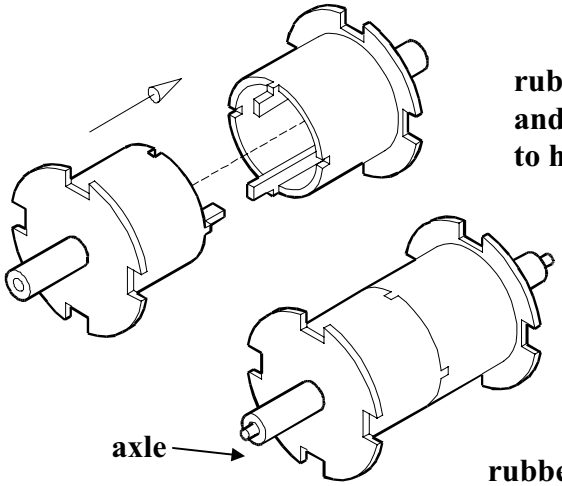
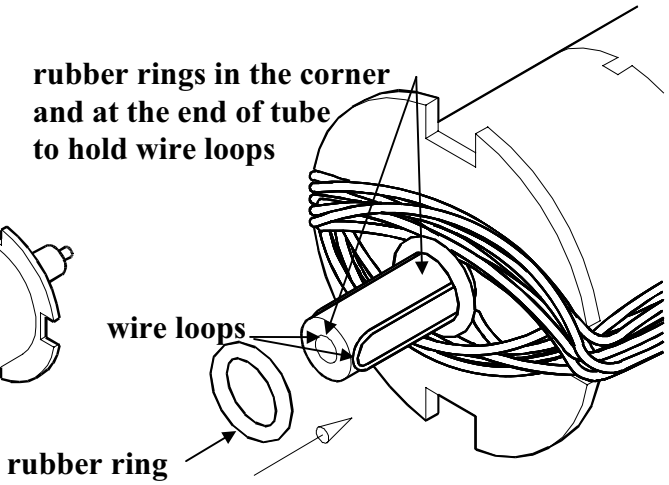
Electric Motor Kit (Cat. No.1035736) ASSEMBLY Instructions:



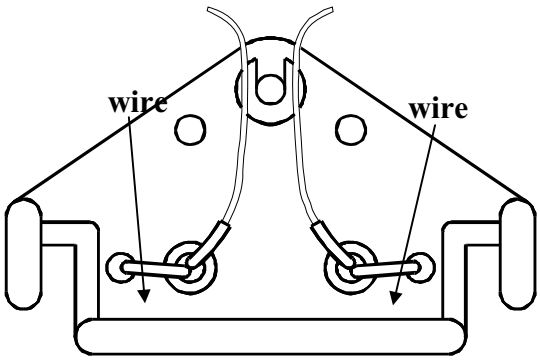
Rotor Assembly



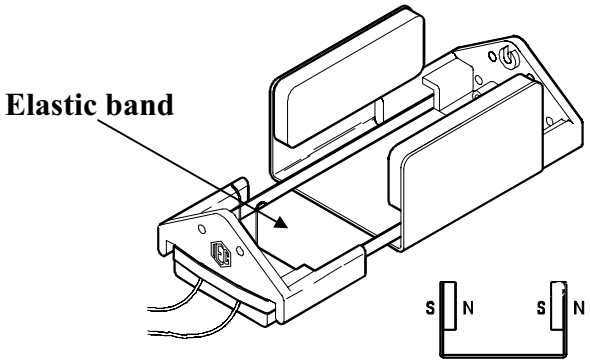
Single Coil Winding

Assemble Rotor by aligning the two halves of the rotor and pressing them together until they 'click'. Fit the Axle Shaft through the rotor to check that the rotor spins freely on the shaft.

Wind a Single Coil rotor as shown. Wind a bundle of about 10 or 12 turns with about half the turns either side of the bearing tube. Skin about 25mm of plastic off the start and finish of the wire and bend the bare wire into a loop about 4mm wide and 10mm long. Position the start and finish loops opposite each other and in line with the coil bundles. Hold the two loops in place by stretching the two rubber rings over the wire loops with maximum space for the brushes to make contact between them. These loops are called the 'commutator'.



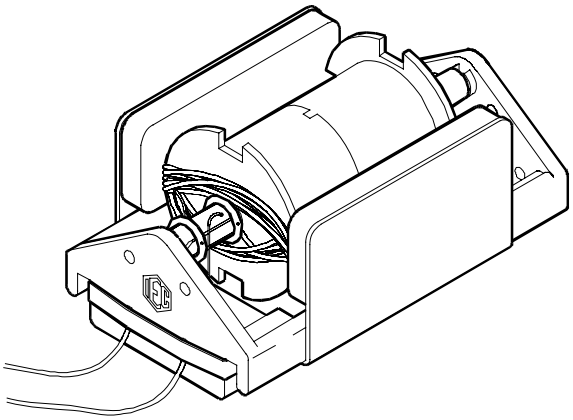
End Plate showing wire 'brushes'

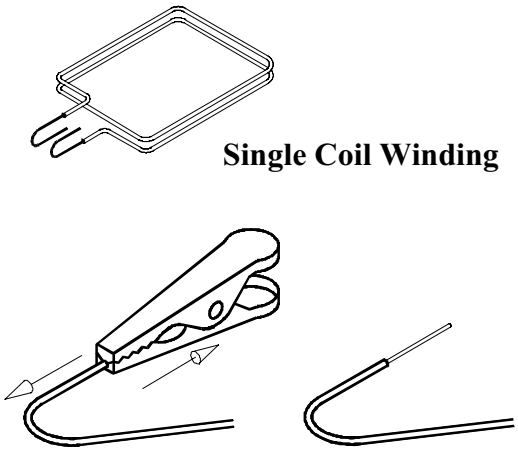


Assembly showing elastic band

Pass a wire through tube on one side of the end piece, loop it back through the other hole and back through the tube again and pull tightly to hold the wire firmly in place. Repeat for the other tube. Skin the ends then bend and curve them as shown so they are about 4mm apart. When the rotor is slid into position, these wires will be pushed apart so they will be rubbing against the wire loops on the rotor to form 'brushes'.

Place the elastic band in the location slots provided in both plastic ends and separate them to stretch the band through the 'U' shaped frame. Engage the two ends to slip over the edges of the frame so that they lock into place. Place the two magnets into position with **opposite poles** facing and press them down to rest on the plastic rails coming from each end piece.





Assembled Motor **Alligator Clip for Skinning Wire**

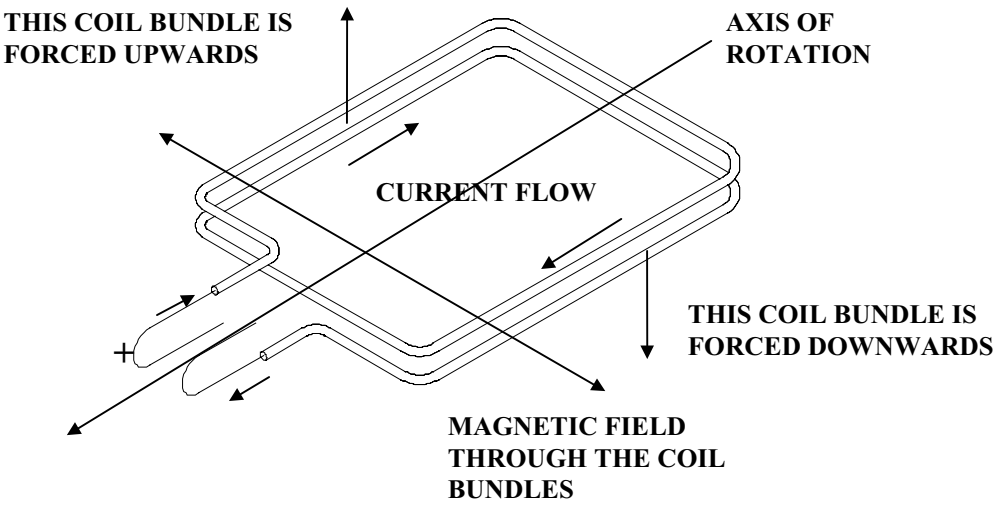
Take the rotor with its axle shaft fitted, pull one plastic end away from the frame slightly and slide the axle vertically down between the two ends and into the two bearing holes. While sliding the rotor down and into position, the two wires (brushes) will be forced apart slightly by the rotor so that they will rub gently on the rotor's wire loops (commutator) to make good electrical contact as the rotor spins.

The above sketch shows a simple single coil rotor with a skinned loop formed on each end of the coil. The other sketch shows how to skin the wire.

Be sure the motor spins freely and check that the two wire brushes are springing together and rubbing on the commutator. Skin the other ends of the red and black wires and connect them directly to a 1-1/2V 'D' size dry cell. If the rotor does not immediately turn, it might need a spin with the finger to start the motion. If still not successful, check that the magnet poles are north pole facing a south pole and check the brushes are rubbing on the loops.

Summary:

1. Align and press the two halves of the rotor together until they 'click'.
2. Insert axle to be sure the rotor spins freely on it.
3. Remove the axle and wind the coil with wire.
4. Form the commutator and hold in place with 2 rubber rings.
5. Thread wires through end plate and form the brushes with wire.
6. Fit the two ends to the metal frame with the elastic band.
7. Fit the two magnets with opposite poles facing each other and slide down firmly.
8. Fit the axle and fit the rotor between the ends and between the brushes.
9. Be sure the two brushes are pressing gently against the commutator loops and be sure the rotor runs free with the brushes positioned between the rubber rings.
10. Connect a 1.5V 'D' battery or 2.0V.DC. power supply to the brush wires to see the rotor spin. Motor may need a flick to start it spinning.



Why the Motor Turns:

The two magnets are North and South poles facing each other so that a magnetic field is present in the air space between the faces of the two magnets.

The rotor can be wound in several ways as shown later in this instruction sheet, but the principles are the same. In a simple single coil rotor, the current passes in from the positive brush wire, through the commutator and coil and out from the negative brush wire.

For the rotor to be forced to turn, the magnetic field of the magnets must react with the magnetic field caused by the current through the bundle of wires so that it pushes both bundles on opposite sides of the rotor vertically out of the magnetic field.

When the rotor has rotated one half turn and the opposite coil bundle is in front of the same pole magnet, the brushes touch the opposite commutator loop and the current is suddenly reversed in the coil. Immediately the coil bundles are pushed out of the magnetic field in the same direction. The motor has only two coil bundles in front of magnets at any time, so the rotational momentum of the rotor must continue the rotation through the places where there are no turning forces. In a real motor there are many coils and there are always several coils in the magnetic field at any time so the rotational force is continuous.

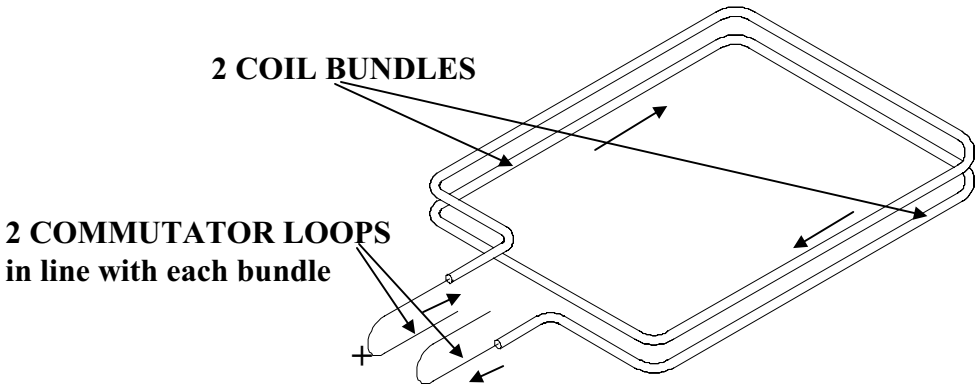
For maximum efficiency, as the coil bundle approaches the magnet, the bundles are first attracted into the magnetic field and, when they are passing half way across the face of the magnets, the current is reversed and they are then pushed out of the same field.

Pull or push must be UP on one side of the rotor and the pull or push must be DOWN on the opposite side of the rotor therefore the current through the bundles on either side of the rotor must be flowing in the opposite directions. As the rotor turns a half turn, the current must be reversed very quickly in the coil while the rotor is turning and this reversal of the current through the rotor coil is the function of the commutator.

It can be seen that the position of the commutator loops on the rotor is very important for the current to reverse at exactly the right moment for the motor to run efficiently.

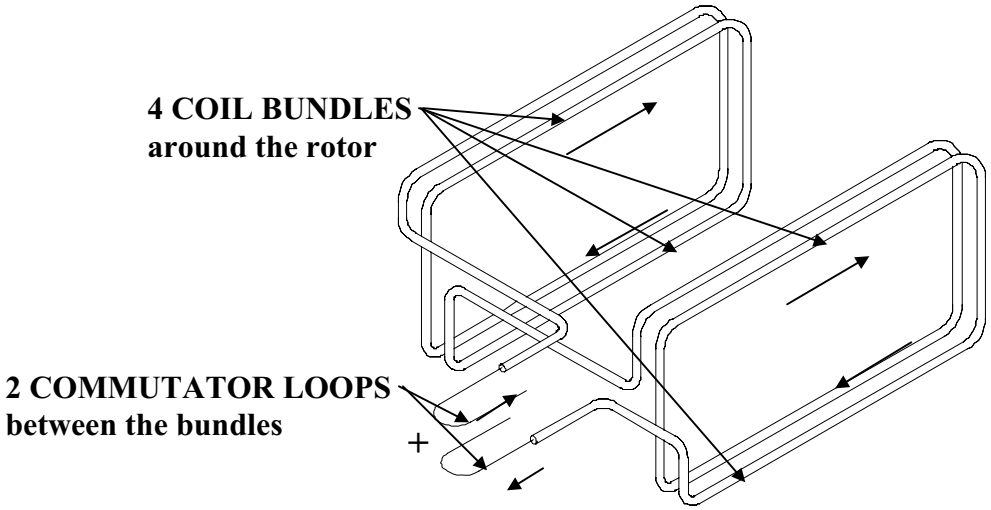
Types of Rotor Windings:

Simple single coil rotor winding.



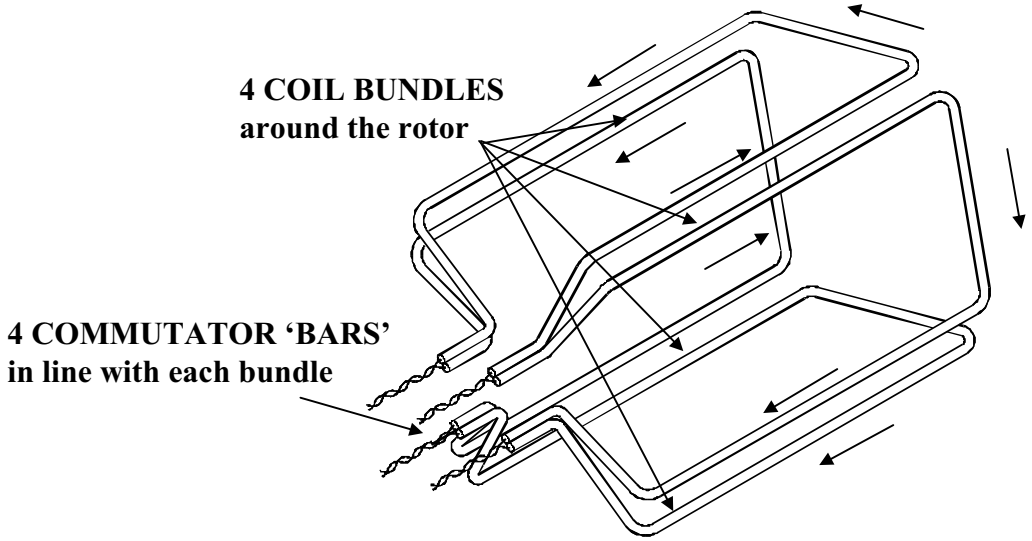
Single coil rotor: The two wire bundles passes each of the magnets once per turn therefore, if current is flowing through the wire in the correct direction as the bundle passes the magnet, there are 2x pushes on the rotor wire bundles per turn. The current through the wire bundles must flow in the correct direction, therefore it is very important that the commutator loops are positioned correctly relative to the coil bundles and, for a single coil, they should be positioned **in line with each bundle**. By turning the rotor slowly and starting at the commutator loops, trace the path of the current through the coils and check that a wire bundle is in front of a magnet when current is flowing through that bundle.

Double coil rotor winding:



Two coil rotor: The four wire bundles pass each of the magnets once per turn therefore, if current is flowing through the wire in the correct direction as the bundle passes the magnet, there are 4x pushes on the rotor wire bundles per turn. The current through the wire bundles must flow in the correct direction, therefore it is very important that the commutator loops are positioned correctly relative to the coil bundles and, for a double coil, they should be positioned **between the bundles**. By turning the rotor slowly and starting at the commutator wires, trace the path of the current through the coils and check that a wire bundle is in front of a magnet when current is flowing through that bundle.

Four coil rotor winding:



Four coil rotor: For simplicity and clarity, the sketch above shows only one turn per coil, but each coil would normally be of 5 or 6 turns.

The four wire bundles pass each of the magnets once per turn therefore, if current is flowing through the wire in the correct direction as the bundle passes the magnet, there are 4x pushes on the rotor wire bundles per turn. The current through the wire bundles must flow in the correct direction, therefore it is very important that the commutator twisted connections are positioned correctly relative to the coil bundles and they should be positioned **in line with each bundle**. By turning the rotor slowly and starting at the commutator wires, trace the path of the current through the coils and check:

- If all the wires in any bundle are carrying current in the one direction
- That a wire bundle is in front of a magnet when current is flowing through that bundle.

Notice that the 4 coil rotor provides 4 commutator connections instead of two. This results in a smoother rotation and better and more reliable starting.

The Commutator:

In the single and double coil rotors, the instructions say that the 'loops' of bare wire be held to the bearing tube of the rotor rather than a single bare wire. It is important that current is flowing through the coil while the coil is entering and leaving the magnetic fields in front of the magnets. The current should be flowing while the rotor is turning almost a half turn and the brushes will remain in contact only if a loop is used rather than a single bare wire. The time that the brushes are not contacting the loops should be small.

Experiment with different shapes and positions of the loops around the tube to obtain the best starting, power and speed. When best performance is found, examine when the commutator is reversing the current through the coil relative to the position of the coil bundles.

Helpful Hints:

Always allow a few centimetres of spare wire at the start and finish of the coil to be trimmed off later. A most important point when inspecting a winding is that the current passing through any bundle of wire must be flowing in the opposite direction to the bundle on the opposite side of the rotor.

Single coil winding. Wind the coil of about 10 to 12 turns across the diameter of the rotor with half the turns split either side of the bearing tube. Direction of winding does not matter.

Bring both the start and finish wires out the same end of the rotor. Cut the wires to be about 10mm past the end of the rotor bearing tube.

Using the Alligator clip, skin about 25mm of plastic from each wire. Fold a loop about 4mm wide and 10mm long in each bare wire and press the extra wire back to the face of the rotor so the bare loops lay along the bearing tube opposite each other but in line with the bundles of wires on the rotor. Do not allow the loops to protrude past the end of the bearing tube. See previous illustrations.

Take the small rubber rings, stretch them over the bearing tube and over the loops to hold them tightly to the tube. Roll the first ring right back into the corner and position the second ring on the end of the tube, leaving the maximum space between the rings for the two brushes to rub against the loops (the commutator).

Double coil winding. Wind one coil of about 10 to 12 turns between adjacent notches in the rotor (the winding bundle is like a chord to the circular shape). Then turn the rotor 180^{o} so that the opposite side of the rotor is facing you. Continue to wind the same number of turns **in the opposite direction** between adjacent notches so that the two coils are on opposite sides of the rotor. The initial direction of winding does not matter providing that the two coils are wound in the opposite direction when looking directly at each one.

Bring both the start and finish wires out the same end of the rotor. Cut the wires to be about 10mm past the end of the rotor bearing tube.

Using the Alligator clip, skin about 25mm of plastic from each wire. Fold a loop about 4mm wide and 10mm long in each bare wire and press the extra wire back to the face of the rotor so the bare loops lay along the bearing tube **opposite each other but between the two coils**. Do not allow the loops to protrude past the end of the bearing tube.

Take the small rubber rings, stretch them over the bearing tube and over the loops to hold them tightly to the tube. Roll the first ring right back into the corner and position the second ring on the end of the tube, leaving the maximum space between the rings for the two brushes to rub against the loops.

Four coil winding. Wind one coil of about 5 or 6 turns between adjacent notches in the rotor in the same way as the double coil. When finished, turn the rotor 90^{o} and take the wire 25mm past the end of the bearing tube, double it back tightly on itself and continue to wind the same number of turns starting in the same notch but wind the coil between the notch you have just wound and the next empty notch on the rotor. After second coil is finished, again form a tight loop in the wire and wind it back into the same notch to wind the next coil into the next notch. The initial direction of winding does not matter providing that, when facing each coil, the windings are all wound in the same direction.

Cut the 4 loops about 10mm past the end of the bearing tube and, using the alligator clip, skin the plastic for about 20mm. Twist the pairs of bare wires together tightly and lay the 4 twisted wires against the bearing tube **in line with each coil bundle**. Do not allow the twisted wires to protrude past the end of the bearing tube.

Take the small rubber rings, stretch them over the bearing tube and over the twisted wires to hold them tightly to the tube. Roll the first ring right back into the corner and position the second ring on the end of the tube, leaving the maximum space between the rings for the two brushes to rub against the 4 sets of twisted wires.