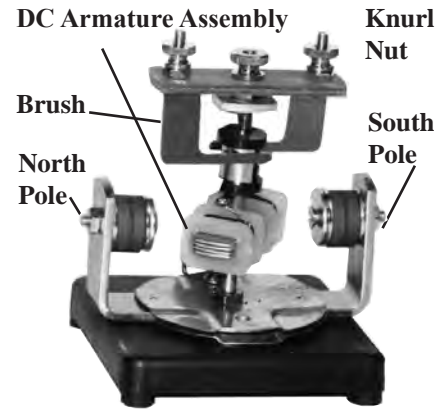# 615-4700 (10-155) St. Louis Motor

You May Need:
- **Galvanometer**
- **Rheostat**
- **DC power supply, 6-12 volt**

Attach 80-0105 Field Coil Assembly (Electromagnet Attachment) by removing Pole Pieces and sliding bracket into Clip.

DC Armature Assembly **Knurl Nut**

Brush

South Pole

North Pole

Product Description:
The value of this motor lies in its open design, allowing you to view and understand the functions and relationships among the working parts of a DC motor. It has the further advantage of sharing parts with **615-4705** Motor Generator. By interchanging magnets from **615-4705** you build a motor with electromagnets.

Warranty and Parts:
We replace all defective or missing parts free of charge. For replacement part orders, we accept credit cards and school P.O's. Products warranted to be free from defect for **90 days.** Does not apply to accident, misuse, or normal wear and tear.

Accessories Recommended:
80-0105 - Field Coil Assembly Pair Makes this motor function as an electromagnet.

615-4065 Battery Kit - low-voltage power supply with clip leads.

611-1045 Table-Top Pulley

Assembly Tips:
To install electromagnet attachment, remove North and South pole pieces by sliding brackets out, slide leg "L" of Field Coil (electromagnet) bracket into slot of clip. To adjust, push in closer to armature or slide back. To adjust brushes, bend slightly if needed so they touch the armature. While brushes are tested in the factory, they may need further adjustment due to shipping.

Activities

1. Transformation of Electrical to Rotational Mechanical Energy
You Need: **Low Voltage Power Supply**

Apply 1.5 - 6 VDC to study the concept of the electric motor. Key components, including the brushes, commutator, windings, and magnetic field are seen in action. By switching the polarity of the applied potential, you see the effects on the fields created.
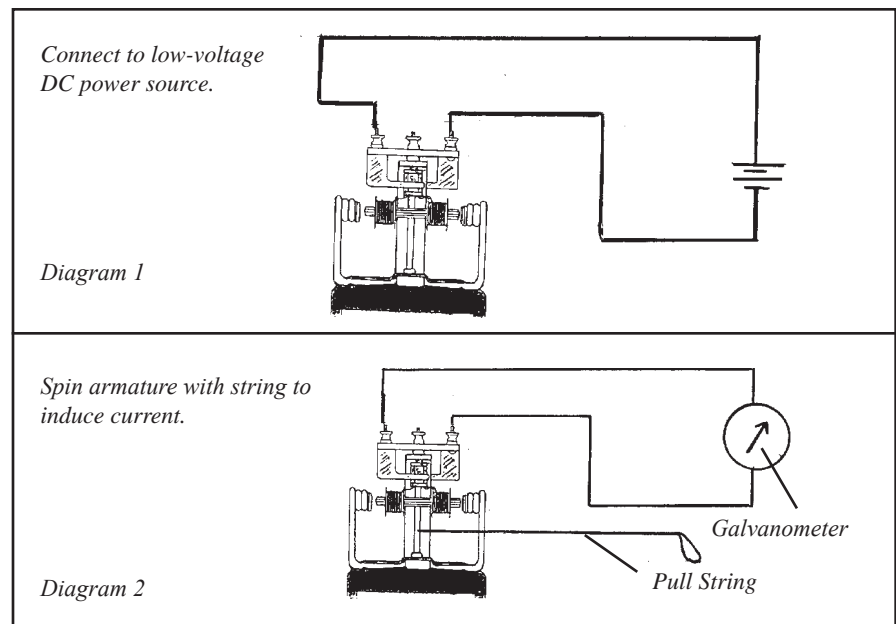
See Worksheet #2.

Trace current flow through meter. What happens when current is reversed? Why may the motor need help to start?

2. Transformation of Rotational Mechanical to Electrical Energy
You Need: **String, Galvanometer**

Wrap piece of string around axle of the armature, pull string to spin coils within the magnetic field, thus inducing a current. Attach galvanometer to your circuit to detect presence and amount of induced current. Spin the coils in the opposite direction and note the difference in the induced current.
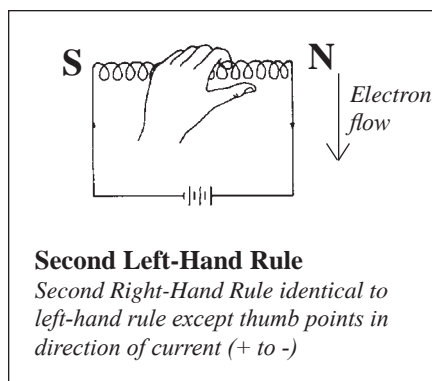
See Worksheet #1.

Connect to low-voltage DC power source.

Diagram 1

Spin armature with string to induce current.

Galvanometer

Pull String

Diagram 2

3. Forces of Magnetic Field Interactions

1. Between Permanent and Electromagnetic Fields

With two-pole armature in place and knowing the direction of the current, you can apply either second left-hand or right-hand rule to determine the magnetic polarity of armature electromagnet. You can then predict how the magnetic forces of attraction and repulsion will cause the armature to rotate. With the split ring commutator, the polarity of the current applied to the coils is reversed as the armature spins, causing a reversal in the field produced.

These rules apply to determine the magnetic polarity of an electromagnet:

Second Left-Hand Rule
Second Right-Hand Rule identical to left-hand rule except thumb points in direction of current (+ to -)

2. Between two electromagnetic fields {with Electromagnetic Attachment 80-0105}

Similar to example above, with use of the left-hand/right-hand rule on both electromagnet and coils on the armature.

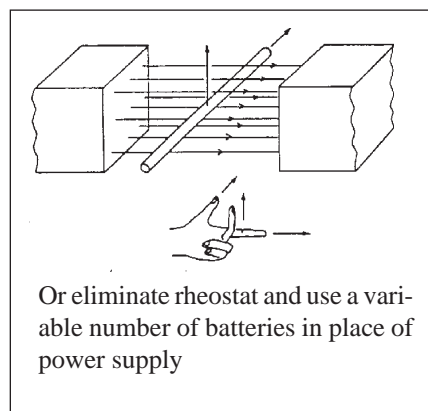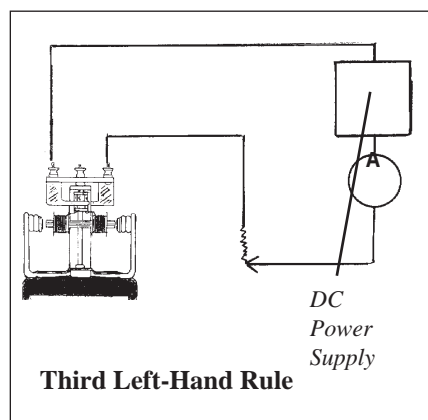## 4. Force on a Current Carrying Wire: $F = B\,I\,l$

Where F = force in dynes, B = magnetic field intensity in gauss, I = current flowing through wire, l = length of wire in magnetic field. Force on wire is perpendicular to magnetic field.

1. With current variable in the wire.

By changing the current in the armature coils, you can demonstrate that the force on a current carrying wire is proportional to the current passing through that wire. As the current is increased in the armature coils, a greater force causes the armature to spin faster. The current in the coils can be changed by changing the applied potential (1,2,3,4 dry cells in series) or by connecting the potential source to a rheostat. (**615-4065** Battery Kit recommended.)
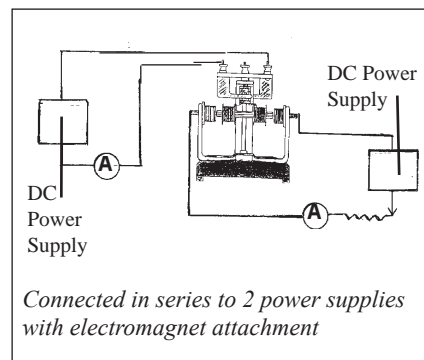
The direction of the force on the armature coil and thus the direction of rotation may be determined by applying the third left-hand/right-hand rule before the current is actually passed through the coils. One could test this prediction by actually applying the current to the coils.

Third Left-Hand Rule

Or eliminate rheostat and use a variable number of batteries in place of power supply

2. With a variable magnetic field about the wire

Requires 80-0105 Electromagnet Attachment

While maintaining a constant current through the armature coils, the effects of how a varied magnetic field strength will alter the force experienced by a current carrying conductor. Again, the current may be varied by changing the number of dry cells applied in **series** to the **electromagnet attachment,** or by using a constant power supply connected in series with a rheostat and the electromagnet attachment. The difference in the force applied may be seen by the speed of the armature's rotation.

Connected in series to 2 power supplies with electromagnet attachment

3. Analysis of force applied to a current carrying conductor in the presence of a magnetic field.

To make more quantitative measurements of the changes in the force on the armature coils of the motor, attach a string to the armature axle that runs over a pulley to a mass. (**611-1045 Pulley** recommended) Time how long it takes the motor to raise the mass a fixed distance.

(You would actually be determining the power generated by the motor, which is directly proportional to the force it exerts.)

$$P = W/t = Fs/t$$

Therefore, the shorter the time to raise the same mass a fixed distance, the greater the force the current carrying wire experiences due to the presence of a magnetic field.

Attach string to armature, pulley & mass
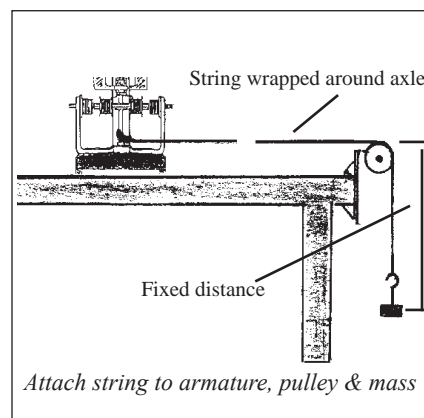
For Shunt Motor You Need:
• **6 clip leads**
• **electromagnet attachment.**
Attach one positive (+) end of battery to both front terminals & one brush. Attach negative end (-) of battery to both rear terminals (of electromagnetic attachment); other brush.

5. Electromagnetic Induction in a Conductor

A. Direction of induced current as conductor moves through magnetic field.

1. This can be predicted again by applying the *third left-hand/right-hand rule* to find the direction of the force on electrons in the conductor.
2. Can be demonstrated by connecting the motor, now acting as a generator, in series with a galvanometer. Determine polarity of induced current by spinning the coils in each direction.
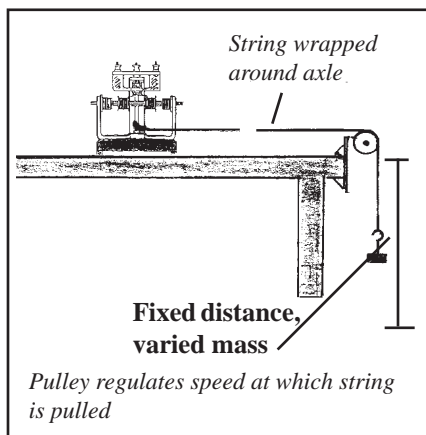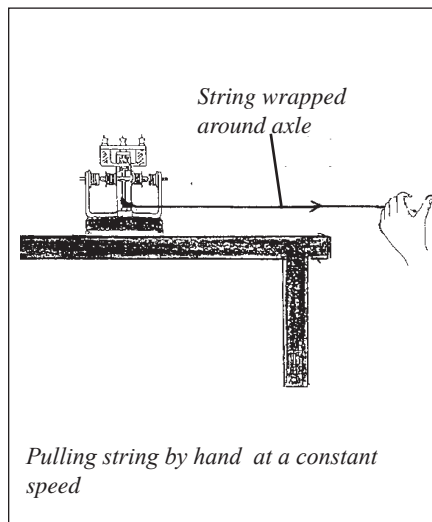
B. The magnitude of the current in conductor is proportional to the velocity at which conductor moves through magnetic field.

Can be demonstrated by connecting the motor, acting as a generator, in series with a galvanometer and winding a string around the armature axle.

1. Pulling the string by hand at a constant rate for several trials with different rates will show an induced current on the galvanometer proportional to the rate at which the string is pulled.
2. Utilize the pulley to regulate the various rates by placing different amounts of weight at the end of the string which will apply a regulated and constant amount of pulling force on the axle to keep the turning velocity of the coils constant.

$$F = qvB = B I l$$

{Velocity is directly proportional to current induced in conductor}

String wrapped around axle

Fixed distance, varied mass
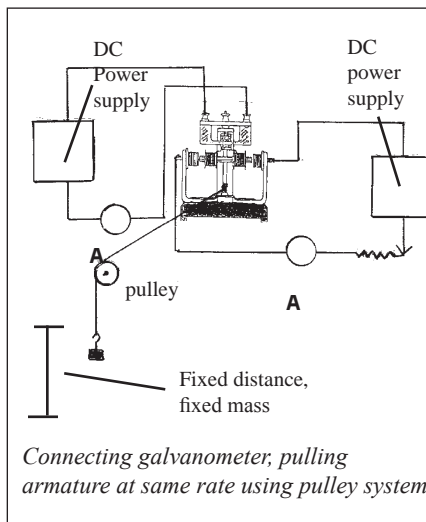
Pulley regulates speed at which string is pulled

C. The magnitude of the current induced in the conductor is proportional to the intensity of the magnetic field that conductor is moving through.

(Requires accessory electromagnet)

Vary strength of magnetic field by:

1. Connecting a **rheostat** in series with a power supply to the accessory electromagnet. By changing the current to the electromagnet, the magnetic field intensity will also be varied proportional to that current.
2. Connecting different numbers of **batteries** (1,2,3,4) in series to the accessory electromagnet, thus varying the current to and the magnetic field intensity produced at the electromagnet. (**615-4065 Battery Kit** recommended.)

The effect of the magnetic field strength on the induced current may them be observed by connecting a galvanometer in series with the generator. In each case of varied magnetic field strength, the armature coils must be turned at the same rate for each trial. This may be more easily achieved by using the pulley system with the same mass for each trial. *See Worksheet 3.*
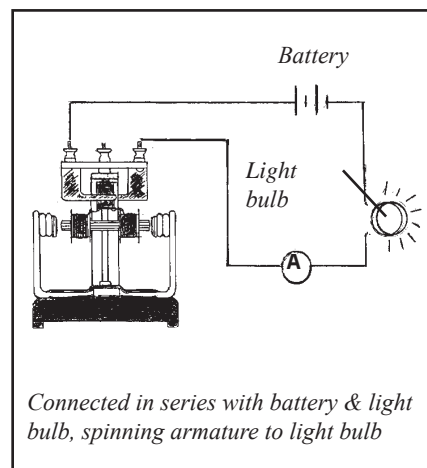
Variations include:

1. Replacing accessory electromagnet, power supply and rheostat with a varied number of batteries.
2. Pulling the string out from the armature axle by hand each trial at a constant rate in place of the pulley system.

6. Induced Electromotive Force on Existing Current

A current induced by the motor, acting as a generator, can have different effects on an existing current depending upon the direction of the current induced by the generator.

This can be demonstrated by connecting the motor in series with battery and small light bulb. When the circuit is completed, bulb will light. By spinning the armature in either direction, the effects of the induced current can be seen by the brightness of the light. If the induced current opposes the direction of current supplied by the battery, the light dims.

If the induced current is in the same direction as the battery's current, the bulb should get brighter. An ammeter connected in series with the circuit will also provide data on the effects of the induced current. *(Note: When using this Motor as a generator, you cannot generate enough current to light a bulb. It can only generate approximately 1 mA.)*

String wrapped around axle

Pulling string by hand at a constant speed

DC Power supply

DC power supply

A

pulley

A

Fixed distance, fixed mass

Connecting galvanometer, pulling armature at same rate using pulley system

Battery

Light bulb

A

Connected in series with battery & light bulb, spinning armature to light bulb

Worksheet #1: *Generators and Motors*

Materials:
- St. Louis Motor
- Galvanometer
- String
- 2 Bar magnets
- Connecting Wires

Name: _____

Hour: _____

Date: _____

Generators use _____ energy to make electricity. Two basic parts of the generator include a coil and a magnetic

field. The coil spins through the magnetic field. When the coil breaks the lines of force, the electrons in the wire are "pushed."

In this lab, you will study the parts of a generator and observe the effects of the magnetic fields.

Procedure:

1. Assemble a generator by placing a bar magnet into the holders on each side of the wire coil. <u>Make sure that the poles are opposite</u>.

2. Hook a galvanometer to the terminals of the generator. Does the needle move? If it does not, check your hookups again. If this does not work call for the teacher.
How much current is produced by spinning the generator by hand? _____

3. Spin the generator in the opposite direction. How much current is made this time?_____

   Does the needle move in the same direction?_____

4. Now reverse the poles of the magnets and repeat Steps 2 and 3. Describe what happens by reversing the magnetic poles.
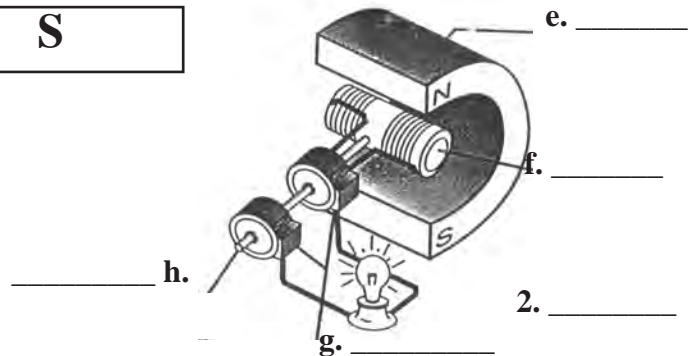   _____

5. Now rearrange the magnets so both NORTH poles are facing the coil. Spin the coil Does this produce any current? Why not? _____

Diagram:
Below you see the poles of two magnets. Draw in the lines of force and be sure to indicate the proper direction.

N		S

Label the parts of the following diagram:

e. _____

f. _____

_____ h.

2. _____

g. _____

Conclusions:

1. When a wire loop of a _____ turns, an electric current is produced.

2. The current produced by a generator is _____ current.

3. Opposite _____ of a magnet must be used to produce a current in the coil.

4. Name 3 ways we can spin the coil without using our finger (ex. Power Stations)
   a.
   b.
   c.

Worksheet #2: *Electric Motor with Bar Magnets*

Materials:
- **St. Louis Motor**
- **Galvanometer**
- **String**
- **2 bar magnets**
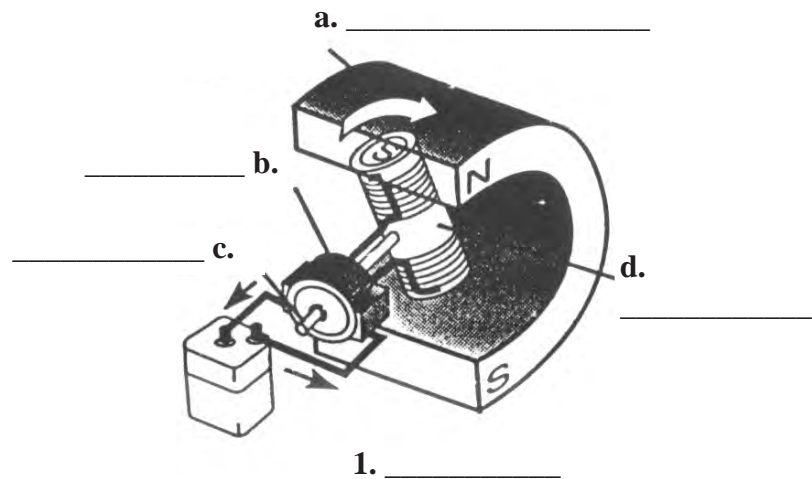- **Connecting Wires**

Name: _____

Hour: _____

Date: _____

     An electric motor converts ELECTRIC energy into KINETIC energy. The idea is that a coil will turn into a magnet when a current is supplied. The magnetic field will repel (or distort) when put into the middle of the bar magnets.

1. Place two magnets into the holders (opposite poles.)

2. Hook the motor up to the dC power supply by connecting to the top knobs. Give the coil a push to get started.

    a.   What direction does the coil spin? **Clockwise/ Counterclockwise**

    b.   Reverse the wire hookups. What direction does the coil spin now?_____

3. Turn up the voltage of the power supply. Describe what you observe. _____
_____

4. Label the parts if the diagram below.

a. _____

_____ **b.**

_____ **c.**

d.
_____

1. _____

5. A motor (uses, creates) an electric current as it turns.

Worksheet #3: *Electric Motor with Electromagnets*

Materials:
- **St. Louis Motor**
- **Galvanometer**
- **String**
- **2 bar magnets**
- **Connecting Wires**

Name: _____

Hour: _____

Date: _____

A motor can turn ELECTRIC energy into KINETIC energy. The electric energy can turn the coil into a magnet. The bar magnets are replaced by an **electromagnet.** The motor coil creates one field which will repel (or distort) the field formed by second electric coil (electromagnet.) This repulsion will cause the motion (spinning.)

1. Hook up the electromagnet to the power supply.

2. Hook up the motor to a second power supply. What direction is the coil spinning? **clockwise/counterclockwise**

   a. Reverse the wires hooked to the <u>electromagnet.</u> What direction does the coil spin now?

      Clockwise/counterclockwise

   b. Now reverse the wires attached to the motor. What direction does the motor spin now?

      Clockwise/counterclockwise

   c. What happens as you increase current?

3. Label the diagram of a motor below.
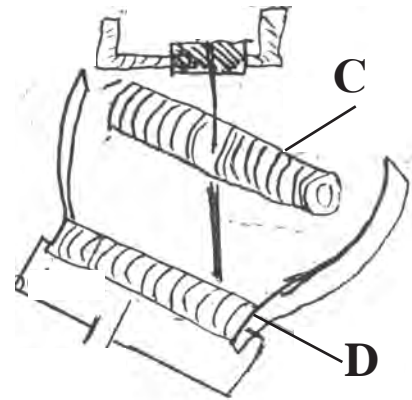
4. Copy the diagram of repelling magnetic fields below.
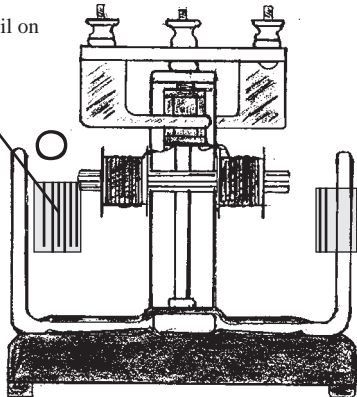
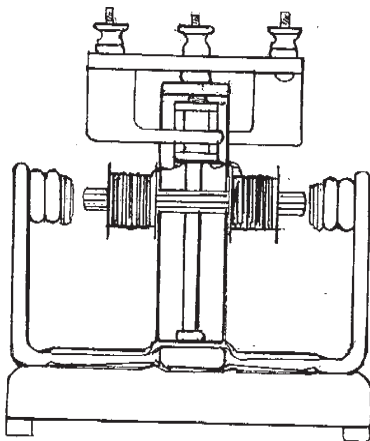**Superimposed Magnetic Fields**
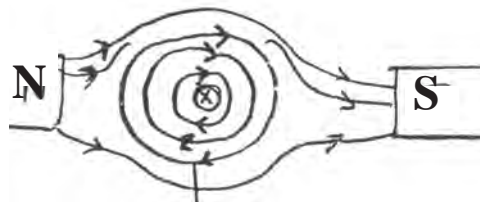
Coil is forced downwards.

A magnetic field around a wire.
x = wire

With electromagnet attachment

80-0105: coil on bracket

With permanent magnets

How To Teach With St. Louis Motor

Concepts Taught: Electromagnetic fields; field magnet, armature; commutator, DC and AC; interactions in electromagnetic fields; electromagnetic induction; relation to magnetic field and speed of conductor; variable current vs. variable magnetic field. Energy conversion; electrical to mechanical and vice versa. Motor vs. generator effects.

Curriculum Fit: PS/Electricity and Magnetism (Unit: Moving Charge & Magnets.) Grades 9-10. PS/Energy (Unit: Energy Transformations). Grades 9-10.

Lab Activities for 9th grade Physical Science courtesy of Cris Knispel, Gallup, NM

Accessories for these experiments:

611-1045 Table Top Pulley -
Clamps to any surface up to 2" wide, rotates a full 360 degrees. Low coefficient of friction.

615-4065 Battery Kit -
Build a power supply from 0 to 6 volts, four clip leads and instructions provided.

80-0105 Field Coil Pair
Consists of two field coils mounted on brackets that fit into clip of **St. Louis Motor,** allow St. Louis to be run as series and shunt motor.
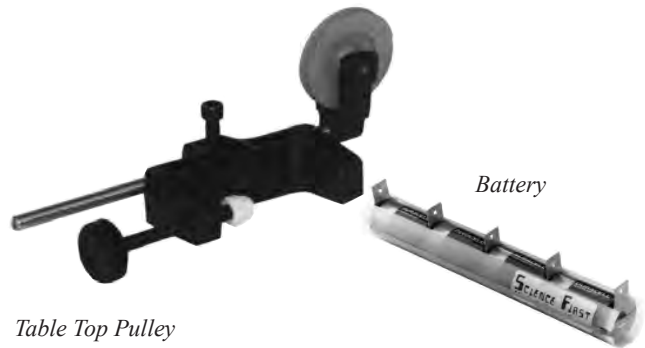
Battery

Table Top Pulley

Related Products:
615-4705 Motor Generator - Similar to St. Louis Motor in design. Able to work as magneto; universal motor; series and shunt generator. Good for technical training.
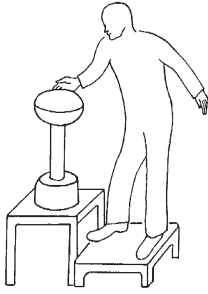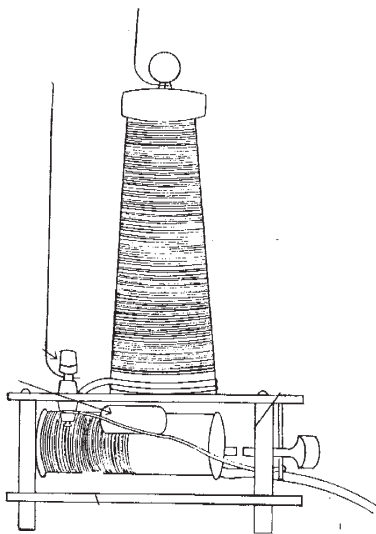
Motor Generator

10-060 Small Van de Graaf - Raise hair instantly - no shock hazard. Astound your friends with 5" sparks. Neoprene belt, spare included. Plastic molded base & housing, 18cm globe, PVC column, ground terminal, 16-page instructions. 200.000 v potentials in humidities to 90%.**Wt: 5 lbs** *Box:7x7 x24"*

**10-085 400,000 volt potential Van de Graaf - Wow!**

10-205 Tesla Coil - Transmit electricity without wires. Watch light bulbs glow in your hand. Hard-to-find source of **high frequency high voltage electricity!** Safe because current flows over, not into your skin. Arcs to 3". 50,000 v potential. *Includes*: vibrator; 2 capacitors; cord & plug; primary & secondary; adjustable spark gap; safety guard. **Accessories** include: lamp socket; 2 sizes antenna plates; neon bulb; discharge electrode; plastic & copper wires; instructions with 19 experiments. Fully assembled. 110v 60 cycle AC.

<u>**10-206**</u> Tesla Coil: 220 volt

10-135 Motor Kit - All you need to construct a working DC motor. *Includes* 2 copper coils; brushes; fasteners; plastic base and snap-in brackets; armature core; field pole; battery clips, assembly instructions with experiments. *Needs 'AA' battery.*

Also in cost-saving bulk packs!
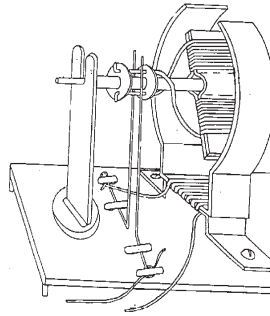
10-140 Primary Secondary Coil Study electromagnetic induction, transformer effects and workings of an induction coil. *Includes:* two coils: with binding posts, plastic mounts. Square bobbin on secondary so apparatus stands upright. With soft iron core, instructions. No magnetic parts touch coil to drain your field. *You need voltmeter.* **Wt: 5 oz.**

10-045 Electroscope - Show how two similarly charged objects repel. 10 cm square glass view area. *Includes* 2 pair die-cut leaves, brass hanger, glass panels, ball terminal, insulator, instructions. *10-050 Assembly fits Ehrlenmeyer flasks.*
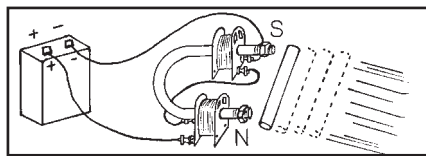
10-110 Electromagnet Kit - Everything you need to build a powerful electromagnet. *Includes:* 2 coils with binding posts; round iron core; square iron core; 2 half-round iron cores; U-shaped double core; plastic card; 4 clip leads; iron filings in reusable jar.

Instructions included labs.

10-100 Motor Generator - Experiment with AC/DC operation. Build a magneto; universal motor; series and shunt generator. *Includes:* 2-pole armature; field coil pair; permanent magnet pair ; 4 brushes; separated commutator and slip rings; instructions. Field coil and permanent magnets on interchangeable brackets. *Wt: 11 oz.* *Similar to St. Louis in design*
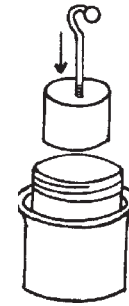
10-125 Leyden Jar - Charge it, dissect it - holds a charge for hours. Prove that a charge is stored in insulator, not in metal. *Includes:* Two aluminum cans (473 ml capacity) , polystyrene dielectric jar, electrode with ball terminal, instructions with lab activities. **Wt: 9 oz.** *Box: 7 x5x 4.75*

***Hint: Use Van de Graaf generator** as your source of static electricity.*

20-030 Compact Electromagnet - Weighs 2 pounds, lifts 200 due to precision machining. Works the same way large magnets lift cars in junkyards. Instructions, alligator clip leads and battery holder. *Need 1 1/2 v 'D' cell battery.* **Wt: .8 kg.**
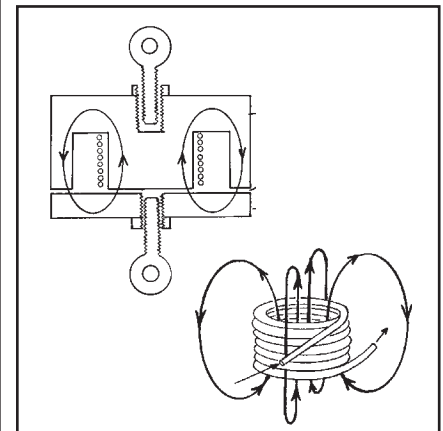
20-035 Large Lifting Magnet - Same as 20-030 but lifts *500 to 700* pounds.