10-135 Toy Motor Assembly Instructions

Parts List:

26-9123	Wire, 100 cm long coil	2
51-1352	Field Pole	1
51-1358	Mounting Bracket	1
51-1350	Armature Half	2
26-9214	Tubing, about 1"	1
31-0135	Motor Shaft	1
57-1005	Commutator Insulators	2
33-0135	Bronze Wire Brushes	2
51-1355	Shaft Supports	2
29-1038	Paper Fasteners	2
26-1040	Battery Clips	2
20-1101	Screws	2
20-2102	Hex Nuts	2
57-0135	Plastic Base	1
24-0135	Instructions	1

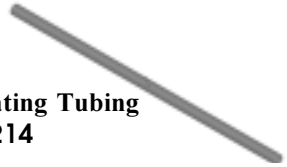
#1 Two (2) Shaft Supports - 51-1355

#2 Two (2) copper wire coils, 100 cm long - 26-9123

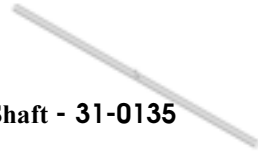
#3 Two (2) Battery Clips - 26-1040.
You supply one new AA or rechargeable Ni-MH battery.

#4 Two (2) Paper Fasteners - 29-1038

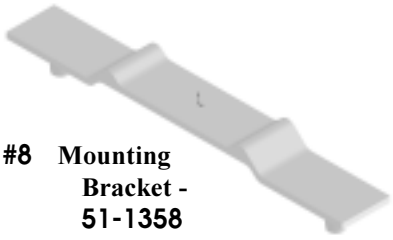
#5 Two (2) Armature halves - 51-1350



#6 Insulating Tubing - 26-9214



#7 Motor Shaft - 31-0135



#8 Mounting Bracket - 51-1358

#9 Two (2) hex nuts 20-2102

#10 Two (2) Wire brushes - 33-0135

#11 Two (2) Round head screws - 20-1101

#12 Two (2) Commutators - 57-1005. Slide halves together as shown.

#13 Plastic Base - 57-0135

#14 Field pole - 51-1352

Warranty and Parts:

We replace all defective or missing parts free of charge. Our products are warranted to be free from defect for 90 days. While we will gladly send missing parts promptly, we do not sell replacement parts singly. **Made in U.S.A.**

Tools Needed:

- Sandpaper
- Sharp knife, scissors, razor blade or wire cutters for cutting and scraping.
- Small (slotted) screwdriver
- Pair of needlenose pliers
- Millimeter scale (see *Diagram 3).*

You need one (1) **new** *AA battery, not included.*

⇨ *A freshly charged, rechargeable Ni-MH battery will work best as it has a higher current available.*

Toy Motor in cost-saving bulk packs

10-137 - Enough parts for 30 students (15 instructions)

10-138 - Enough parts for 48 students (24 instructions)

- These bulk packs have been used repeatedly by a number of loyal teachers, who like the savings.
- The idea, in fact, was suggested by one of them - **Dr. Aronson** of *Case Western Reserve.*

P/N 24-0135

Motor Assembly:

Important! The copper wire supplied with this kit has an insulating coating on it. Using sandpaper, clean the coating of insulation to a length of 1" off **all wire ends**.

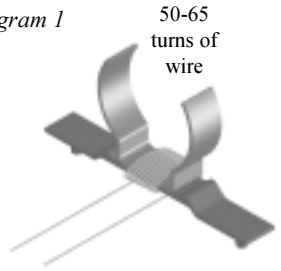
A. Field Coil

1. Unroll one of the wire coils (**#2**). Place the coil on one of your fingers and pull one end to unwind.

2. Cut off a 6" piece from one end (use the scale in *Diagram 3.)* Using **sandpaper,** scrape off 1" of the coating from each end. Place this piece to the side. (It will be used in **Section E**.)

3. Hold field pole (**#8**) and mounting bracket (**#14**) together. Leaving 2" of wire free, begin winding the coil tightly around the two parts as shown in *Diagram 1.* Continue wrapping the coil until there are 6" left. Using **sandpaper,** scrape off 1" of the coating from each end.

Diagram 1



Scrape 1" insulation off each wire end

B. Armature

1. Unroll the second coil wire coil. Using **sandpaper,** scrape off 2" of the coating from each end.

2. Put the two halves of the armature (**#5**) together with the motor shaft (**#7**) between them.

3. Leaving 2" of wire free, wrap the wire coil 8 times around one side and then cross over the other side and wrap the coil 8 times around that side. Repeat until there are 2" of wire left. When finished, it should look like *Diagram 2.* Be sure to have the windings always go in the **same direction** and to have about the same amount of windings on each side.

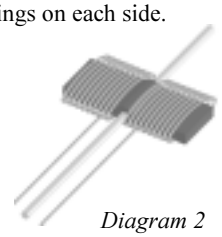


Diagram 2

C. Commutator

1. Cut a 7/16" piece of tubing (**#6**). Slide one end of the motor shaft into the tubing. Tubing **must** be pushed directly against the armature halves.

2. Place the halves of the commutator (**#12**) together as shown below.

3. On the same side as the tubing, slide the motor shaft through the commutators' large middle hole.

4. Run the wire from one side through one of the small holes of the commutator. Repeat with the wire from the other side.

5. Cut a 1/4" piece of tubing. Slide onto motor shaft so that the commutator is between the pieces of tubing. Trim off the wire.

6. Cut a second piece of tubing 7/16" long and slide onto the opposite end. Trim off the wire.

Important! Both commutator halves must be at right angles to the armature. The holes should be in a vertical position when armature is horizontal. Your motor won't run well if this is not done.

D. Assembling motor (*Diagram 4)*

1. Fasten the field coil to the plastic base (**#13**) using 2 screws (**#11**) and nuts (**#9**). Wire ends should be pointing toward the middle of the base.

2. Place one shaft support (**#1**) into the rectangular hole closest to the field coil. The support should be perpendicular to the base.

3. Loop the 6" long wire (Step 2 - Field Coil) through one of the paper fasteners and twist. Slide the fastener through **Hole #3**.

4. Loop the 6" long single wire (from **Section A -** Field Coil) through the other paper fastener and twist. Slide the fastener through **Hole #4.** (Don't open the fastener yet.)

5. Using **sandpaper,** scrape the coating off both brushes (**#10**). Bend looped end of brush. Flip the base over. Slide one brush through **Hole #5.** Then slide the loop at the end of the brush over the fastener in **Hole #3**. Spread the fastener open. Slide the second brush through **Hole #7**. Then slide the loop over the paper fastener in **Hole #4**. Spread the fastener open.

6. Place the second shaft support (**#1**) into the rectangular hole farthest from the filed coil. The shaft support should be perpendicular to the base.

7. Using a light oil, lubricate the armature shaft. Then lay the armature on the two shaft supports and pop into place. (The commutator should be touching the brushes.) *See Diagram 8.*

E. Connect Motor To Battery

1. Lace the 2" wire from the field coil into the small hole in one of the battery clips (**#3**). Snap the battery clip into **Hole #8.**

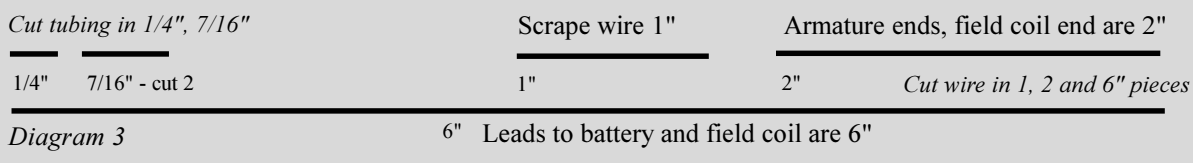


Diagram 3

2. Lace the 6" single wire into the small hole in second battery clip (**#3**). Snap battery clip into **Hole #9**. (Terminals on clips point away from each other.)

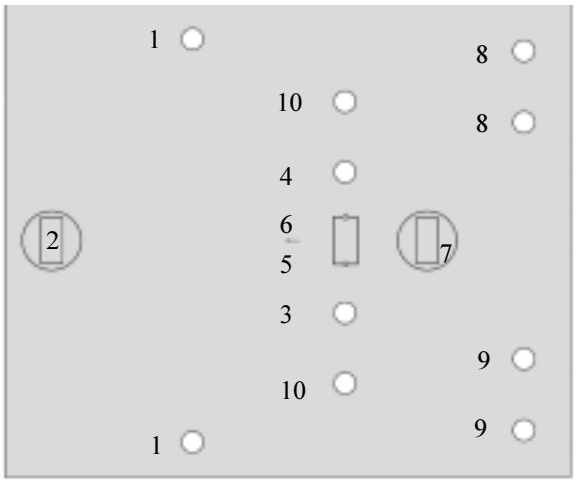
3. Place new battery in clips. A freshly charged, rechargeable Ni-MH battery will work best as it has a higher current.

4. Spin the shaft by hand to get the motor started. *See Diagrams 7 and 8.*

Hint: *You may need a* ***needle nose pliers*** *to bend the uprights of the field coil so the armature turns freely but is not too far from the field coil uprights.*

Experiments:

1. **Put the battery in the other way.** What does the motor do? Will it spin the same or opposite way? Answer this *before* you do the experiment.
2. What happens to the direction of shaft rotation if you **turn the commutator 180°**? Answer *before* the experiment.
3. Put the **commutator in the same plane** as the armature and try to run the motor. How important is the plane of the commutator relative to the plane of the armature?
4. Handle the shaft with your fingers as it rotates at low speeds. Note how the twisting force (**torque**) is not constant as the shaft rotates through one revolution. Plot out the graph of torque vs. angular position. Define 0° starting point for the arma-ture, then feel the torque as the shaft rotates through 360°. Explain your graph.
5. **Short out the commutator with fine wire.** Attach two wires from each brush to an armature wire. What is the resting, stable position of the arma-ture when power is connected? (Use short, quick connections since the armature will heat up.)
6. The field pole extends up and around the armature but has no wire around it. Do you need this? Could you wind wire around the middle of the mounting bracket instead? Unwind the field coil and remove it.
- Now wind the coil of wire back again and connect up the motor. Does removal of the field pole reduce the efficiency of the motor? Explain.
7. Connect **higher voltage batteries** to the motor (**10-171 Battery Kit**). Connect a power supply of 6- 9 volts or more. What happens?



1. For field coil
2, 7. For shaft support
3. For lead to battery
4. For wire lead to field coil
5, 6. For brush
8, 9. For battery clip
10 Unused

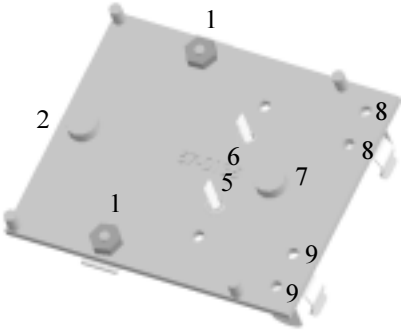


Diagram 4

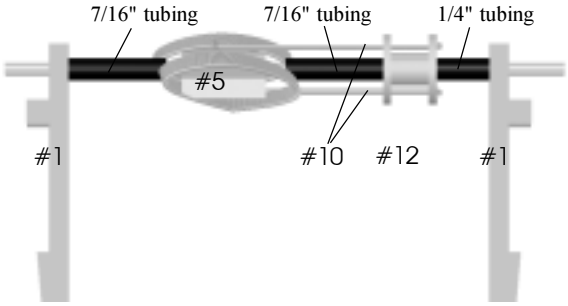


Diagram 5

- How would you redesign the motor to run on 15 volts? Note the blackening around the brushes and commutator. Why does this happen?
- Leave the motor going with 9 volts attached and run it to destruction. What part fails first? What part do you think would have failed next? Fix it if you can and run it again until it fails. This is called destructive testing. What does it teach you?

8. Try connecting an AC voltage source such as a 6-12 volt AC wall trans-former in place of the battery. (*Do not use the 110 volt line outlet directly as this is dangerous and will instantly destroy your motor!*) Does the motor run? Why?

Hint: *This kind of motor is known as a universal motor. Explain.*

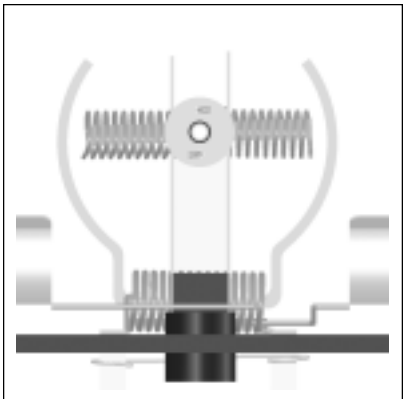


Diagram 6

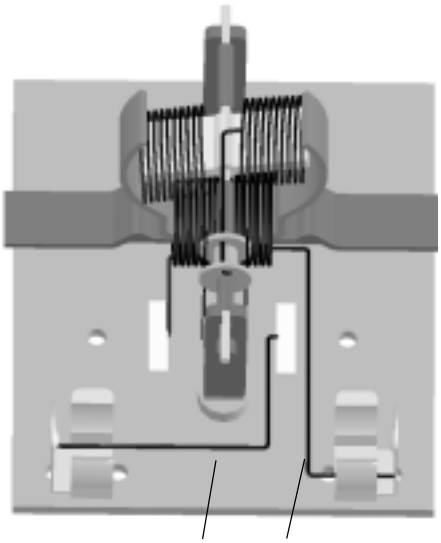


Diagram 7

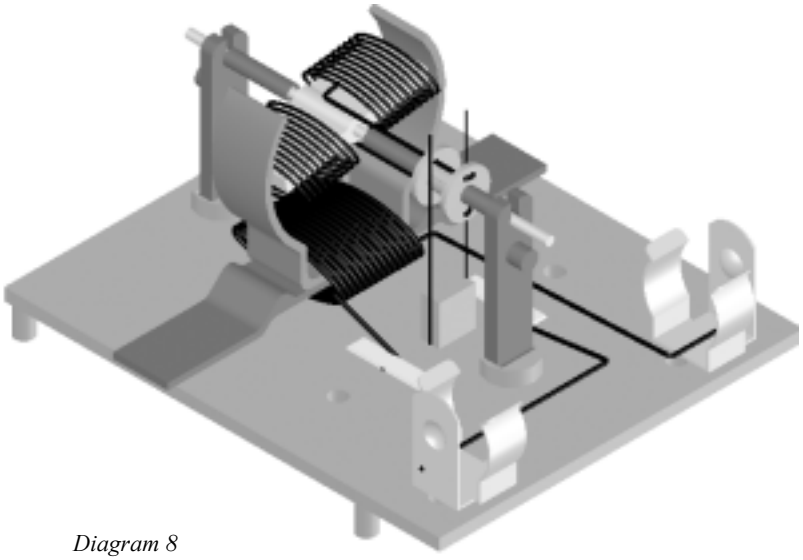


Diagram 8

Theory:

Every magnet has 2 poles **- north**, or *positive*, and **south** or *negative*. "Like" poles repel each other; "unlike" poles attract. One north pole repels another north and attracts a South.

The attracting and repelling of the magnets causes the motor to run. The field poles become an electromagnet when an electric current flows through the wire coil around them. The armature becomes an electromagnet when an electric current passes through its wire coil. The armature, however, produces a reversing magnetic field while the magnetic field produced by the field poles remains stationary.

The North pole of the field pole attracts the South pole of the armature, which turns in response to this magnetic attraction. But in order to keep the armature turning, you must break the current and change the polarity of the armature magnet. Otherwise the armature would remain permanently fixed in one position for as long as electric current was flowing and nothing would move.

Breaking the electric current through the armature and reversing its direction is done by a switch consisting of brushes and commutators. The com-mutators attach directly to the motor due to their location on the shaft and are connected to the armature by the wires threaded through them. The brushes rest lightly against the wires con- necting the commutators to the armature. The brushes complete the electric circuit and enable the electric current to flow into the armature wires.

If the electricity always flowed in the same direction, the field magnet would pull the armature in the same position. It would freeze in this position and there would be no motion. However, just at the height of the attraction of field magnet for armature magnet, when the armature magnet has turned halfway around, the brush strikes the armature wires on the motor shaft to reverse the current's direction. Instead of flowing from the left wing of the armature through to the right, it now flows in the other direction, reversing North and South poles.

The arrangement of wires from armature through commutators is what causes this reversal. Remember that you twisted the wires 90° to position them at right angles to the armature. Due to this orientation, the armature magnet reverses itself as the armature turns halfway, and the armature completes its revolution as what is now a North pole is repelled by the North pole of the field magnet. The South pole of the armature will be continually turning in a series of half turns to seek the stationary North field pole.

The reason the armature revolves in a complete circle of 360° rather than flipping back and forth in half circles is because the momentum of the motor will carry the attraction of North and South a little past the point of peak attraction; as polarity changes, the armature completes its revolution in an attempt to "catch up" with the change in location of the poles.

What to do if your motor doesn't work:

1. Check all electrical connections. Are they scraped free of insulation? (Places to check: both wires from the armature threaded through the com- mutators - one to the battery, one to the brushes; both ends of wire leading from the battery to the brushes.)
2. Can the shaft spin freely by hand? If not, you may have to trim your tubing. (If the field pole interferes with armature rotation, gently bend it out of the way.)
3. Make sure holes in both commutators are at right angles to the armature.
4. Is your battery fresh?
5. Do both brushes contact the commuta- tor lightly? Adjust by trial and error.
6. Use an occasional drop of oil at both ends of the motor shaft where it meets the shaft supports.
7. The “bright” surfaces of the bronze wires may oxidize eventually. This may lead to poor contact between brushes and commutators. To prevent this, coat the “bright” surfaces with solder by “tinning” the surfaces using an electric solder iron.
8. To keep the armature and commutators at right angles to each other, you can apply some “**super glue**” to make a permanent bond at the contact points.
9. You may have to bend the field poles to get them close to the armature assembly. They should be as close as possible.