screw a couple of screw eyes into the baseboard 1 inch from one end and 2½ inches apart, slip the dowel through the screw eyes and then glue the wheels on the ends of it, all of which is shown at A in Fig. 48.

Use a couple of half spools for the front wheel, screw a couple of screw eyes into the baseboard 1 inch from the other end and 2½ inches apart; slip a piece of dowel 4½ inches long through them for the axle and glue the spools on the ends of it, as shown at B. Now screw down the motor to the end of the base nearest the drive wheels (see C). Then screw the grooved coupling sleeve to the end of its shaft and belt them together with a rubber band as at D. Mount a dry cell on the front of the base by means of a couple of wires screwed fast to the sides of the base and, finally, connect the dry cell with the motor and your tractor is complete, as shown at D.

(57) HOW TO MAKE AN OLD DUTCH MILL: The pictures shown at A and B in Fig. 49 are so clear that you can build the old Dutch

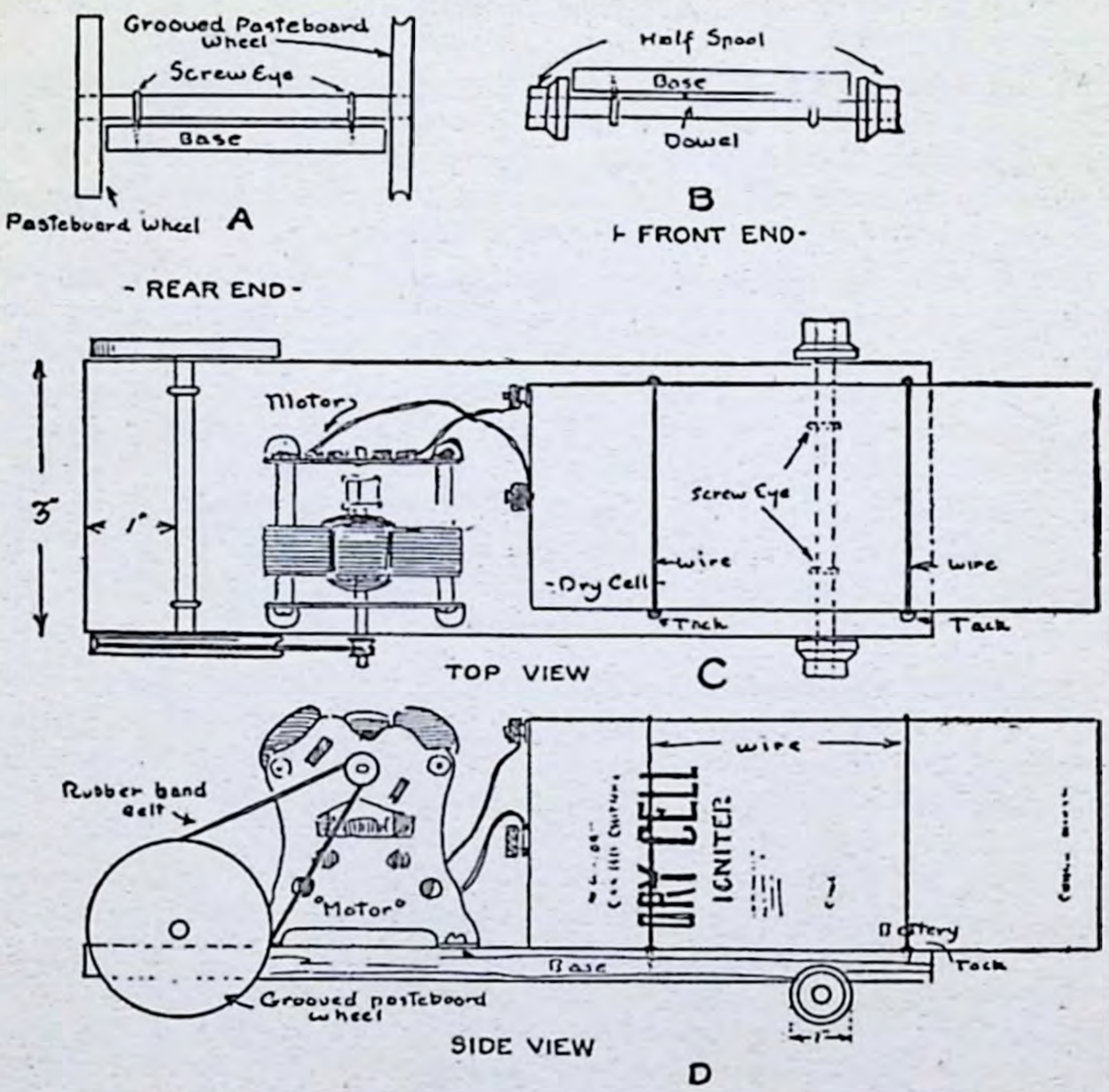
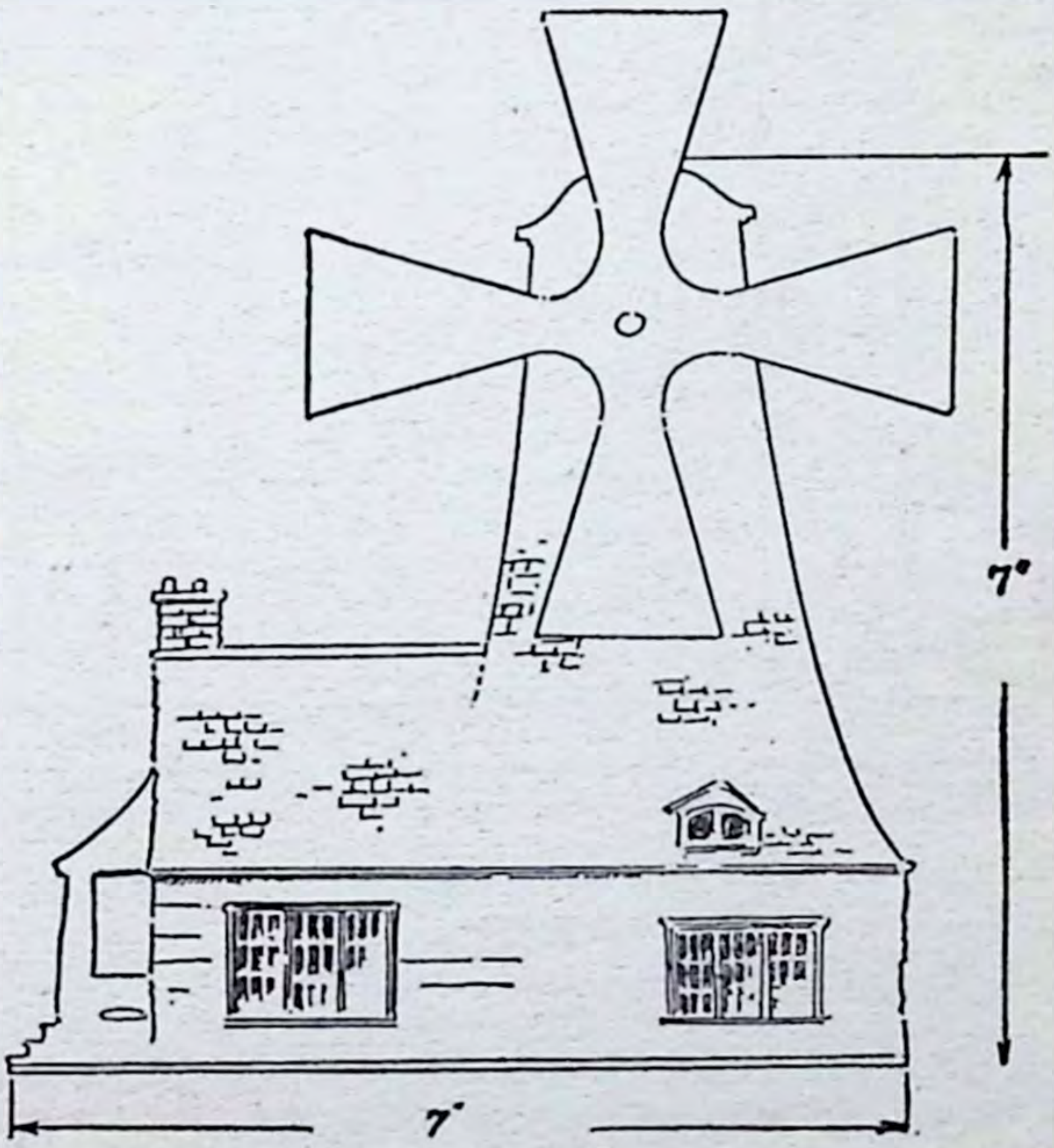


Fig. 48

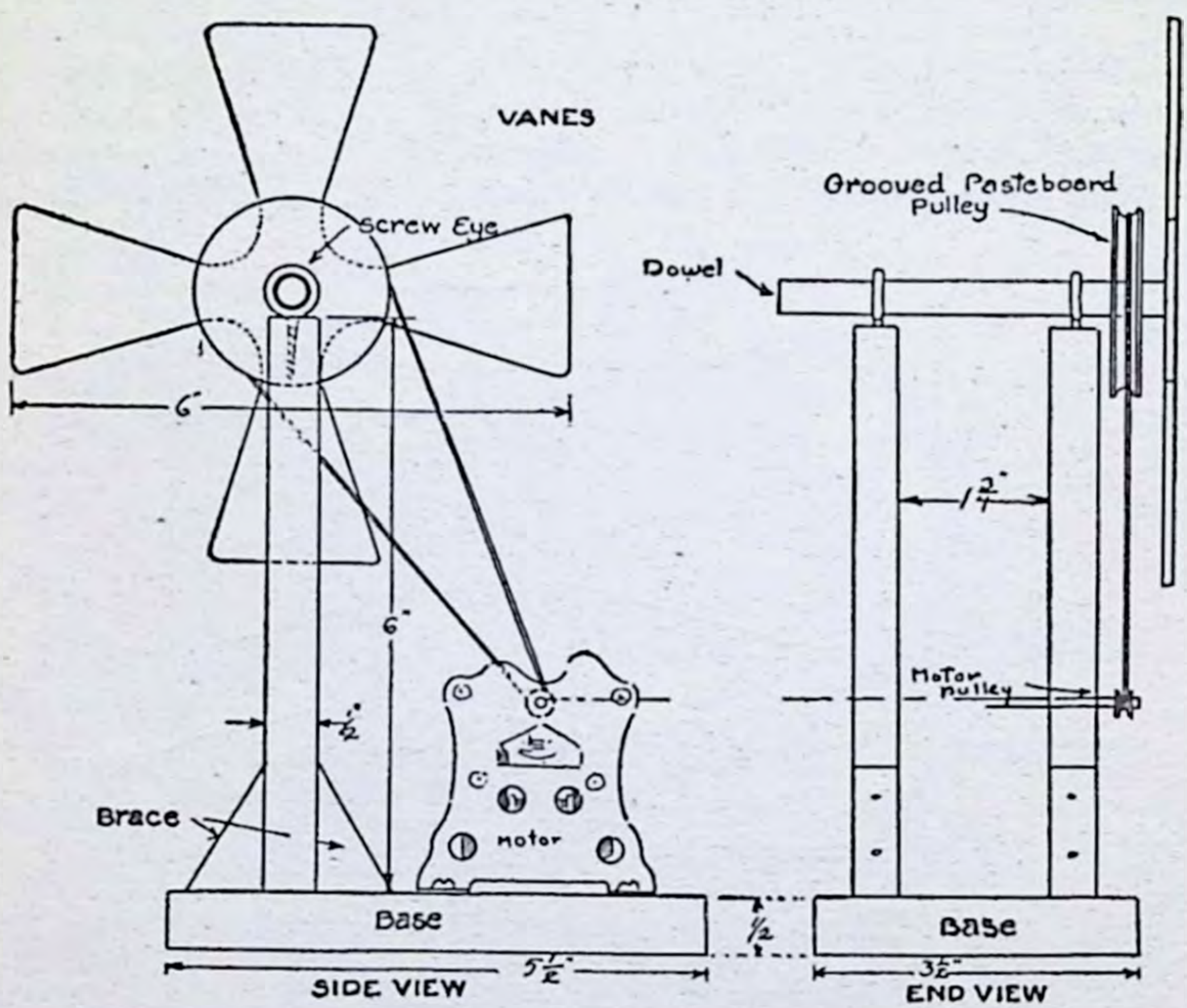
mill from them without the slightest trouble. Get a baseboard ½ inch thick and about 3½ by 5½ inches on the sides. Take two pieces of wood, round or square, about ½ inch thick and 6 inches long for the uprights and nail and brace them to the base 1½ inches apart. This done, screw two screw eyes into the tops of the uprights and slip a piece of dowel 4 inches long through them for the shaft. Make a pasteboard pulley ¼ inch thick and 2 inches in diameter and groove it (see Experiment 51), cut a ¼-inch hole in its center and slip it on to the shaft and glue it there. Draw a circle 6 inches in diameter on a piece of pasteboard, mark out four vanes on it, as shown at A, cut it out and glue it to the end of the shaft. Screw down your motor to the other end of the board and belt the pulleys together with a soft string. Finally, draw a picture of an old Dutch mill on a sheet of cardboard, as shown at B, and glue it to the front edge of the base, when your old windmill is ready to run and grind its grist.



A

Fig. 49

(58) HOW TO MAKE A MODEL STEAM ENGINE: While this little model must be driven by your electric motor, it has a piston that works to and fro in a cylinder like a real steam engine. As it changes rotary motion into reciprocating motion it is wonderfully interesting. To make the engine cut out two support blocks of the size and shape



B

Fig. 49

shown at A and B in Fig. 50. Get a board next, about ¾ or 1 inch thick, 3⅜ inches wide, and 7¾ inches long, on which to mount the engine.

Make a grooved pasteboard pulley (see Experiment 51) ¼ inch thick and 1½ inches in diameter and glue it on the end of a piece of dowel that is 2⅜ inches long, as shown at C, and to make it rigid, glue a half spool to it. This done, screw a couple of screw eyes into the top of the taper block A and slip the shaft through them. Next mount a spool on the support block B by means of two pieces of wire fastened to it with brads; this forms the cylinder.

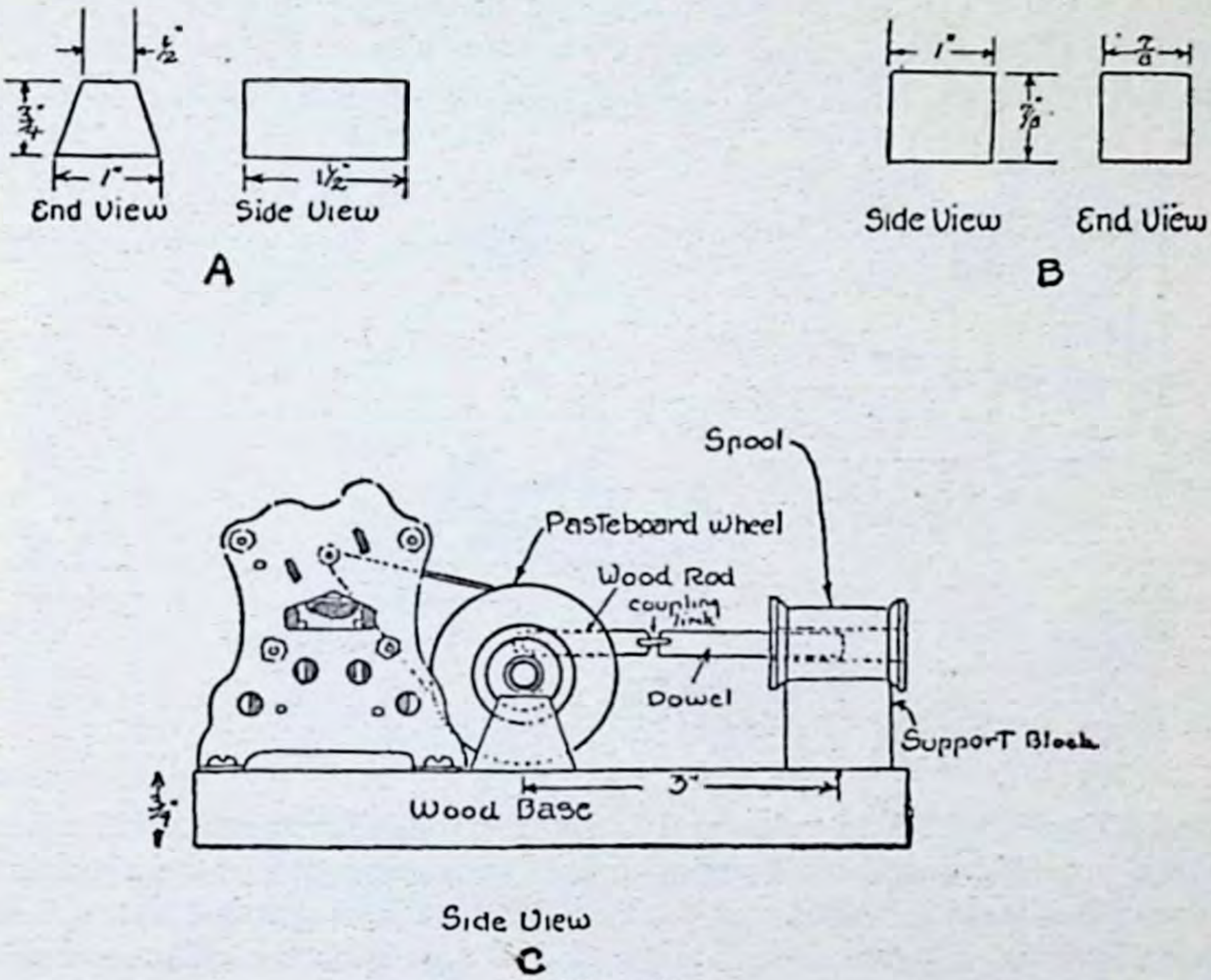


Fig. 50

The piston is made of a piece of dowel 1¾ inches long with a hole drilled in one end. Make a connecting rod of a piece of wood 1/16 inch thick, ½ inch wide, and 1½ inches long; drill a hole in each end of it and couple this up with the piston with a link of wire, as shown at C. Attach the free end of the rod to the paper pulley with a brass-headed tack and push the free end of the piston into the spool on the block. This done, glue the support blocks to the wood base, as shown in the pictures, and screw your motor down to the base with both pulleys in a line. Finally, belt them together with a rubber band, connect the battery with the motor, when the engine will run for all the world as if it was generating the power and driving the electric motor instead of the other way about.

(59) HOW TO MAKE AN ELECTRIC-MOTOR-DRIVEN DERRICK: First get a cigar box of medium thickness (the exact size doesn't matter). Cut away 3⅞ inches of one end of it to a depth of 4 inches and then bore three ¼-inch holes clear through the box at the places marked with the circles at A in Fig. 51. Next make the power-winding drum (see

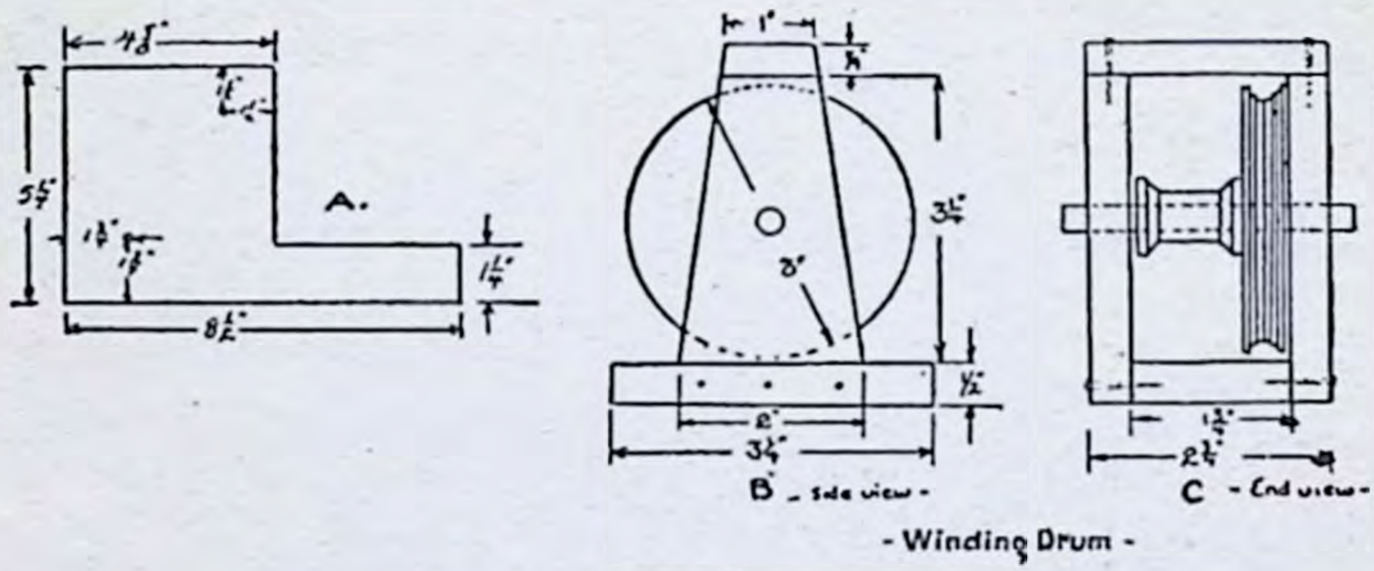


Fig. 51

B and C) with which to raise and lower the loads by means of the boom. Make a grooved pasteboard pulley (see Experiment 51) ¼ inch thick and 3 inches in diameter; cut out a disk of thick pasteboard and cut a ¼-inch hole in it; glue it to one end of a spool and then glue the other end of the spool to the pulley and all of them on a shaft made of a dowel 2¾ inches long, as shown in the top view D.

This done, make the hand-winding drum with which to raise and lower the boom of the derrick. To do this, glue a spool to a dowel 3 inches long and make a little crank 1½ inches long, but do not glue this on the end of the shaft yet. Make the boom next out of two strips of wood ¼ inch thick, tapering from ½ an inch to 1 inch wide at the ends and 12 inches long and bore ¼-inch holes through both ends of both sticks, as at E. Cut off a piece of dowel 1½ inches long, slip a grooved spool over it and then glue the ends of the dowel to the small end of the boom sticks, but let the spool be free to rotate.

Now slip the large ends of the sticks on a dowel 2¾ inches long and glue them 1¾ inches apart. To finish the boom glue a block near the spool end and screw a screw eye into it, all of which is shown at D and E. Cut out a disk of wood (or it can be square) 3 inches in diameter for the turntable and drill a ⅛-inch hole through it. Last of all, make a base of a piece of wood about 1 inch thick and 6 inches square.

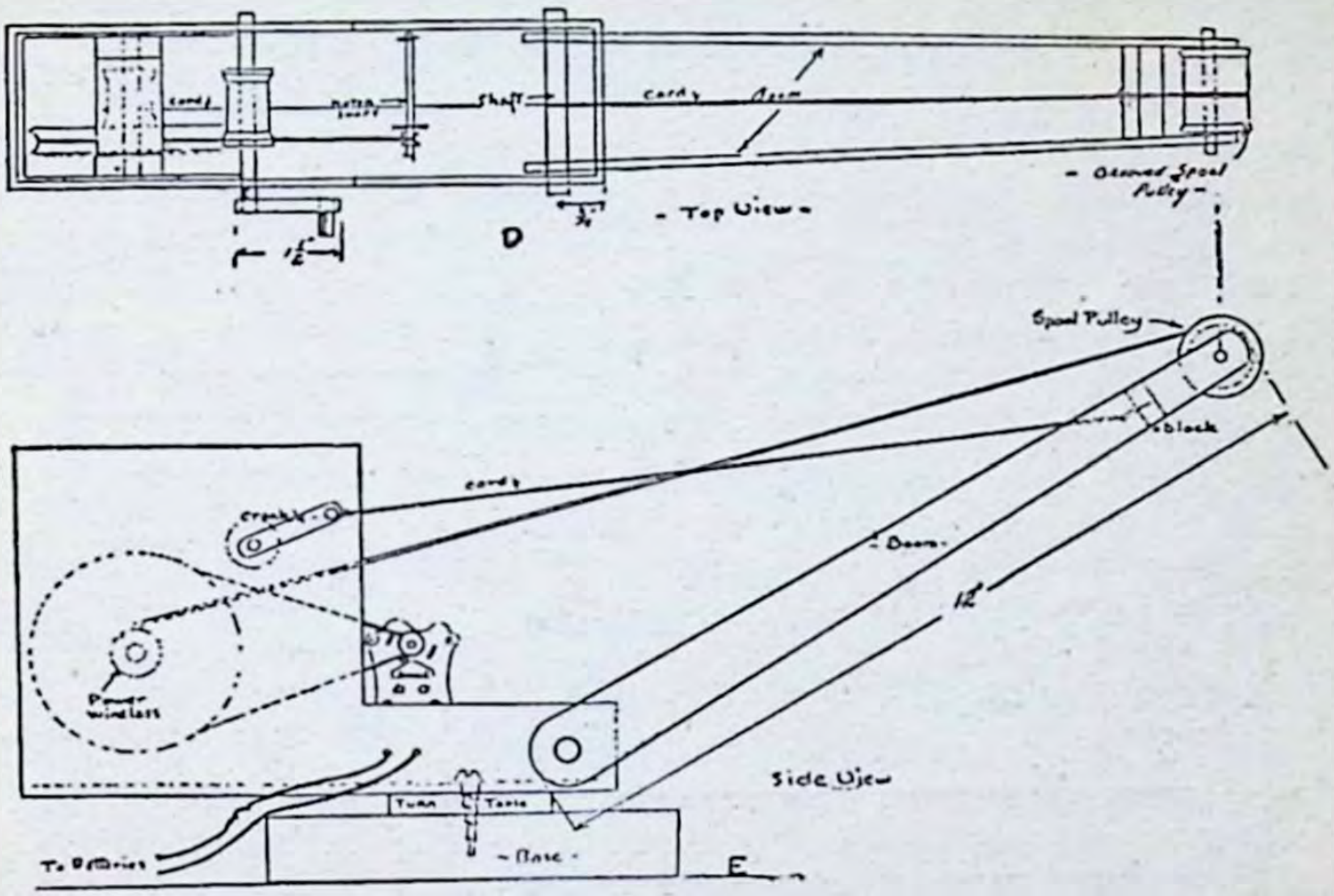


Fig. 51

You are ready now to assemble the derrick. To do this take the lid off of the cigar box and set the ends of the shafts of the power-winding drum, the hand-winding drum and the boom in their respective holes. Then put the lid on the box so that the other ends of the shafts will project through the holes and nail it on tight. Screw the box through the turntable to the base, as shown at E, and then screw your motor to the bottom of the box and bring the wires out of the bottom. A top view of the derrick is shown at D and the derrick complete at E.

Fasten a 2-foot length of strong soft string to the spool of the power-winding drum with a little tack and bring it out, up, and over the spool in the end of the boom. Take another string 1 foot long and fix it to the spool of your hand-winding drum, tie the other end to the screw eye in the brace block. To keep the hand-winding drum from turning after you have got the boom at the angle you want it, drill a hole ½ an inch from the shaft and slip a brad into it. Connect the wires from your motor to a switch and the battery or transformer, throw on the current and your derrick will hoist anything within reason — except a 10-ton safe.

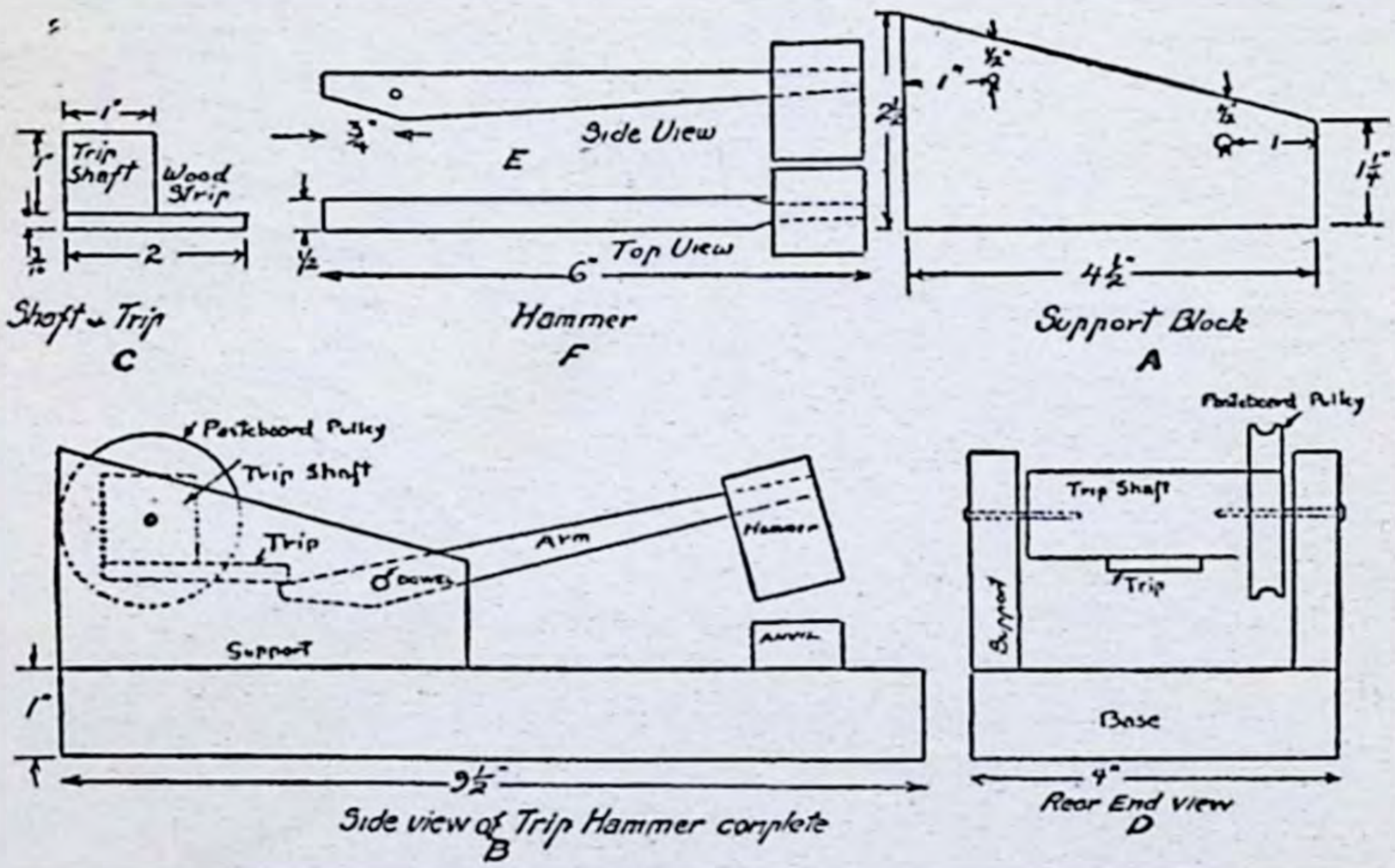


Fig. 52

(60) **HOW TO MAKE AN ELECTRIC TRIP HAMMER:** Get a board 1 inch thick, 4 inches wide, and 9½ inches long, and then cut out two support blocks ½ an inch thick, 1¼ inches high on one end, 2½ inches high on the other end and 4½ inches long; drill two 1/16-inch holes in them near the top and bore two ¼-inch holes in them near the bottom, as shown at A in Fig. 52. Nail these supports to the base at one end and

glue a hardwood block, called the anvil, ½ an inch thick, 1 inch wide, and 2 inches long to the other end, as shown at B.

The next step is to make the rotating trip and for this use a piece of wood 1 inch square and 2¼ inches long and glue and screw a piece of wood ⅛ inch thick, 1 inch wide, and 2 inches long to one side of the square trip shaft so that it projects over it, as shown at C. Now make a grooved pasteboard pulley (see Experiment 51) ⅜ inch thick and 3 inches in diameter and glue and nail this to one end of the shaft, as shown at D. Set the shaft between the upper holes in the support, push a wire nail through each hole and drive them into the ends of the shaft.

The next and last thing is to make the hammer. Get a hardwood block 1 inch thick and 1½ inches long and make a tapering hole through it near the top, as shown at E and F. Cut out a wood lever ½ an inch thick, ½ an inch wide at the point and tapering at both ends as shown by the dotted lines at E and F. Make a ¼-inch hole through the lever ¾ inch from one end and glue the other end into the hammer block. Now push a dowel, 4½ inches long, through one of the lower holes in the support block, slip the hammer lever on to the dowel and glue it to the middle of it. Finally, run the dowel through the other hole in the support, when your trip hammer will look like F. Belt the motor to your trip hammer, throw on the current and you will have an anvil chorus for fair.

(61) HOW TO MAKE AN ELECTRIC CABLEWAY: Make the carrier of your cableway first, and for the running gear construct a frame of two strips of wood ¼ inch thick, 1 inch wide, and 4 inches long, as shown at A and B in Fig. 53. Nail a wood block ½ an inch thick and 1½ inches long between them and into each end of both strips screw a screw eye. Make two grooved pasteboard wheels (see Experiment 51) ⅜ inch thick and 2 inches in diameter, cut a ¼-inch hole in the center of them, slip each one on a piece of dowel 1 inch long and glue it to the middle of it. Now place the ends of the dowels between the screw eyes and drive a small nail into the center of each one, as shown at C.

For the car, take the lid off of a cigar box, nail a piece 1 inch wide across it and screw two screw eyes into it, as at D. Loop a piece of stiff wire around the wood block in the frame (see B) and bend up the ends to form a pair of hooks. Next make a cable drive, as shown at G, by nailing two uprights 1 inch thick, 1½ inches wide, and 3½ inches high on one end of a wood base 6 inches wide and 12 inches long. Make two grooved pasteboard pulleys ⅜ inch thick, and have one of them 4 inches in diameter (this is for the cable drive) and the other 5 inches in diameter (this is belted to your motor pulley). Glue these pulleys together and then glue them to the middle of a piece of dowel 2¼ inches long. Screw the screw eyes into the top of each standard, slip your dowel shaft through

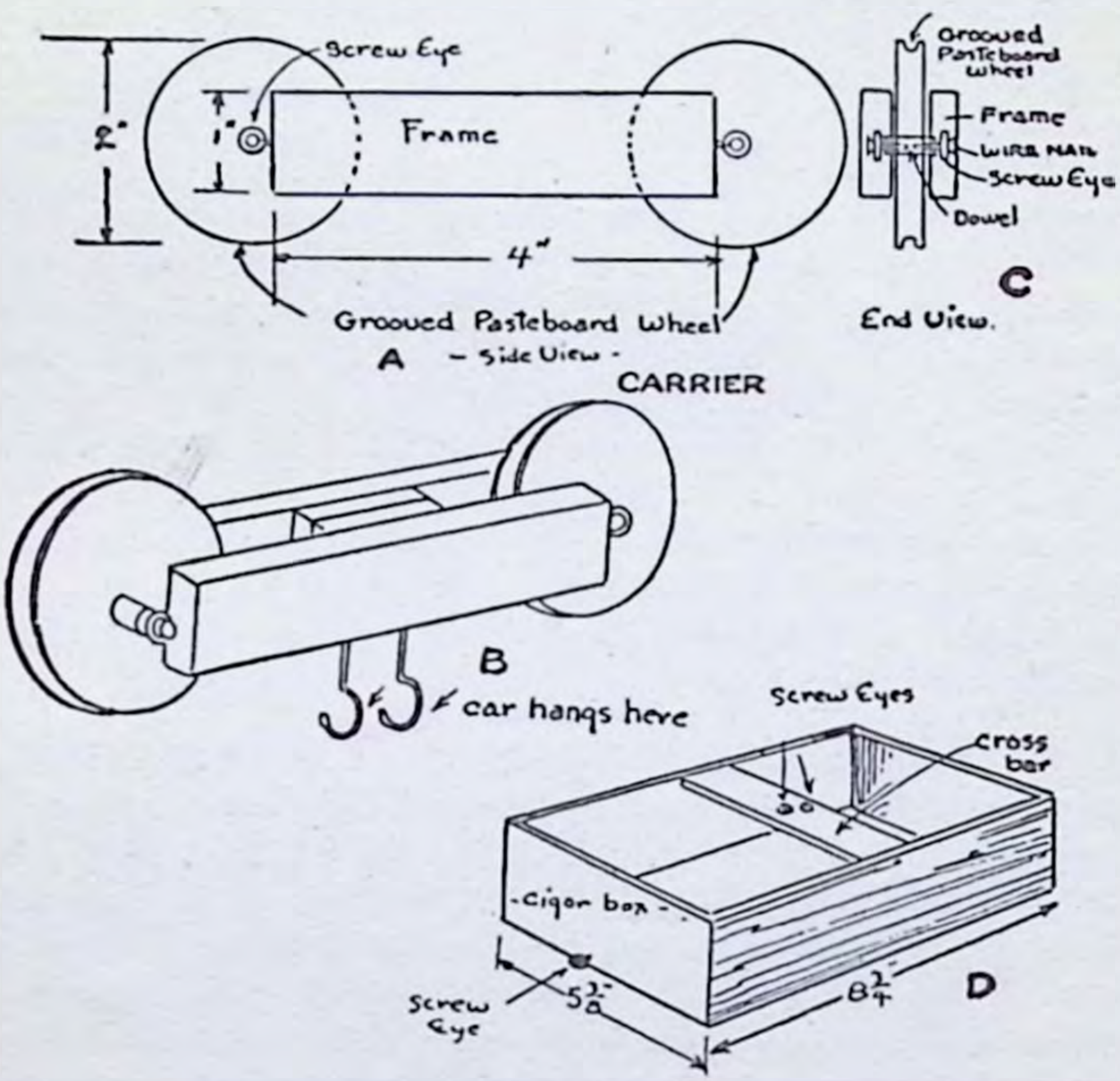


Fig. 53

them and the grooved pulleys; screw down your reversing switch and your motor to the other end of the baseboard and belt the pulley of it to the large pasteboard pulley.

For the driven pulley at the other end of the cableway make a grooved pasteboard pulley ½ an inch thick and 4 inches in diameter, glue it on to the middle of a dowel shaft 1¾ inches long and mount it between a pair of uprights 3½ inches high which you have fixed to a base 6 inches wide and 8 inches long. Now set these pulleys at the distance apart you are going to have your cableway and drive stakes around the base of each one to keep them from slipping. Get four poles 6 or 8 feet long and make two pairs of shears of them, as shown at **G.** Run a wire over the tops of the shears and guy it out at the ends by fastening them to stakes. Fasten the ends of another and shorter wire to the stakes for the tram cable and then solder two hooked wires to the latter and supporting wire, as at **G.**

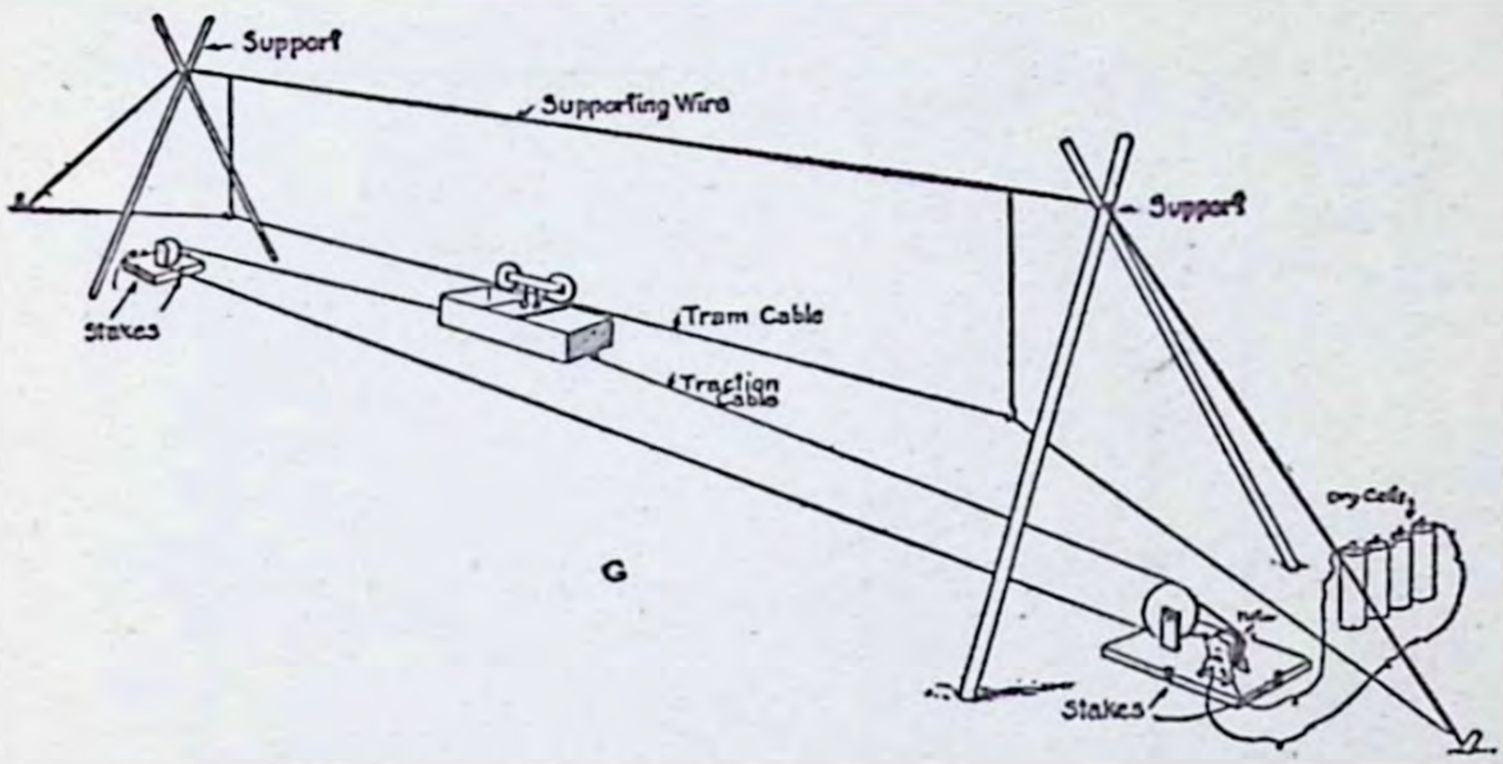


Fig. 53

Tie the end of a long, strong, soft cotton string or a piece of fish-line, to one of the screw eyes in the cigar-box car, loop it around one of the pulleys at the end of the cableway, then bring it around the opposite pulley and tie the other end to the remaining screw eye. All you have to do now to make the car travel to the other end of the cableway is to throw over the switch and when it gets there you need only to throw the switch the other way to make it travel back again.

(62) HOW TO MAKE AN ELECTRIC PILE DRIVER: This model is easy to make, and it is a mighty interesting one. Get a base-board 1 inch thick, 7 inches wide, and 15 inches long. Bore a 1-inch hole

through it 2½ inches from one end and then nail two upright sticks of wood 1 inch square and 14 inches high to the board on each side of the hole and brace them, as shown at A and B in Fig. 54. Screw two screw eyes to the upper ends of the uprights, glue a spool in which you have cut a groove on the middle of a dowel 2¾ inches long, set it between the screw eyes.

This done, mount the reversing switch (see Experiment 20) back of the uprights and have the switch handle close to the edge of the base, as shown at A. Next make the winding drum, and this you do by first con-

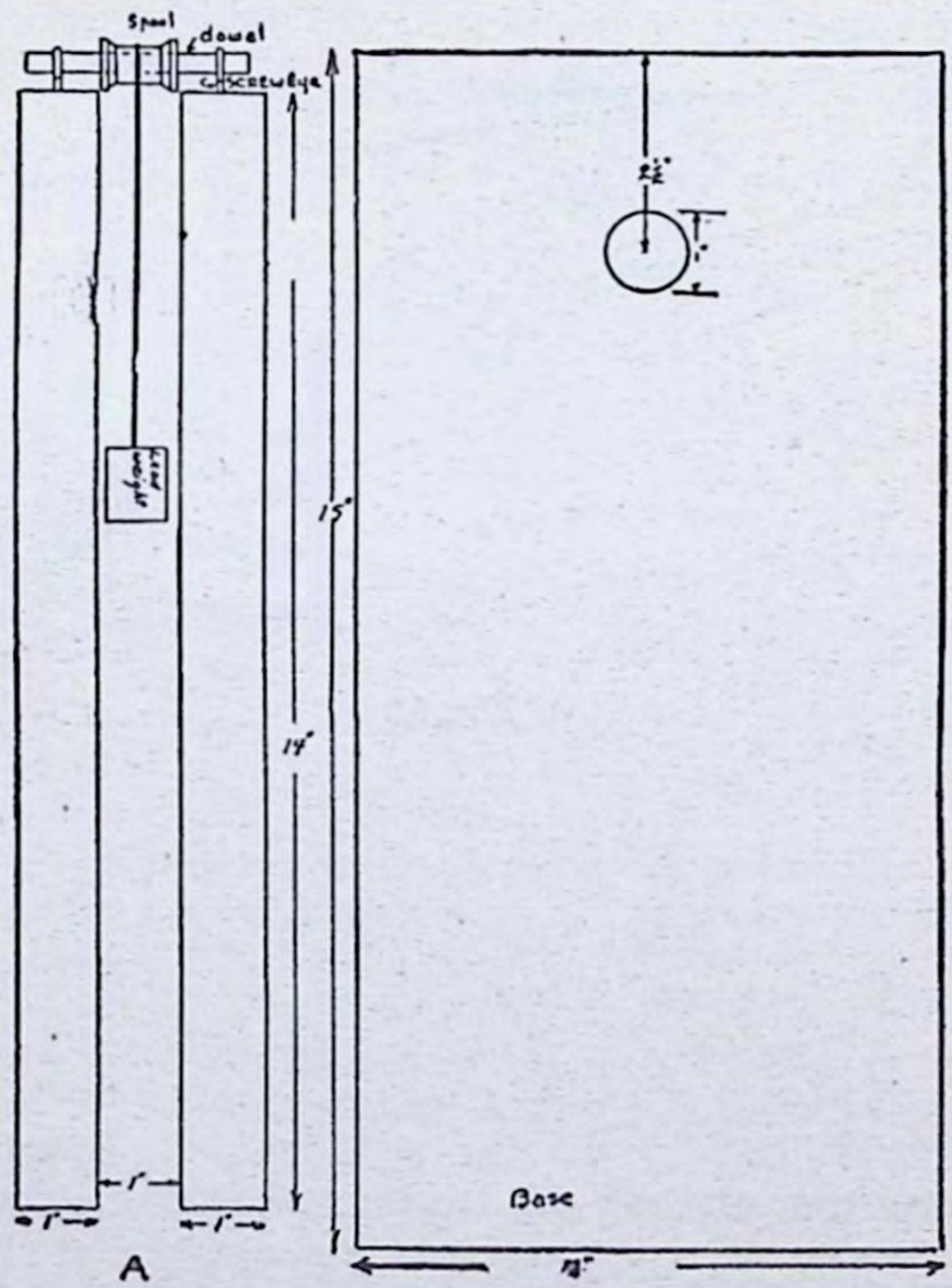


Fig. 54

structing the frame, as shown at C and D. Cut out a base of ½-inch stuff, 1¾ inches wide and 3½ inches long. On each side of this base nail two uprights formed of ½ inch thick wood, 2 inches wide and 3¼ inches long; nail a cross bar on top and then bore a ¼-inch hole halfway between the ends of the sides and clear through them, as at D.

Make a pasteboard wheel (see Experiment 51) 3/16 inch thick and 1½ inches in diameter and glue it to one end of a spool and then make a

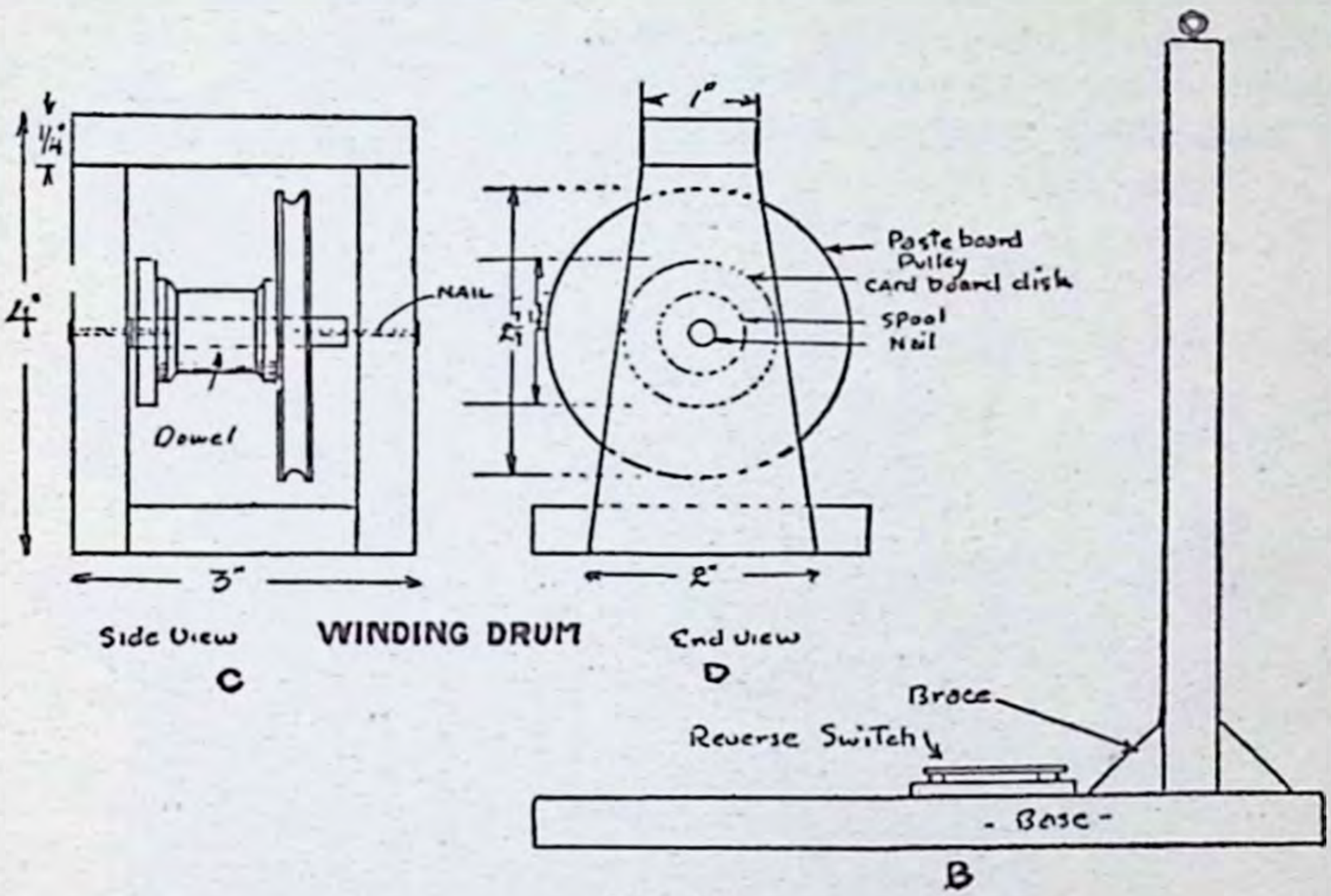


Fig. 54

grooved pasteboard pulley ⅜ inch thick and 2¾ inches in diameter and glue it to the other end of the spool; cut ¼-inch holes in the center of the wheel and pulley and smear glue on the inside of them; push a piece of dowel through one of the uprights and then through the spool and pulley and on through the other hole in the other upright. When the glue sets the spool and pulley will be securely fixed to the dowel.

Screw the winding drum down to the base just back of the switch, then fasten a long, strong, soft string to one end of the spiral with a small tack and bring it up, over, and around the grooved spool at the top of the uprights and hang a lead weight on the other end. Connect up your battery, switch, and motor, throw over the switch lever and the motor will make the drum wind the weight up to the top of the uprights in the twinkling of an eye. Switch off the current and the weight will drop swiftly on the pile you want to drive into the earth and with considerable force.

(63) HOW TO MAKE AN AUTOMATIC PILE DRIVER: Make your pile driver exactly the same as explained in Experiment 62, then make two brass trip levers 1/16 inch thick, 3/8 inch wide, and 2 inches long and drill a hole in the middle and one in the end of each one. Screw one of the trip levers to one of the uprights, close to the bottom of it, and tie

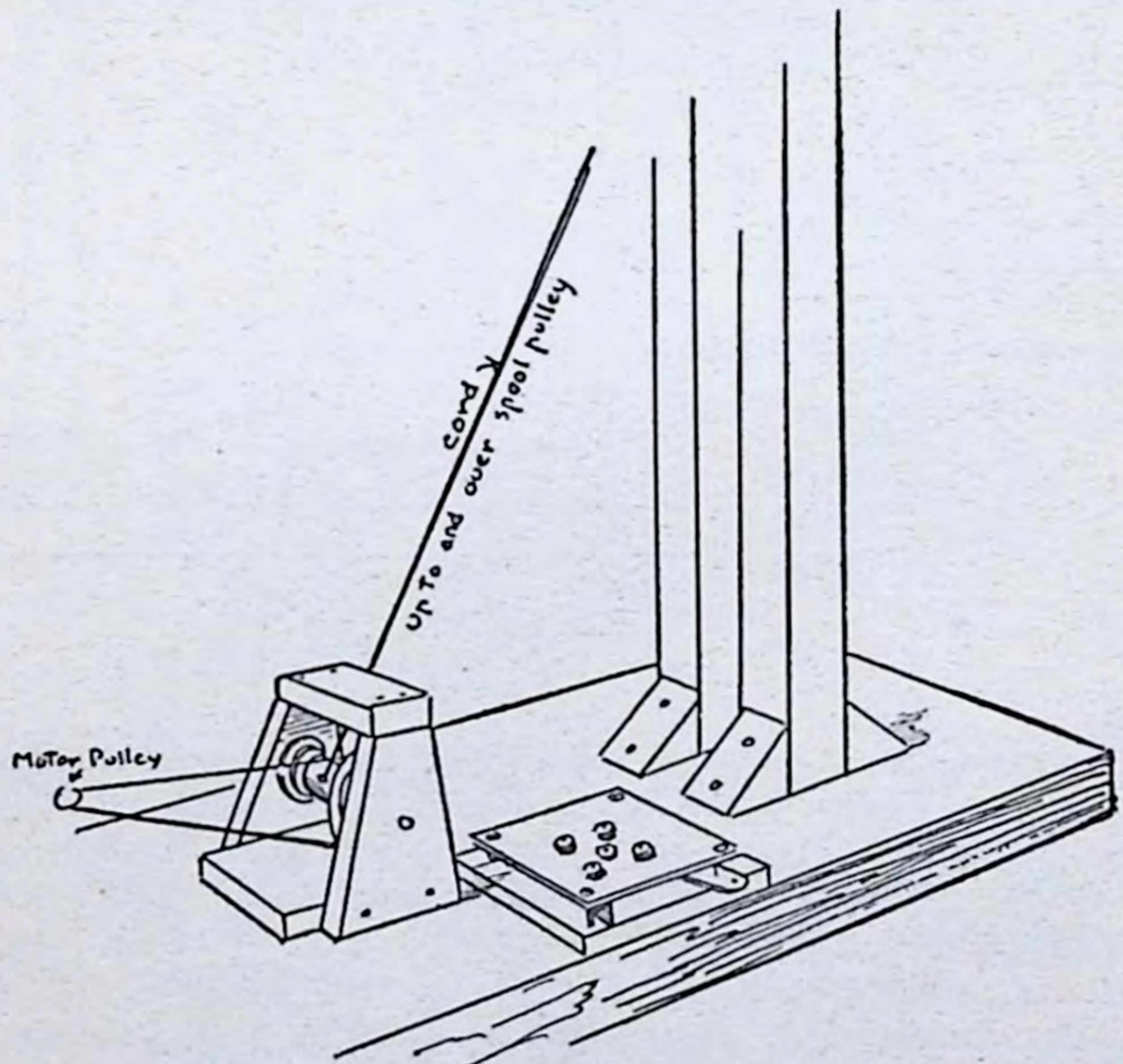


Fig. 54

a string to the end of the lever, run it through a screw eye under it and tie the other end to the switch lever.

Screw the other trip lever near the top of the upright, tie a string to the end of the lever, run it through a screw eye above it, then down to the screw eye in the base over to the screw eye at the middle and in front

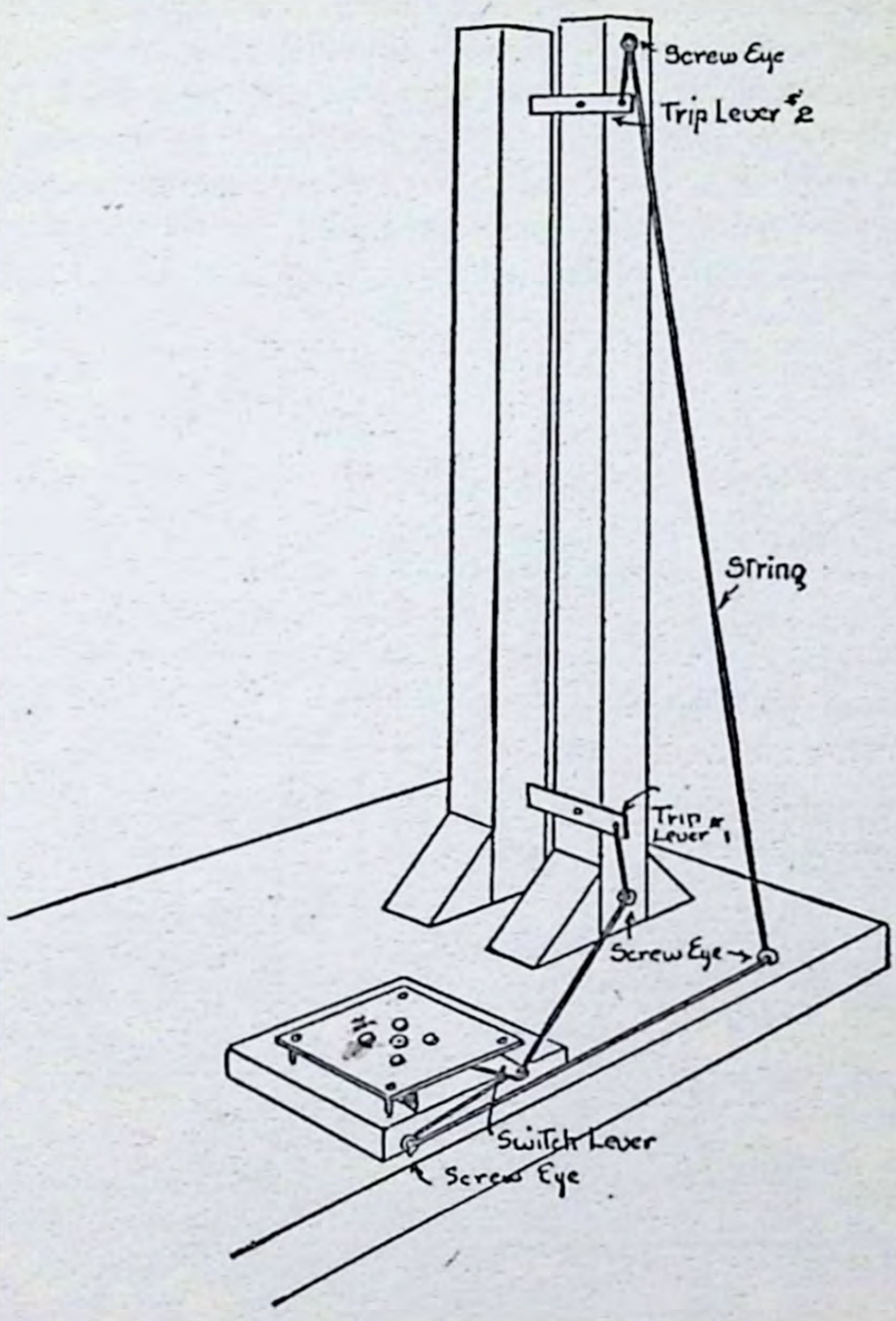


Fig. 55

of the reversing switch block, and tie the end to the switch lever, all of which is shown in Fig. 55. Now, when the weight strikes the trip lever at the bottom it will puli the switch lever over and start the motor, and when the weight reaches the top it will strike the trip lever there and this will pull the switch lever over to the middle, when the current will be cut off, thus stopping the motor when the weight will fall again.

(64) HOW TO MAKE AN ANIMATED SHOOTING GALLERY: Here is an easy model to make and one that will give you and your chums an endless amount of fun. Saw out a wood base 1 inch thick for the drive pulley, 6 inches wide, and 9 inches long; nail on two uprights ½ an inch thick, 1 inch wide, and 3 inches high and put a brace between them. Make a grooved pasteboard pulley ¼ inch thick and 4 inches in diameter, cut a ¼-inch hole in the center of it, glue it on to one end of a spool, as shown

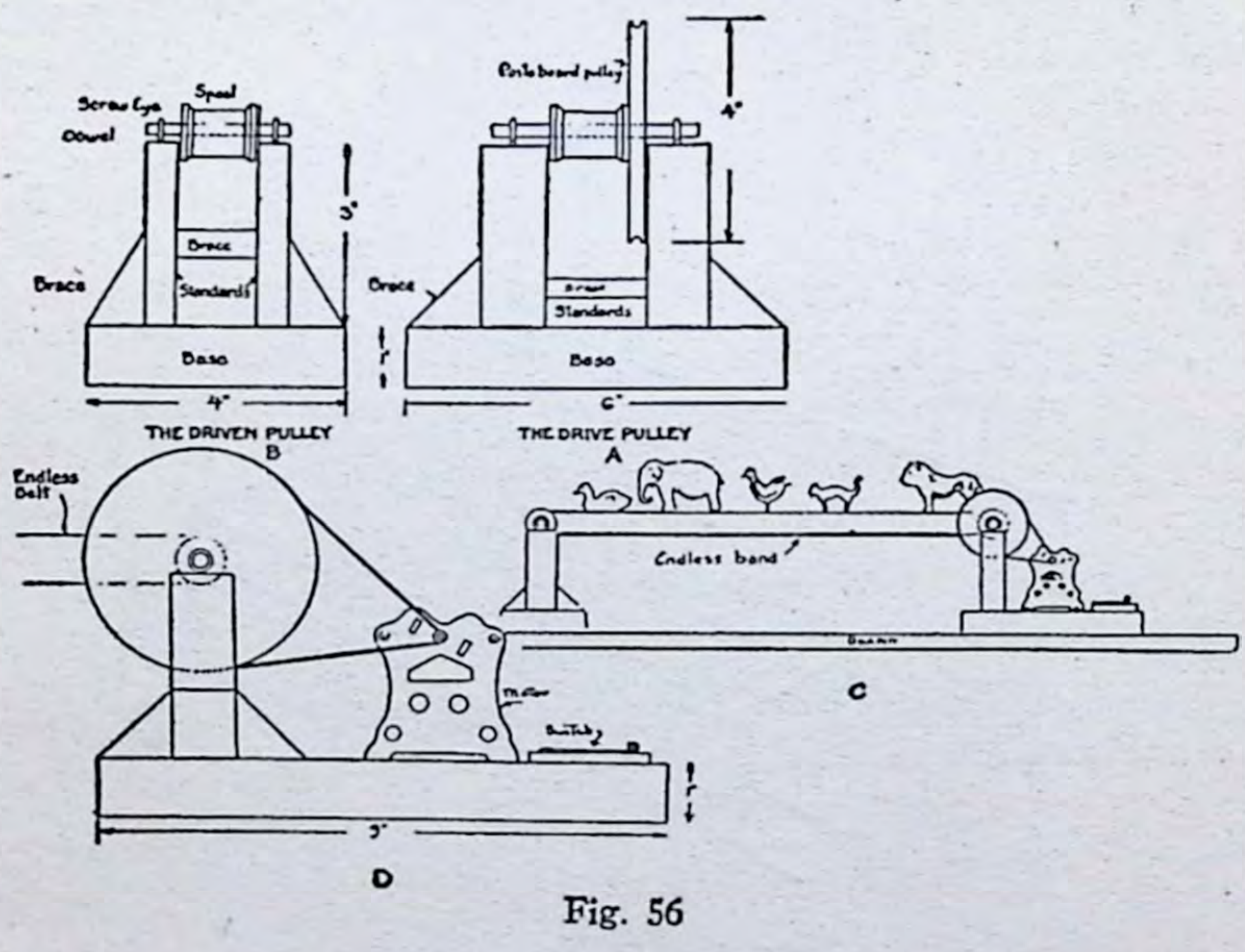


Fig. 56

at **A** in Fig. 56, and smear the inside of them with glue. Screw a screw eye in the top end of each upright, hold the spool and pulley between them and slip a dowel 3¼ inches long through one eye, then through the spool and pulley and, lastly, through the opposite screw eye. When the glue sets the spool and pulley will be fixed tight to the dowel.

Next, saw out another base for the driven pulley 1 inch thick, 4 inches wide, and 4 inches long; nail two uprights on it 1⅛ inches apart and brace them. Put a screw eye in the top end of each one, smear some glue on the inside of a spool and then push a piece of dowel 2 inches long through an eye, the spool and the other eye. Now screw the pulley bases, shown at **A** and **B**, to a board that is from 1 to 4 feet long, then take a strip of soft tape, or muslin, ¾ inch wide, loop it around both spools and sew the ends together. Cut out a lot of pasteboard animals and fasten them to the endless band, as shown at **C**. Belt your motor to the pulley, as at **D**, and start it going, when the animals will travel slowly between them. Set a piece of thick sheet iron back of the figures, get out your .22 rifle, and blaze away at the moving targets.

(65) HOW TO MAKE AN ELECTRIC ELEVATOR: This is an elevator that runs up and down the outside of your house from one window to the other. To make it get a board 1 inch thick, about 6 inches wide, and 18 inches long; screw into it two screw eyes 5¼ inches apart and in a line, as shown at **A** in Fig. 57. Next, make a winding drum exactly like the one described for the electric pile driver in Experiment 62. Screw this

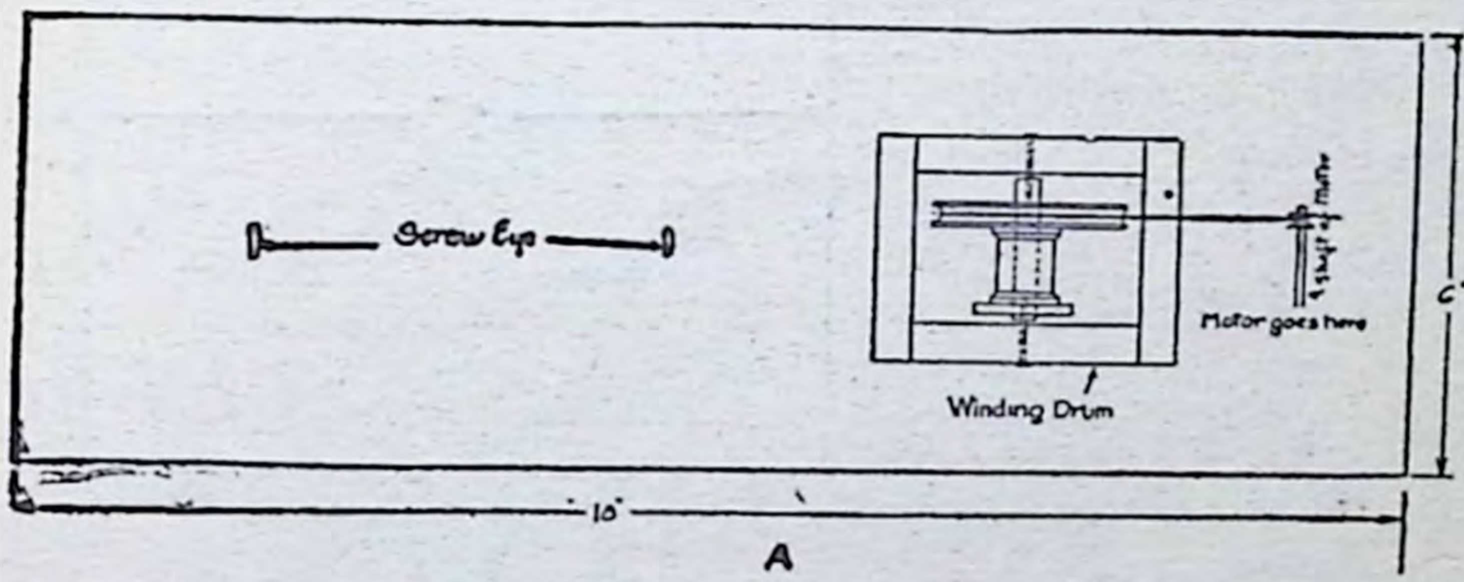


Fig. 57

down to the board so that the middle of the spool is in a line with the screw eyes, then screw the motor to the base so that its pulley is in a line with the pulley of the winding drum and belt them together with a rubber band. This drive gear rests on the ground.

Now get another board 1 inch thick, 7 inches wide, and 12 inches long.

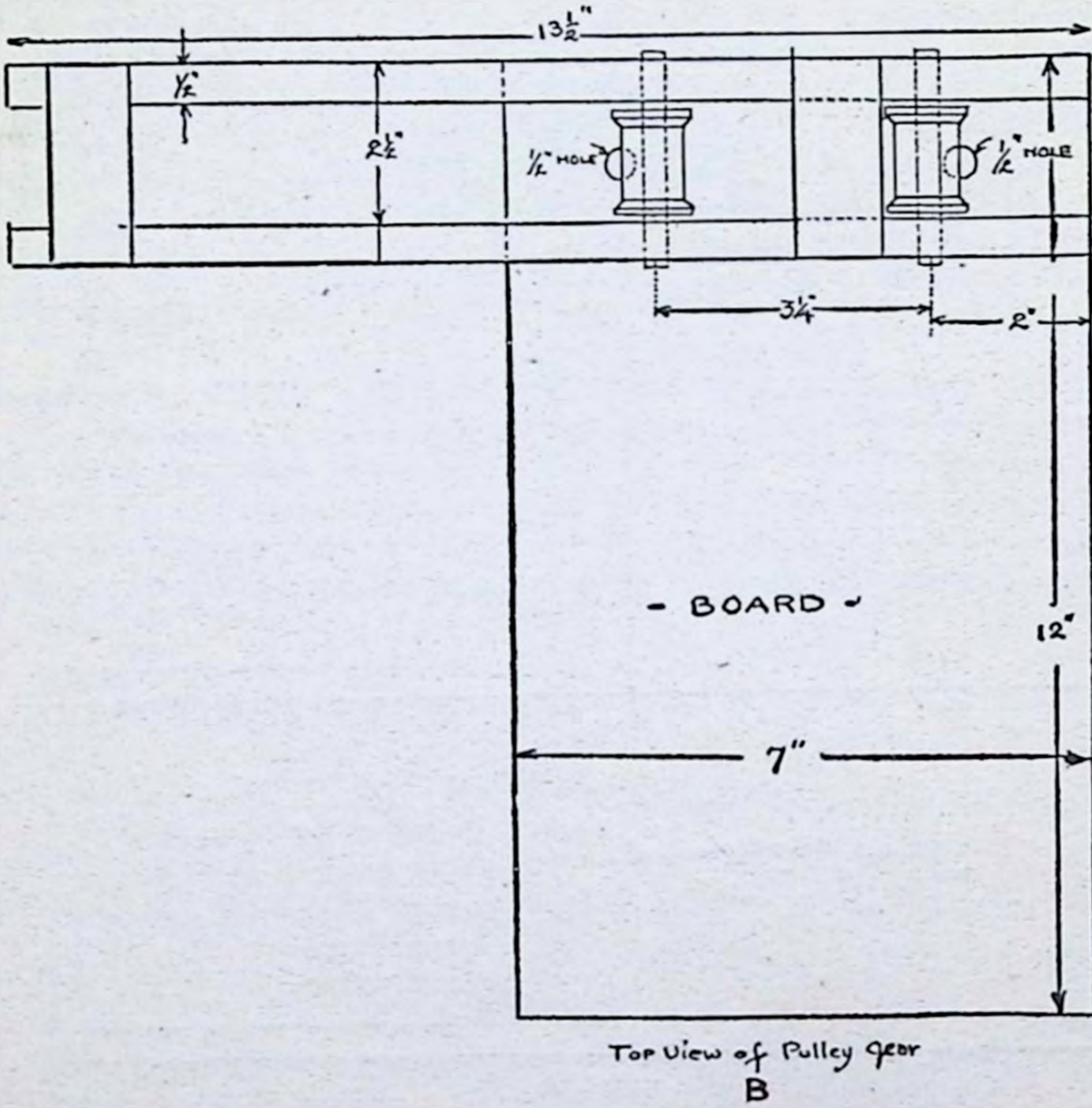
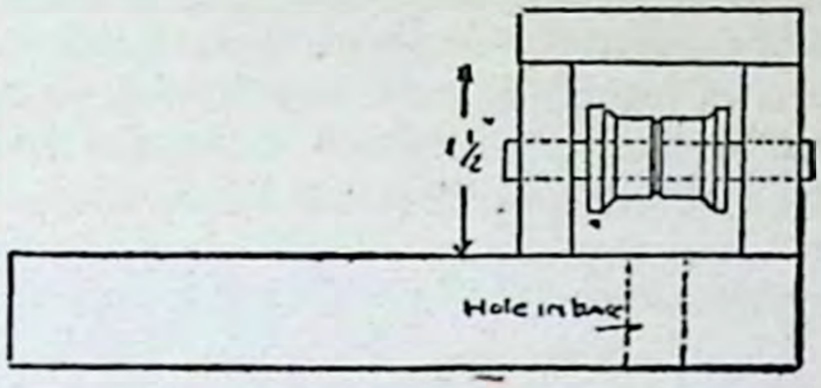


Fig. 57

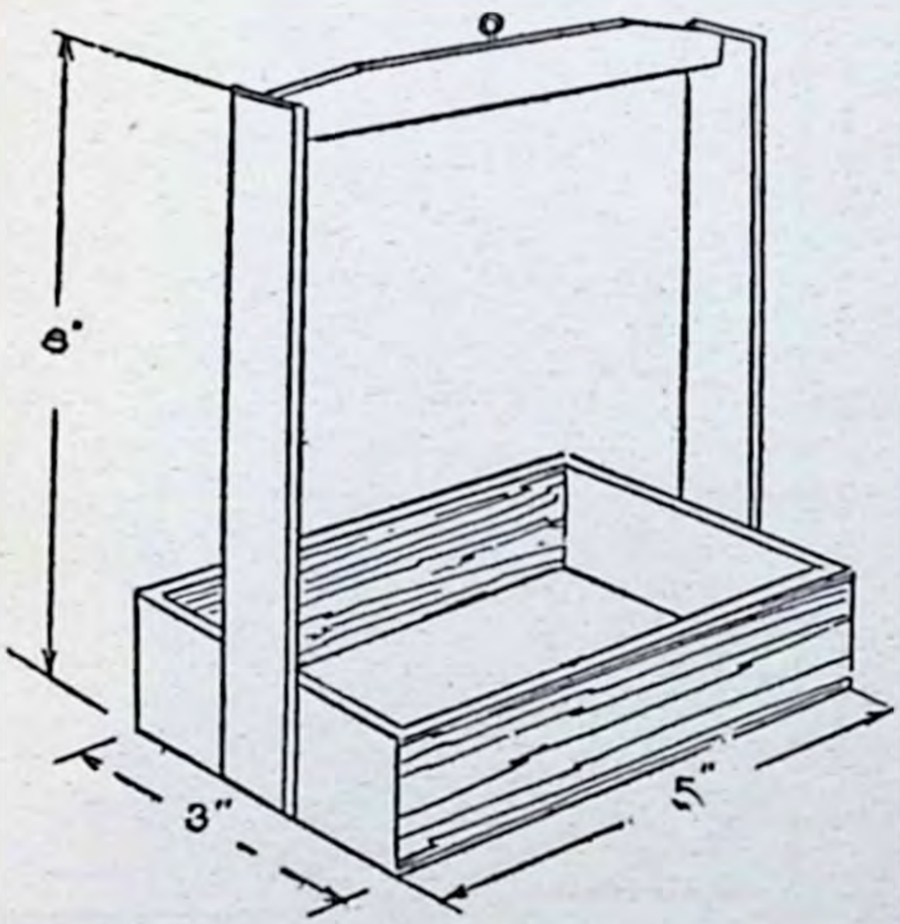
Cut two sticks ½ an inch thick, 1½ inches high, and 13½ inches long, and bore two ¼-inch holes through both of them so they are 3¼ inches apart and one of them is 2 inches from the edge of the board, as shown at B and C. Nail these two strips to one end of the board so that the spools will go between them and the ends are flush with the edge of the board on one side and project over on the other side, as at B. Cut a groove in a couple of spools, push a pair of dowels 3 inches long through the holes in the strips and the spools and then bore two ½-inch holes in the base on the outside of the spools, as at B, for the string to run through. Nail two strips across the top of the pulley gear 9 inches apart and screw a screw eye into each one. This pulley gear is to be nailed to the top of the window casing outside and must be braced to hold it in place.



C END VIEW OF PULLEY GEAR

Fig. 57

For the car get a small box and take off the lid, then make a beam ½ an inch thick, 1 inch wide, and exactly as long as the box. Nail a strip of wood 8 inches long to each end of the box and the beam, as shown at D, and put a screw eye in the top of it. Screw a screw eye into each end of the box and the beam for the guide wires and your car is complete.



D

Fig. 57

Now tie two guide wires, or stout pieces of string, to the screw eyes in the pulley gear in the upper window, thread them through the screw eyes in the car and tie them to the screw eye in the board of the driving gear that is on the ground, as at A. Then tie a long, strong, soft string to the screw eye in the beam of the car and run it up and over the spools in the pulley gear and down to the winding drum and your elevator is ready to run. While the driving gear will pull the car up without a counterweight, the car will run speedier and smoother if you use one on the string that goes to the winding drum. You can make the counterweight of lead.

(66) HOW TO MAKE A TOONERVILLE TROLLEY LINE: Get the largest cigar box that is used, that is one with square ends, and cut a hole in the bottom ½ an inch wide and 2 inches long, as shown at

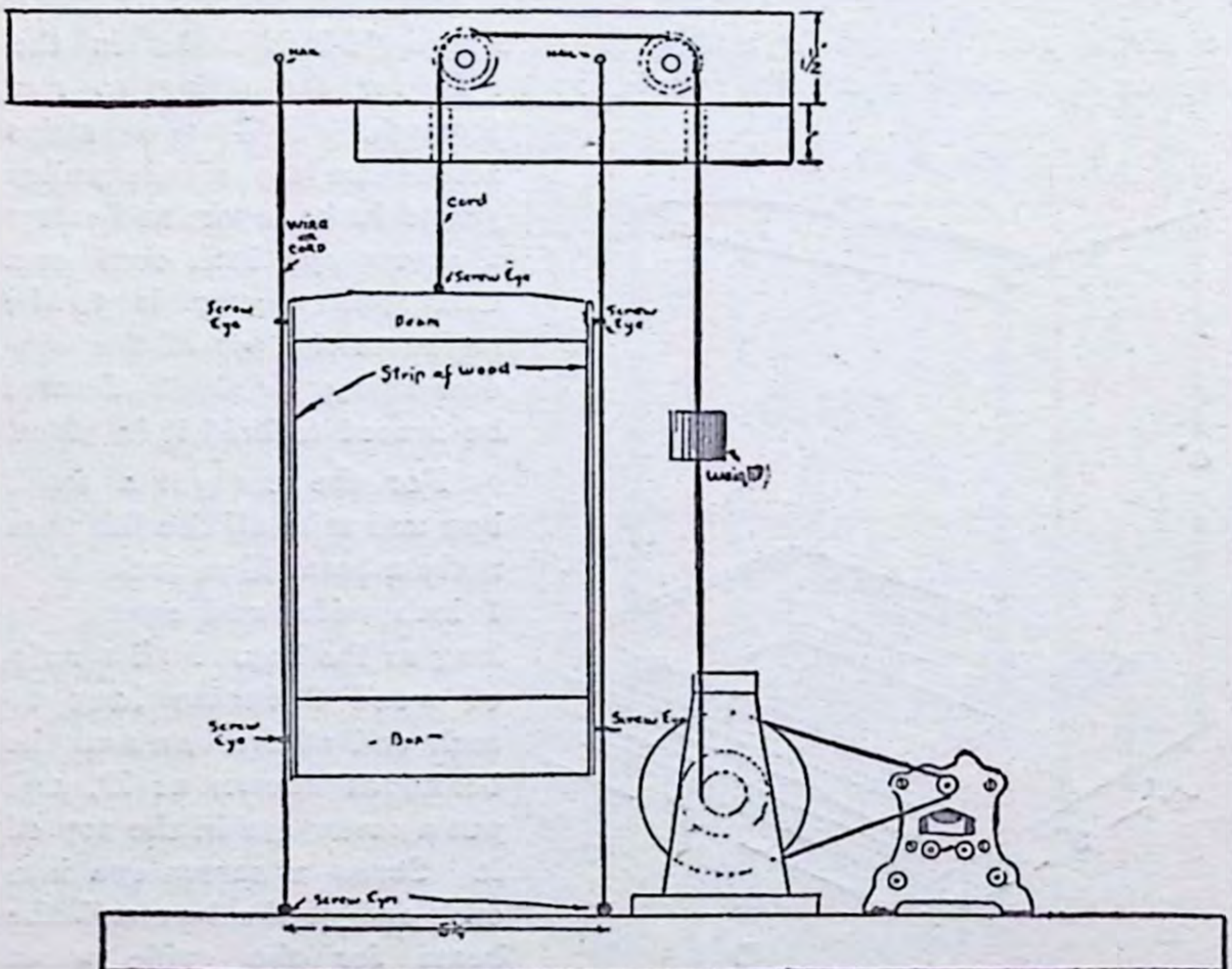
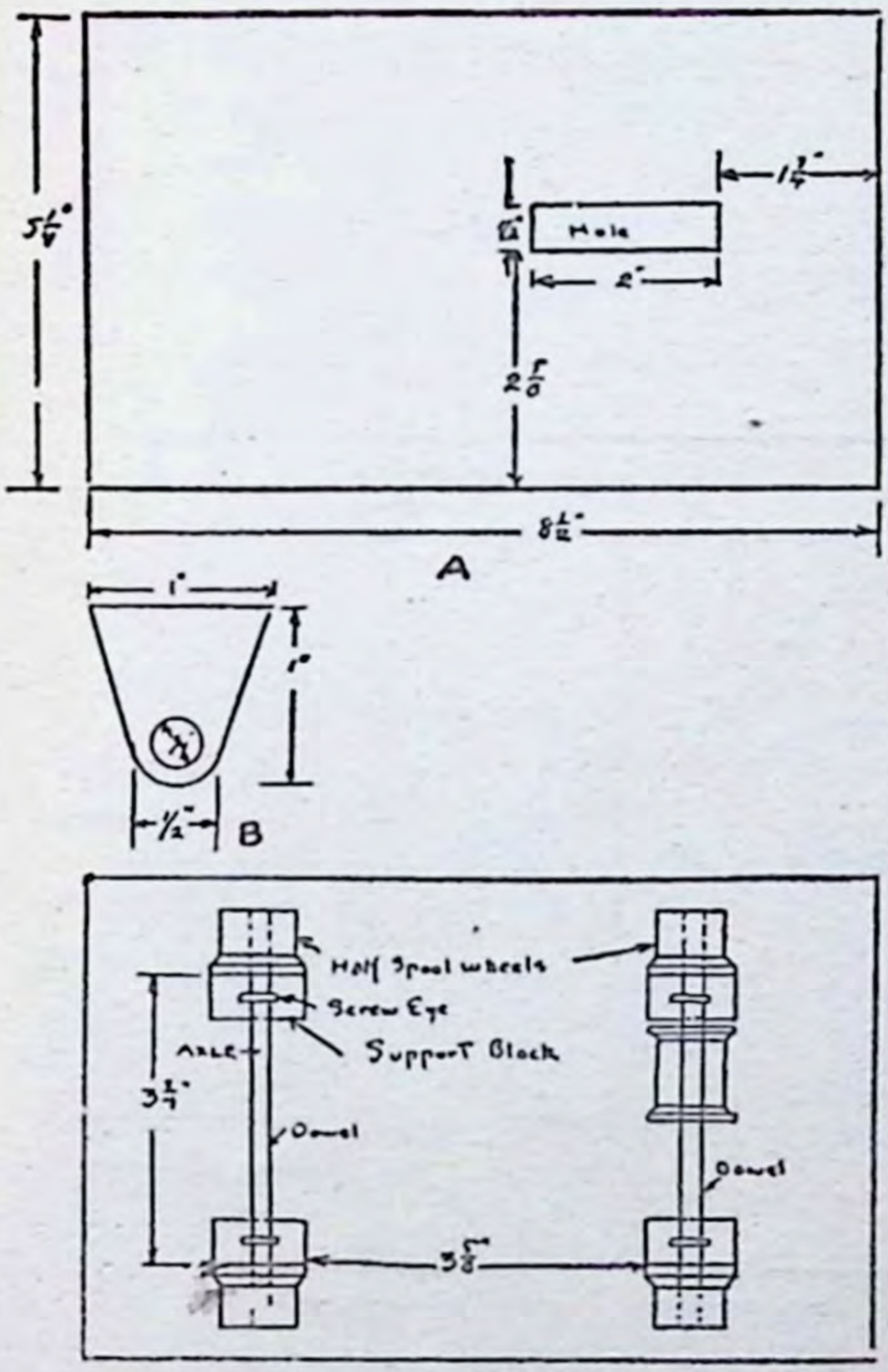


Fig. 57

A in Fig. 58. Then make four supports for the car wheels ½ an inch thick, 1 inch wide at the top, and ½ an inch wide at the bottom, and 1 inch high, and bore a ¼-inch hole in the small end of each one, as shown at B, and nail them on the outside of the bottom of the box, as at C. Screw a screw eye into the end of each support, run a dowel 5 inches long through one of the eyes, then through a spool in which you have smeared some glue and on through the other screw eye; run another dowel through the other pair of screw eyes and glue a half spool on each end of each dowel with the flanges inside, as at C.



C

Fig. 58

Next make two supports 1 inch thick, 1 inch wide at the top, 2 inches wide at the bottom, and 2½ inches high; nail these on the inside of the bottom of the box, as shown at E. Make a grooved pasteboard pulley ¼ inch thick and 3 inches in diameter with a ¼-inch hole in it for the shaft and glue it to a spool; smear some glue in the pulley and spool and slip a dowel 3¼ inches long through the screw eyes, pulley, spool, and washers, as at D.

This done, screw down the motor to the middle of the box at one end, then belt the motor pulley to the pasteboard pulley and the spool on the motor-driven shaft to the spool on the axle, as at D-1.

Now make a trolley pole of a strip of wood

⅛ inch thick, ⅜ inch wide, and 2½ inches long, as at **F.** Take two pieces of No. 16 or 18 bare copper wire, bend them into a pair of contact forks and fasten them to one end of the trolley pole; solder two pieces of No. 18 insulated copper wire about a foot long to the forks

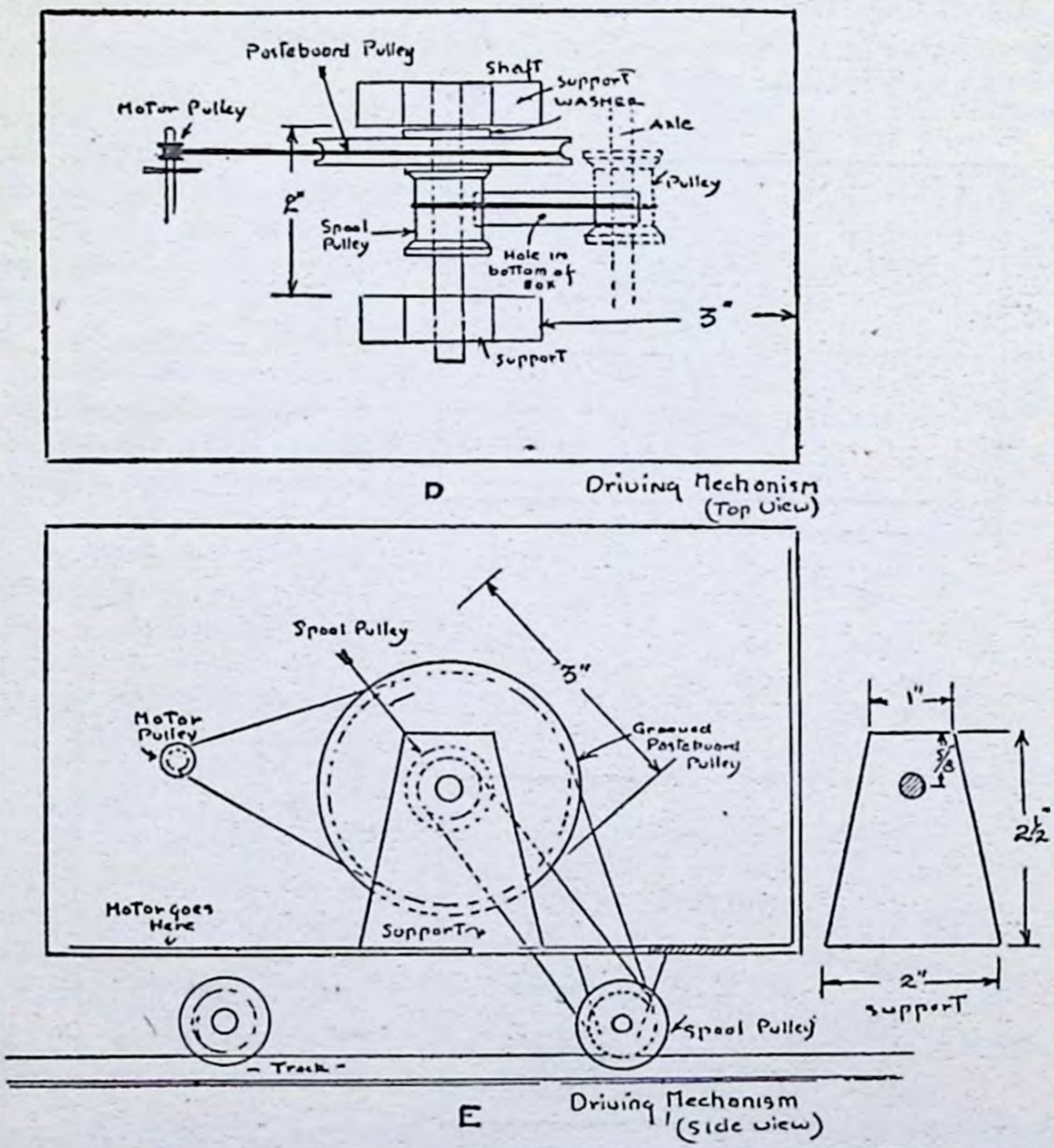
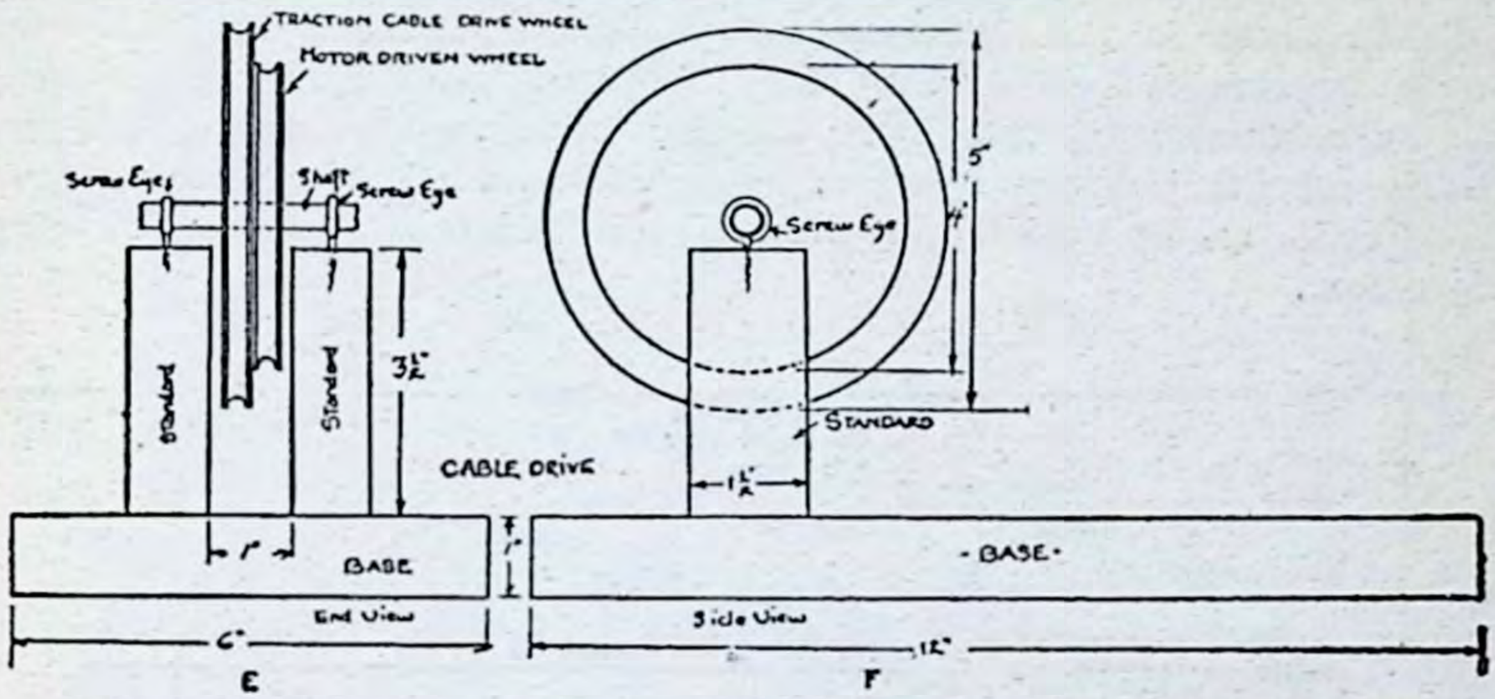
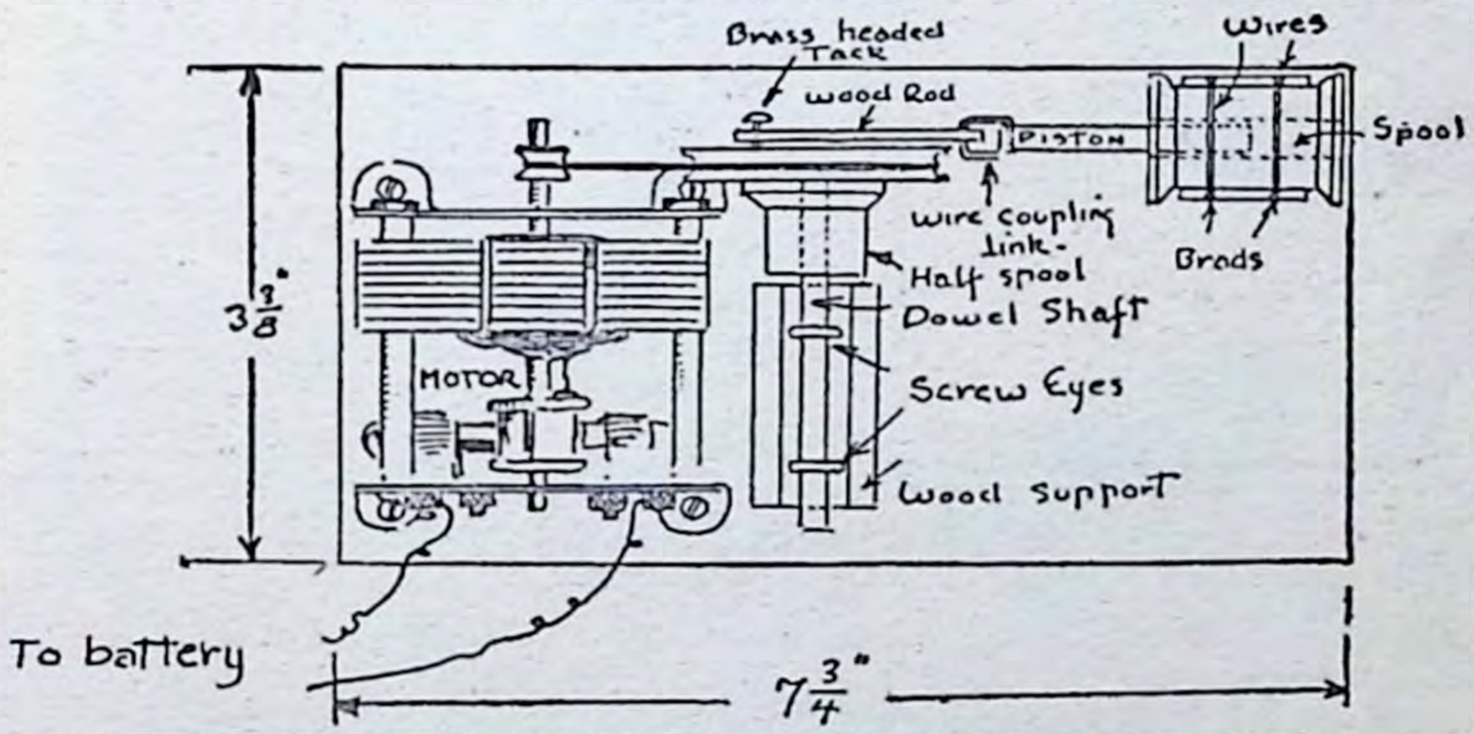


Fig. 58

and fasten them to the lower end of the pole. Fix a little brass hinge to the lower end of the pole and to the end of the cigar box, and then bring the wires into the box and connect them to the motor, as at **G.** Screw a screw eye into the trolley pole and another one in the front





D-1

Fig. 58

end of the car and tie a rubber band to them when your car is ready to run.

For the trolley line fasten the ends of two No. 12 or 14 bare copper wires to a piece of hard fiber ¾ inch apart and support these 10 inches above the track. Solder a pair of wires to the trolley wires at one end and connect them with your reversing switch and a battery of six dry cells, or better, a Gilbert transformer. Finally, make a track of wood strips that are ⅜ inch wide, ½ inch high, and as long as you want it, and space them 3⅞ inches apart on ties. Turn on the current and your trolley car will pull out at a lively rate of speed. You can make a real Toonerville car by building up the body of the car of pasteboard on the cigar box.

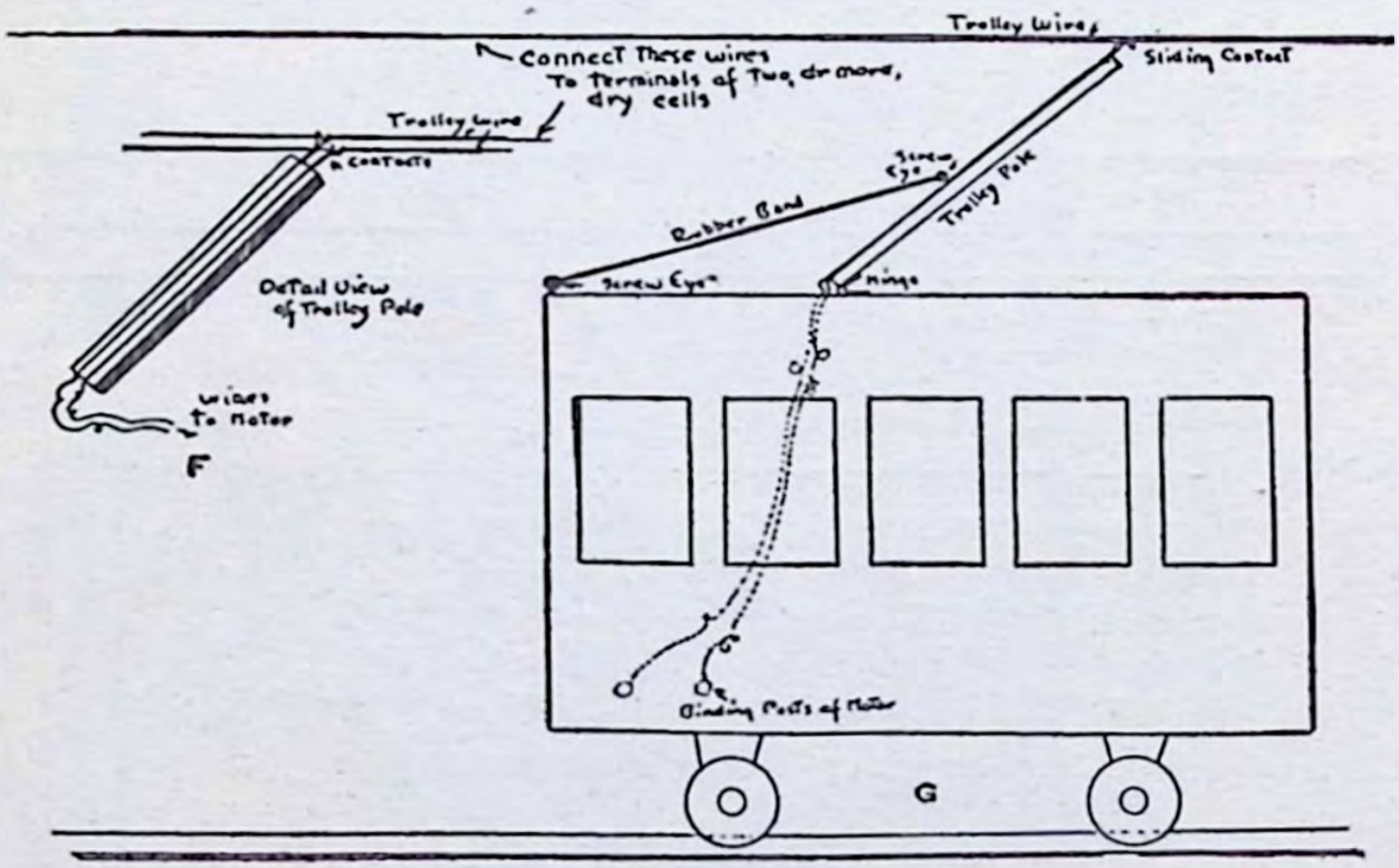


Fig. 58

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