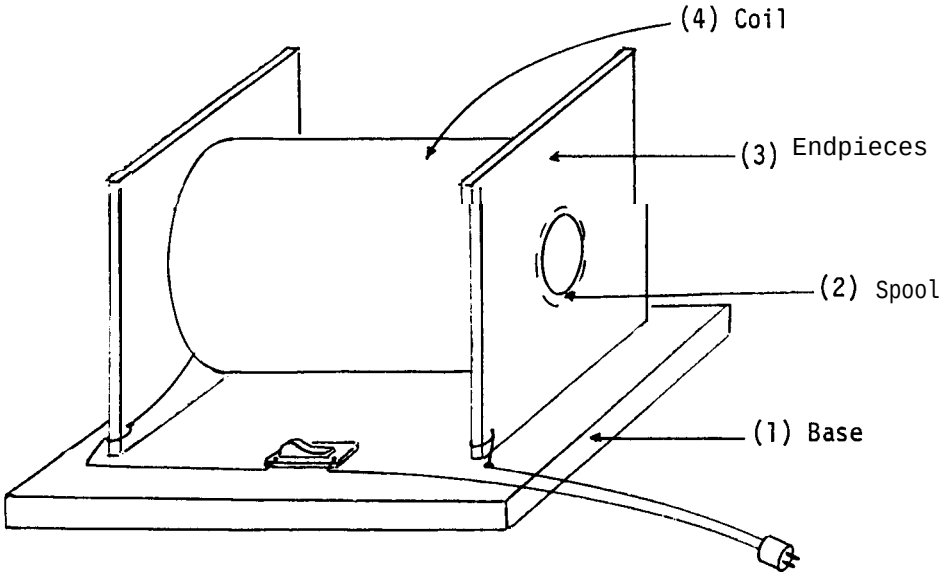
IX. ELECTROMAGNETISM APPARATUS

A. ELECTROMAGNETISM APPARATUS

The apparatus in this group is primarily concerned with the creation of magnetic fields in various forms.

A. ELECTROMAGNETISM APPARATUS

A1, Magnetizing Coil and Magnets ©



a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Base	1	Wood (A)	15 cm x 15 cm x 2 cm
(2) Spool	1	Wooden Dowel (B)	3 cm diameter, 8 cm long
(3) Endpieces	2	Wooden Strips (C)	8 cm x 8 cm x 0.5 cm
(4) Coil	1	Roll of Magnet Wire (D)	#22, 1 kg
	1	Switch (E)	220 volts
	1	Double Electrical Cord (F)	#20, 200 cm long
	1	Two Pin Plug	220 volts
	1	Insulating Tape (H)	--

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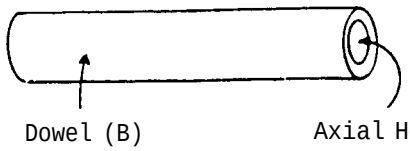
b. Construction

(1) Base

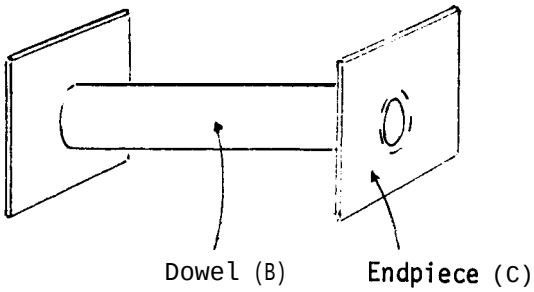
Use wood (A) as the base.

(2) Spool



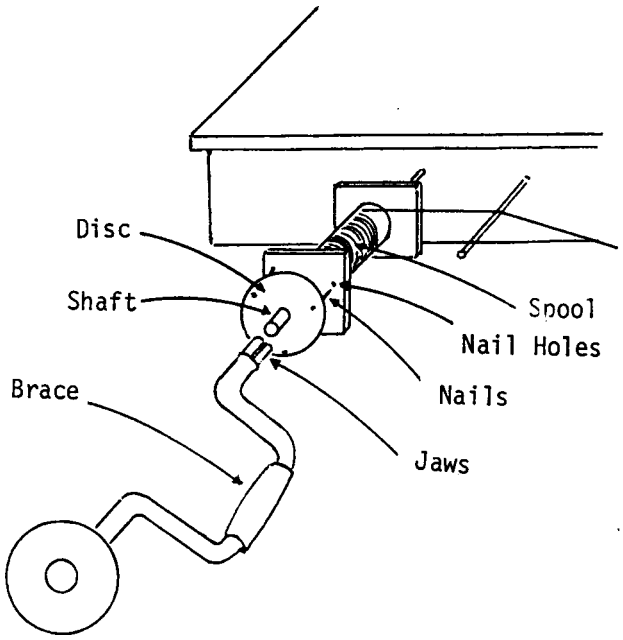
Drill a hole (2 cm diameter) along the axis of the wooden dowel (B) to make an appropriate spool.

(3) Endpieces



Drill a hole (2 cm diameter) in the middle of each wood strip (C) and attach the strips to either end of the spool with wood cement.

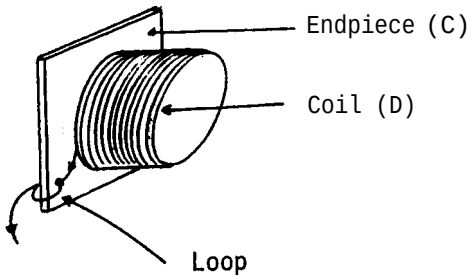
(4) Coil



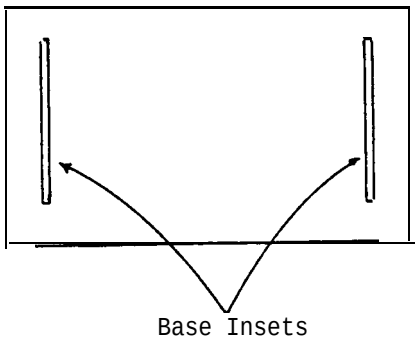
Wind all of magnet wire (D) on to the spool taking care to leave about 25 cm of free wire at either end of the coil for appropriate connections. The winding of the coil may be facilitated by the use of a brace as follows.

Hammer two large nails (15 cm long) into the side of a bench so that they protrude horizontally some 50 cm apart. Place the spool to be wound on one of the nails. Fasten the first turn of magnet wire around the spool in such a way that it will not slip on turning the spool. Then get your partner to hold the wire taut over the second nail so that it may be wound under tension.

Attach a short shaft (2 cm long, 1 cm diameter) to the center of a circular disc (7 cm diameter, 0.5 cm thick) by means of a screw. Hamner three nails through the perimeter of the disc and drill three corresponding holes in the endpiece of the spool to take the protruding nails. Clamp the jaws of the brace firmly on to the shaft. Lock the disc and spool together by means of the disc nails, and then begin to wind the coil by turning the brace.

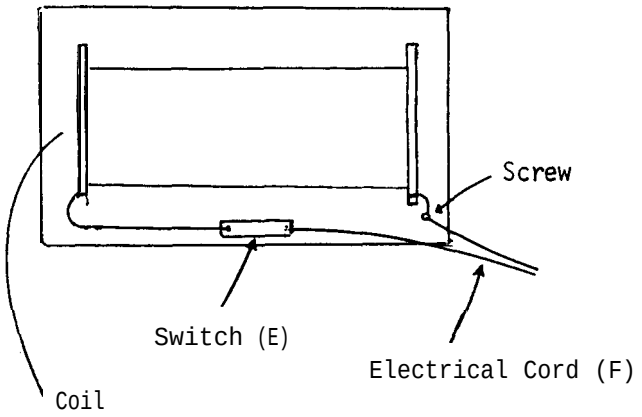


Drill a small hole in each endpiece and loop the wire ends through these holes to prevent unwinding of the coil.



Make two insets (8 cm long, 0.5 cm wide, 0.2 cm deep) in appropriate positions on the base to hold the endpieces. Fix the endpieces firmly in the insets with wood cement.

Attach switch (E) to the base, and connect one of the loose wires from the coil to the switch. Insert a screw into the base as indicated, and attach the other wire from the coil.to the newly inserted screw. Take



the double electrical cord (F) with two pin plug (G) attached, and connect one wire to the screw, and the other wire to the switch.

Since the coil and wires will carry a high voltage (220 volts), it is important that all wiring should be covered with insulating tape (H). Cover the coil, the wire and the screw with the tape.

C. Notes

(i) To magnetize an item, place a suitable steel specimen in the center of the coil. Switch the current quickly on and off. The specimen will be magnetized on removal from the coil.

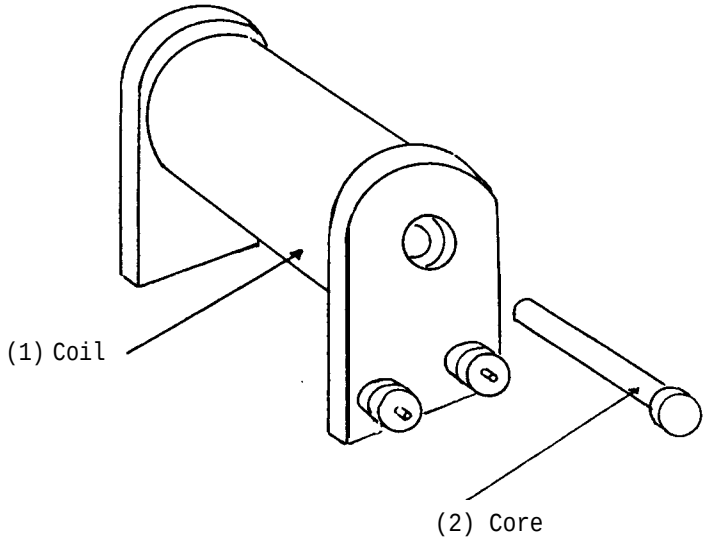
Ticonal is an ideal alloy for making magnets, but is rarely available on local markets. High quality tool steel is a good second best, and is generally found in good quality tools (chisels, screwdrivers, drill bits, etc.), as well as domestic items such as razor blades and sewing needles.

Unfortunately, the "high grade steel' sold on many local markets tends to to be of poor quality, and does not retain magnetism well. However, if the steel is heated to red heat in any oxy-actylene flame, and then quenched in cold water, it tends to be hardened, and hold magnetism somewhat better. (It should be noted that "steel rods" used in construction work for reinforcing concrete are made of soft iron, and cannot be permanently magnetized.

This magnetizing coil is designed for use with a 220 volt mains supply, and is capable of producing extremely strong magnets, It would also work with a 110 volt supply, but the magnetism induced in a given specimen would be weaker than with a 220 volt supply. The magnetizing coil should never be switched on and left on, as it would overheat and burn out. It is designed for usage over very short periods of time (2 or 3 seconds only).

To demagnetize a specimen, place the magnet inside the coil and hold its end very firmly. Switch on the current, and remove the specimen from the coil maintaining a firm grip on it. The current is not switched off until the specimen is completely out of the coil.

A2. Multipurpose Coil with Cores



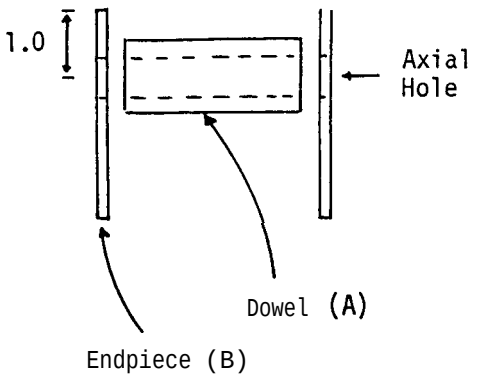
a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Coil	1	Dowel (A)	1.2 cm diameter, 3 cm long
	2	Wood Strips (B)	3 cm x 2 cm x 0.5 cm
	1	Roll of Magnet Wire (C)	#22
	1	Masking Tape (D)	--
	2	Brass Bolts (E)	0.3 cm diameter, 1.5 cm long
	4	Nuts (F)	0.3 cm internal diameter
(2)Core	1	Bolt (G)	0.4 cm diameter, 4.5 cm long
	1	Soft Iron Plate (H)	3 cm x 2 cm x 0.3 cm

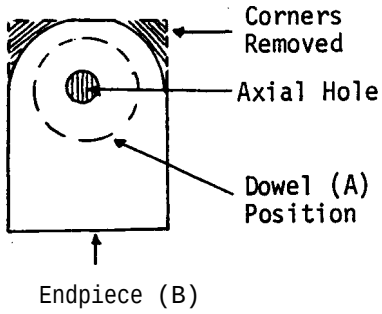
b, Construction

(1) Coil

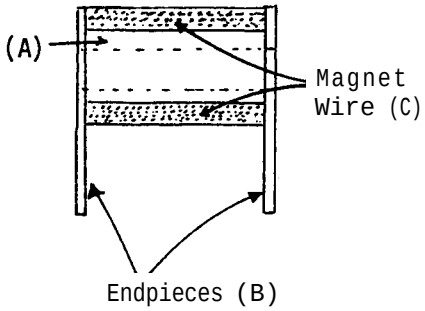
The size of the coil is not critical, but it does affect the spacing and size of components used on the Magnetic Field Apparatus (IX/A4) and Moving Coil Galvanometer (X/C2).



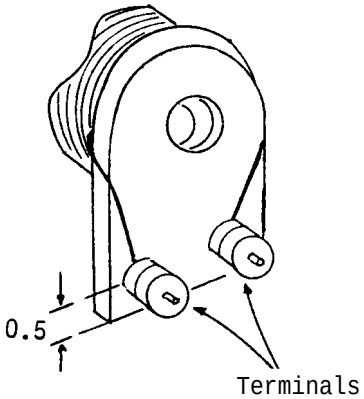
Drill a hole (0.6 cm diameter) along the axis of the dowel (A).



Drill similar holes in the two wood strips (B), at a distance of 1.0 cm from the ends, so that when the strips are attached to either end of the wooden dowel (A) they serve as endpieces with a common axial hole. cut off the top corners of the end-pieces, and smooth them down with sandpaper.



Wind ten layers of magnet wire (C) on to the dowel, leaving about 10 cm of wire free at either end of the coil. Cover the final layer of wire with masking tape (D) to hold the coil in position.

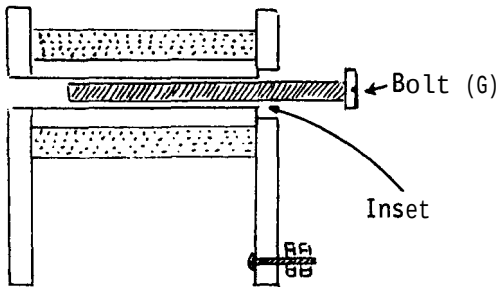


Use bolts (E) and nuts (F) to make two terminals as described under VIII/A2, Component (4), and attach them to one endpiece as indicated.

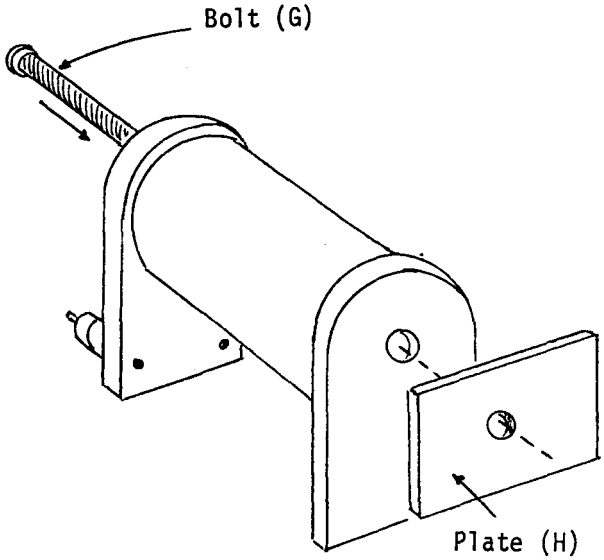
Clean the ends of the two wires from the coil, and fasten them under the locking nuts of the respective terminals. Make sure that it is possible to see the

way in which the wire from each terminal begins to wind around the coil, for this makes it possible to determine the direction of the current around the coil, and hence the direction of the magnetic field produced.

(2) Core



Drill an inset (0.4 cm deep, 1.0 cm diameter) over the hole in the endpiece which contains the terminals. Insert bolt (G) in that the bolthead sits snugly in the inset.

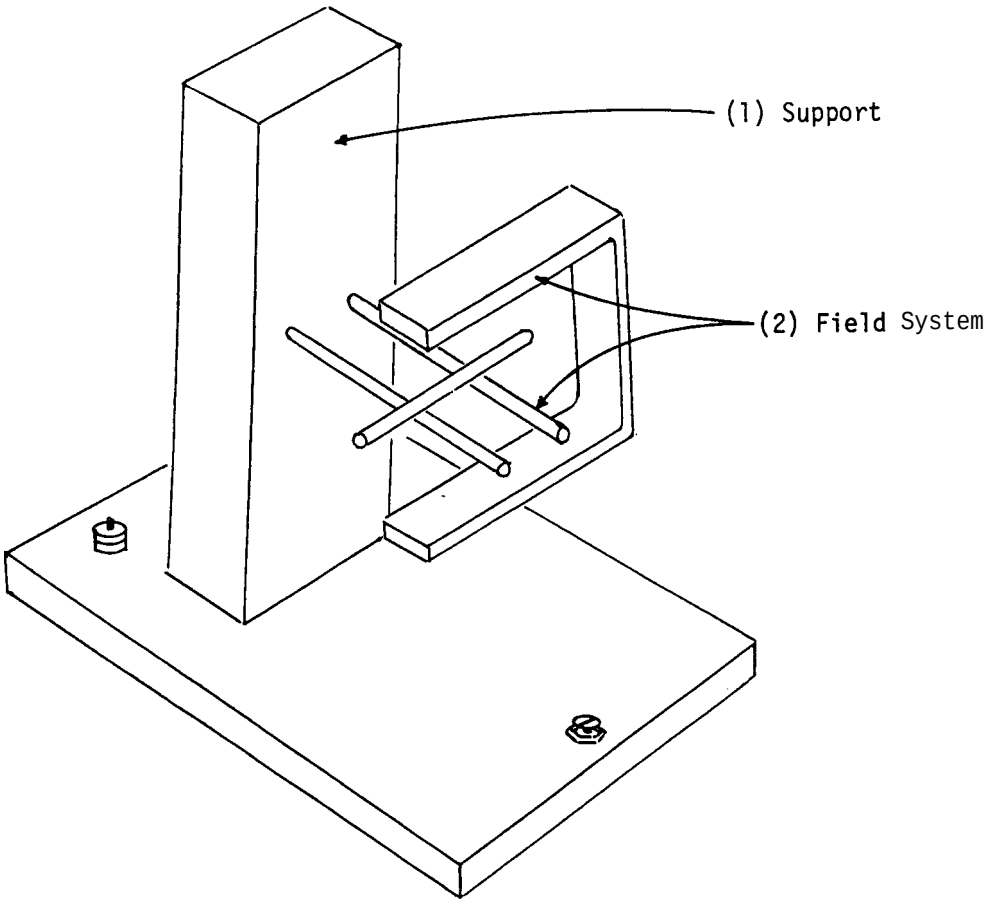


Drill a hole (0.4 cm diameter) through the center of the iron plate (H). Make a thread (0.4 cm diameter) in the hole, and attach the iron plate to the bolt (G) by means of the threaded hole.

C.Notes

(i) The multipurpose coil may be used in a wide range of experiments to produce magnetic fields. It may also be used in instruments [e.g., the Magnetic Field Apparatus (IX/A4) and the Moving Coil Galvanometer (X/C2)] where a fixed magnetic field is required.

A3. Magnetic Field Apparatus ©



a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Support	1	Wood (A)	10 cm x 7 cm x 1 cm
	1	Wood (B)	10 cm x 4 cm x 2 cm
	2	Wood Screws (C)	2 cm long
	2	Brass Bolts (D)	0.3 cm diameter, 2 cm long
	4	Nuts (E)	0.3 cm internal diameter
	1	Bolt (F)	0.2 cm diameter, 2 cm long
	1	Nut (G)	0.2 cm internal diameter
	2	Thumbtacks (H)	--

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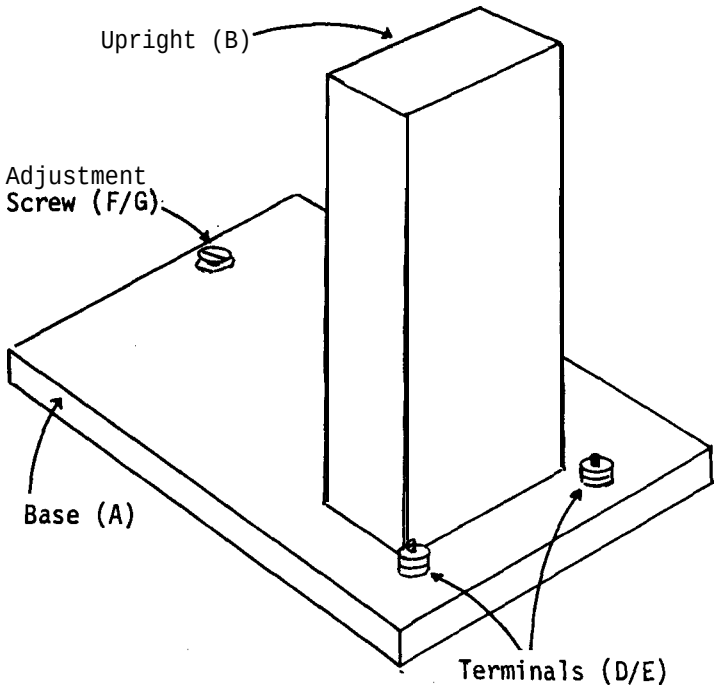
(2) Field System	2	Brass Rods (I)	0.4 cm diameter, 5 cm long
	2	Nuts (J)	0.3 cm internal diameter
	2	Magnet Wires (K)	#22, 8 cm long
	1	Aluminum Rod (L)	0.3 cm diameter, 4 cm long
	1	Horseshoe Magnet (M)	--

b. Construction

(1) Support

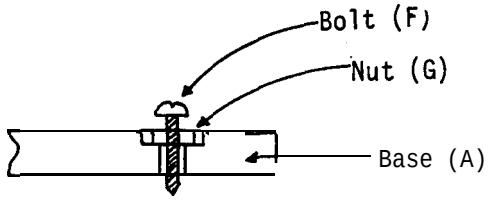
Use wood (A) as the base.



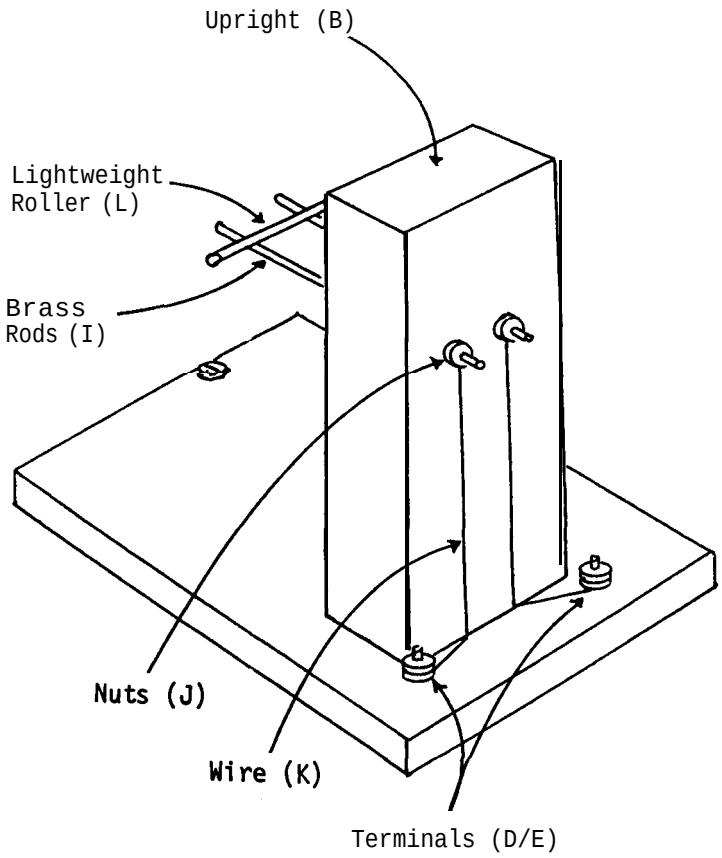
Attach wood (B) vertically to the base with two wood screws (C) passed through the base (4 cm from one end). Use wood cement to insure a firm joint between the upright and base.

Use the bolts (D) and nuts (E) to make two terminals, as described under VIII/A2, Component (4), and attach these to the base (A) just behind the upright (B).

Drill a hole (0.3 cm diameter) through the base to take bolt (F). Inset nut (G) over the hole by striking it into position with a hammer Thread the bolt through the nut thus producing an adjustment screw for levelling the base. At opposite corners on the other side of the base, insert two thumbtacks (H) beneath the base, so that the latter sits on three points, the adjustment screw and two thumbtacks.



(2) Field System



Drill two horizontal holes (0.4 cm diameter) through the upright (B). It is important that the two holes should be at exactly the same height (6 cm) above the base, and that they should be perfectly horizontal.

Take the two brass rods (I), and thread the end of each (thread diameter 0.3 cm). Pass the rods through the newly drilled holes, and use epoxy resin to hold them firmly in position. (Avoid getting the resin on the protruding rod since it is an insulator). Attach nuts (J) to the rod ends, and connect the rods and terminals to one another with magnet wire (K).

Place rod (L) across the horizontal brass rods to serve as a lightweight roller.

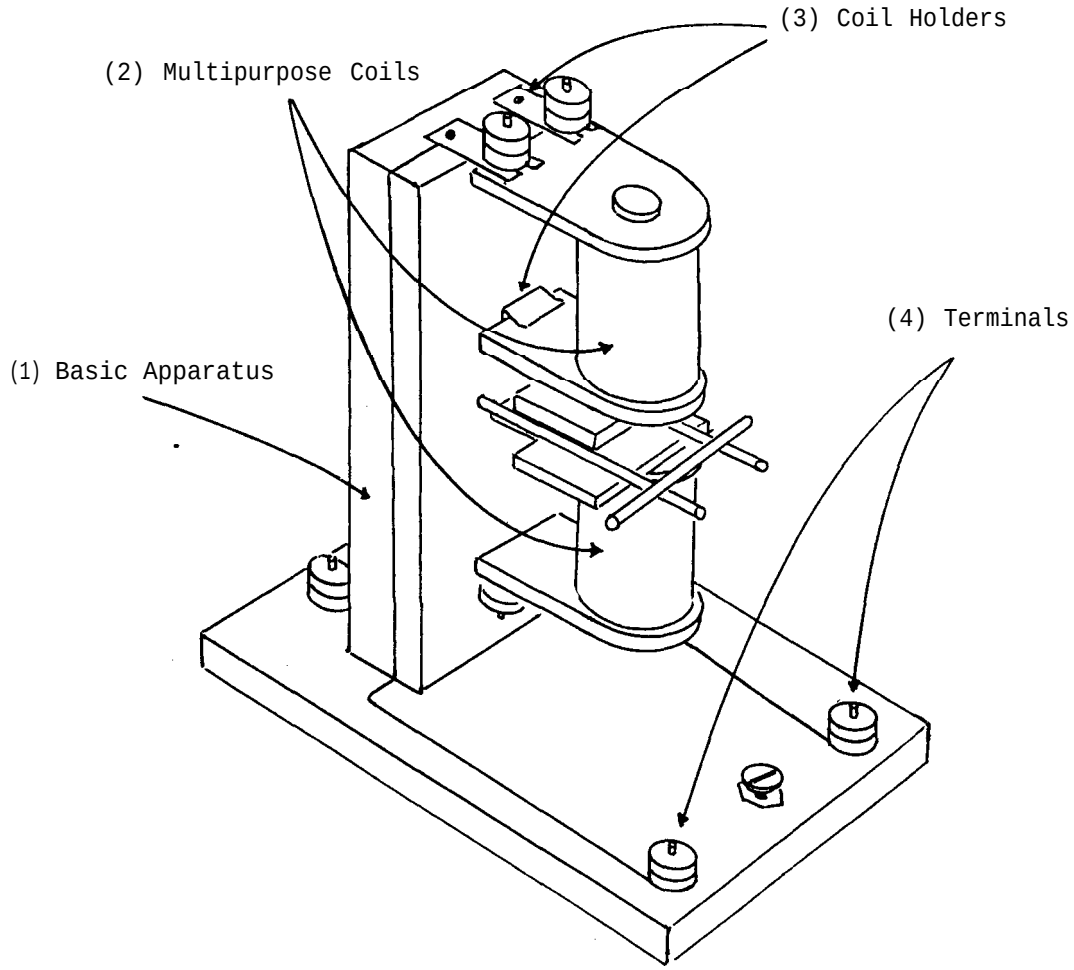
Purchase a strong horseshoe magnet (M) from a local shop. It may be held in position by hand, thus creating a vertical magnetic field at right angles to the lightweight roller.

c. Notes

(i) If three dry cells (1.5 volts each) are connected across the terminals, a current will pass through the lightweight roller at right angles to the magnetic field, and the roller will be propelled along the horizontal rods. This piece of apparatus may be used for studying the force exerted on a current carrying conductor placed in a magnetic field.

(ii) Should there be any difficulty in obtaining a strong horseshoe magnet, then multipurpose coils may be used to replace the magnet. Such a system is described in the next item (IX/A4).

A4. Magnetic Field Apparatus with Multipurpose Coils @



a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Basic Apparatus	1	Magnetic Field Apparatus (A)	IX/A3, No magnet required
(2) Multipurpose Coils	2	Multipurpose Coils with Cores (B)	IX/A2
(3) Coil Holders	2	Brass Sheets (C)	2 cm x 2 cm x 0.02 cm
	4	Screws (D)	Approximately 0.6 cm long
	4	Brass Sheets (E)	3 cm x 0.8 cm x 0.05 cm

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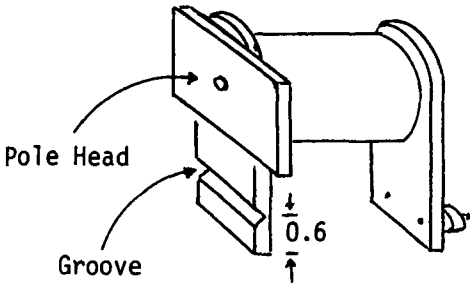
	4	Screws (F)	Approximately 0.6 cm long
(4) Terminals	2	Brass Bolts (G)	0.3 cm diameter, 2 cm long
	4	Nuts (H)	0.3 cm internal diameter
	1	Magnet Wire (I)	#24

b. Construction

(1) Basic Apparatus

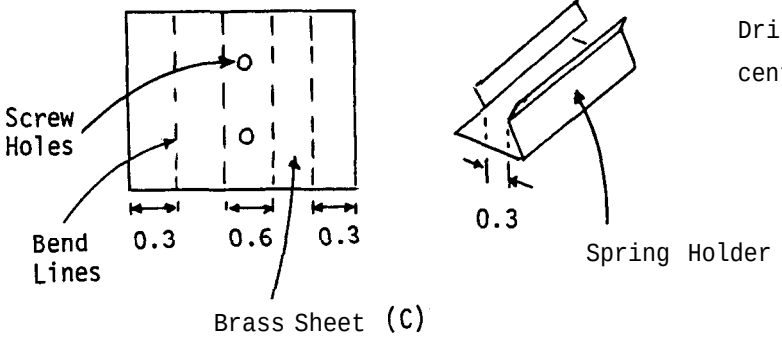
Make the Magnetic Field Apparatus (A) as described under IX/A3. A horseshoe magnet is not required, and the magnetic field is produced by means of the additional components described below.

(2) Multipurpose Coils

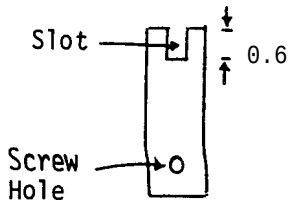


Make two Multipurpose Coils (B), complete with pole heads, as described under IX/A2. Cut a horizontal groove in the front endpiece of each (just beneath the pole heads) to insure a good grip for the coil holders.

(3) Coil Holders

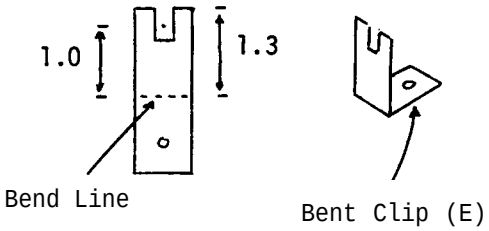


Bend the two brass sheets (C) into spring holders as indicated. Drill two screw holes in the center portion.



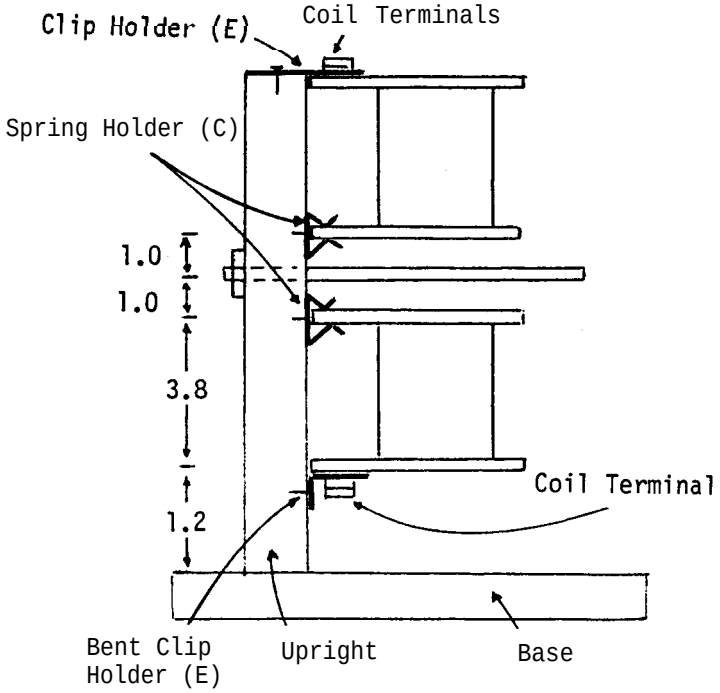
Clip Holder (E)

Cut a slot (0.7 cm x 0.3 cm) in the end of each of the brass sheets (E) and drill a screw hole in the other end, thus producing four clip holders.



Bend two of the holders at right angles to make L-shaped clips as follows.

Measure the distance from the center of the coil terminal to the upright. Let's say this is 1 cm. Then the clips must be bent at right angles at 1.3 cm from the slotted end. Fit the slotted end of each clip holder under the locking nut of a terminal on the lower coil, and use screws (F) to attach the clips to the upright.



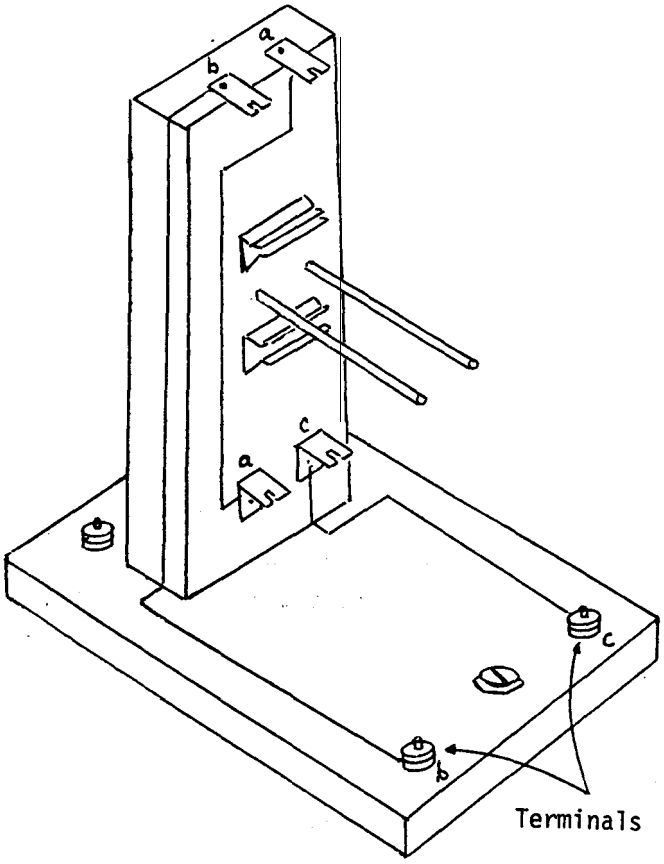
Use screws (D) to attach the spring holders horizontally to the upright of the apparatus, 1 cm above, and 1 cm below, the horizontal rods. Clip the multipurpose coils temporarily in the spring holders, and mark out the positions of the free endpieces of the coils.

Cut the top off the upright, so that it is level with the top of the upper coil. Take two clips, and fasten the slotted end of each under the locking nut of a terminal on the top end of the coil. Then holding the coil close to the upright, attach the

clips to it with small screws (F).

(4) Terminals

Use bolts (G) and nuts (H) to make two terminals, as described under VIII/A2, Component (4). Attach them to the front of the base. Finally connect the terminals and coil holders by magnet wire (I) so that electrical connections exist between points a to a, b to b, and c to c (see diagram), thus insuring that current will flow through the multipurpose coils in the same direction once the terminals at the front of the base are connected into a circuit.



C. Notes

(i) The apparatus may be used to study the relationship between the force exerted on a current carrying conductor and the magnetic field surrounding the conductor. For this purpose a suitable magnetic field may be created by connecting two dry cells (1.5 volts each) and a torch bulb in series with the multipurpose coils. A strong current may be passed through the lightweight roller by momentarily connecting three dry cells in series with the terminals leading to the horizontal rods. Under such conditions the roller will be propelled along the rods.