VII. LABORATORY ACCESSORIES

Where a science room has an electric outlet teachers will wish to take advantage of the mains' supply. The apparatus described here considerably extends the usefulness of the electric outlet.

A. TRANSFORMERS

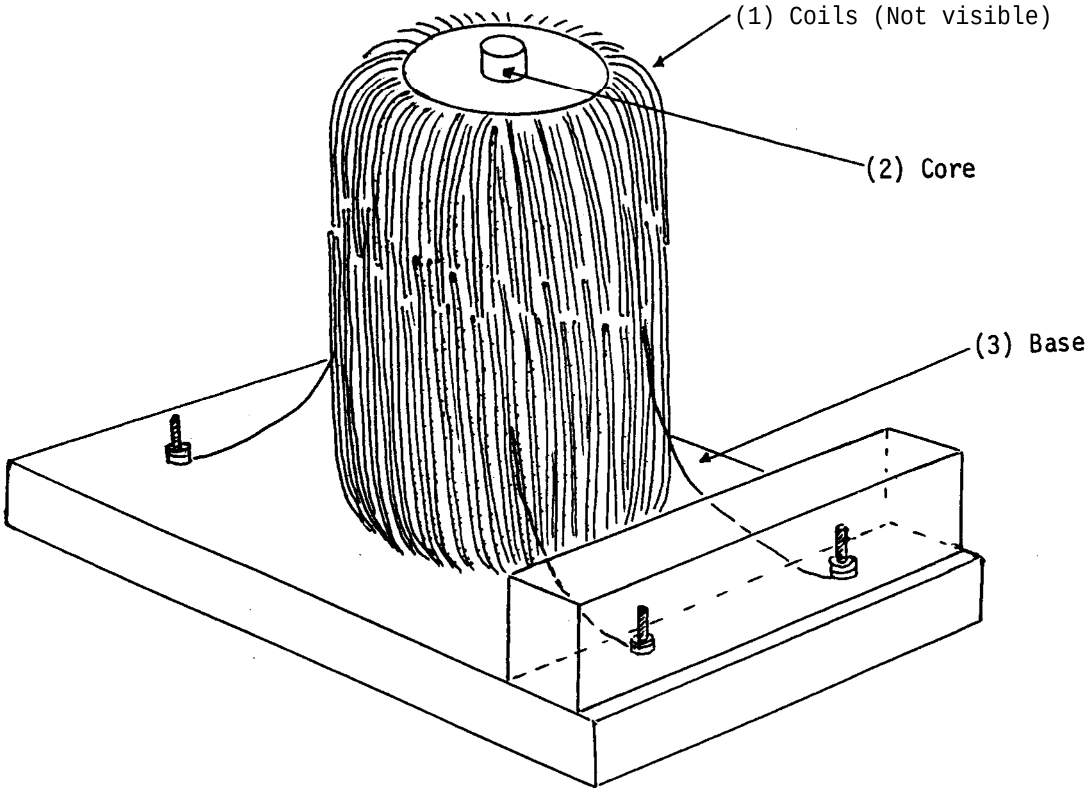
This section describes different types of transformers which may be used to produce low voltage AC outputs. The limitations of each transformer are carefully described in the notes.

B. RECTIFIERS

This section describes rectifiers, which may be used with the foregoing transformers, to produce low voltage DC current.

A. TRANSFORMERS

Al. Transformer, Iron Wire Core (6 volt output, 120 volt mains)



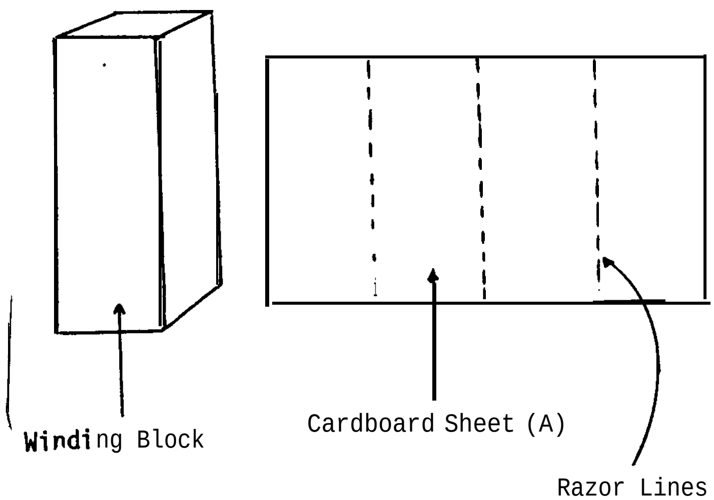
a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Coils	1	Sheet of Cardboard (A)	12 cm x 7.5 cm
	1	Roll of Magnet Wire (B)	#24, 250 g
	1	Roll of Magnet Wire (C)	#20, 60 g
	1	Roll of Masking Tape (D)	--
(2) core	1	Galvanized Wire (E)	#12, 30 meters
	--	Varnish (F)	--
	1	Bolt (G)	0.5 cm diameter, 14 cm long
	1	Nut (H)	0.5 cm internal diameter
	2	Washers (I)	4 cm external diameter
(3) Base	1	Wood (J)	20 cm x 15 cm x 1.5 cm
	1	Wood (K)	15 cm x 3 cm x 2 cm

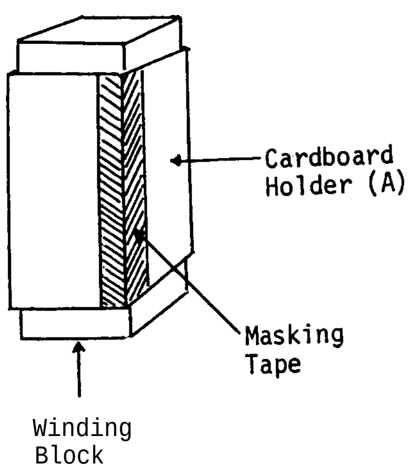
4	Bolts (L)	2.5 cm long, 0.3 cm diameter
8	Nuts (M)	0.3 cm internal diameter
--	Insulation Tape (N)	--

b. Construction

(1) Coils

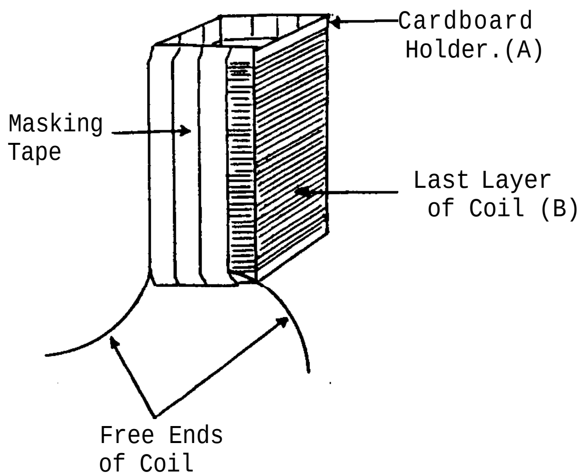


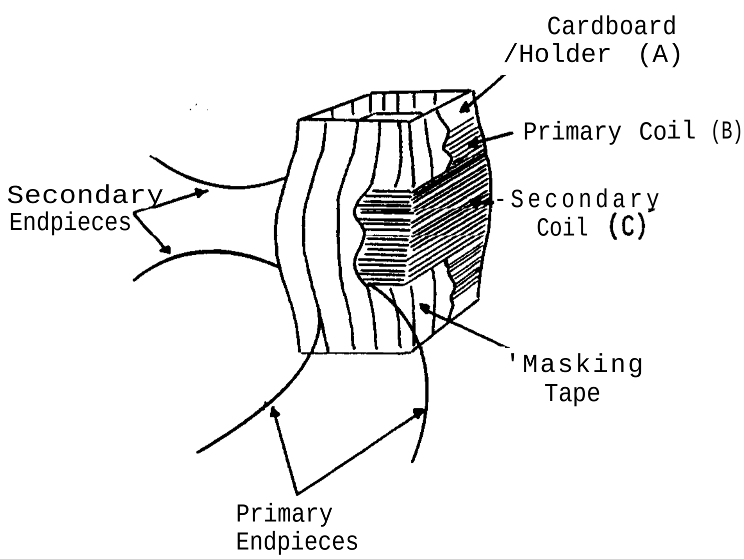
Cut a piece of wood (10 cm x 3 cm x 3 cm) to serve as a winding block for the primary and secondary coils. Take the sheet of cardboard (A) and use a razor blade to score parallel lines on it at 3 cm intervals so that it may readily be bent to the shape of the wooden block.



Wrap the cardboard around the block, fastening the two loose edges together with masking tape (D), thus producing a cardboard holder on which to wind the coils.

Wind 800 turns of #24 magnet wire (B), approximately 250 g, on to the cardboard holder to make the primary coil, leaving about 10 cm of wire free at



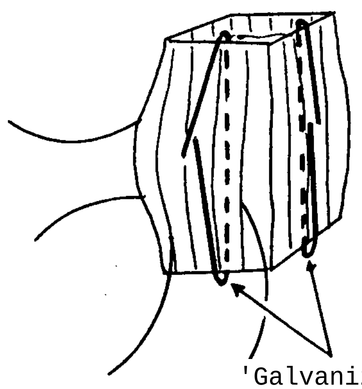


both ends. To do this a system of winding such as that described under IX/A2 should be adopted. (A variation is described in th notes below.) Wind the turns on to only the middle 6 cm or so of the cardboard holder. After winding each additional layer of turns, temporarily remove the cardboard holder (and turns) from the winding block, and cover the turns with masking tape. This not only holds the new layer of turns in position, but also insulates it from the next layer to be added.

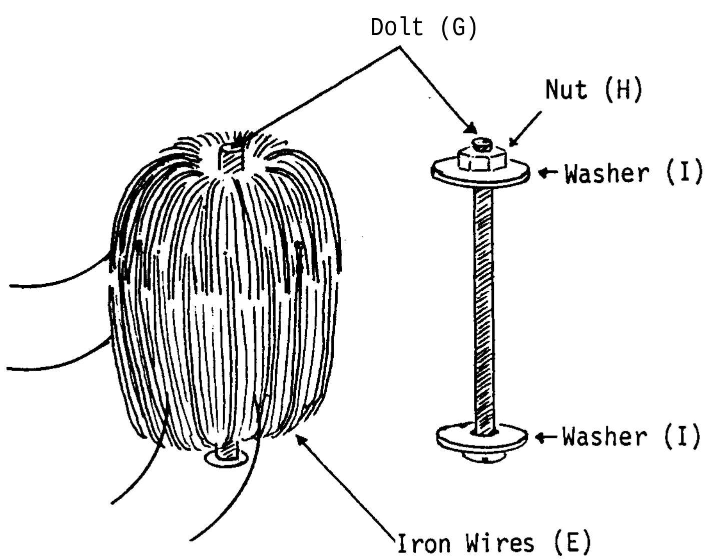
Next, take wire (C), and wind 40 turns, approximately 60 g, on top of the primary coil following the same procedures described for the primary coil, but in this case making each layer only about 3.5 cm long, instead of 6 cm. As before, insure that each layer of turns is insulated from the next with masking tape, and that some 10 cm of wire is left free at both ends of the coil. The newly added coil is appropriately labeled the secondary coil.

(2) Core

Cut the galvanized iron wire (E) into a series of 20 cm lengths. Dip these in varnish (F), and then lean them against a vertical surface to dry, in such a way that varnish is not removed from the wire in the process of drying. One to two days will be required for the varnish to dry.

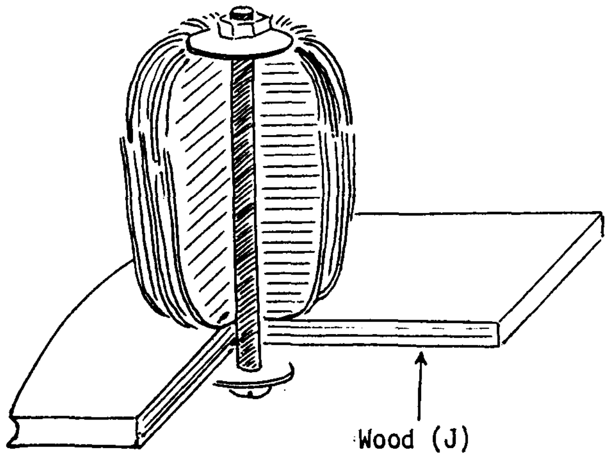


Take the dry wires one at a time, and bend them through, and around, the coil so that the wire ends just touch, or overlap, one another. If the wire is too long, cut the ends. Continue adding the iron wires to the coil in the same way, distributing the wires equally on each face of the coil, until the coil is almost full of iron wire. However, leave enough space to squeeze bolt (G) through the middle of the wire core.

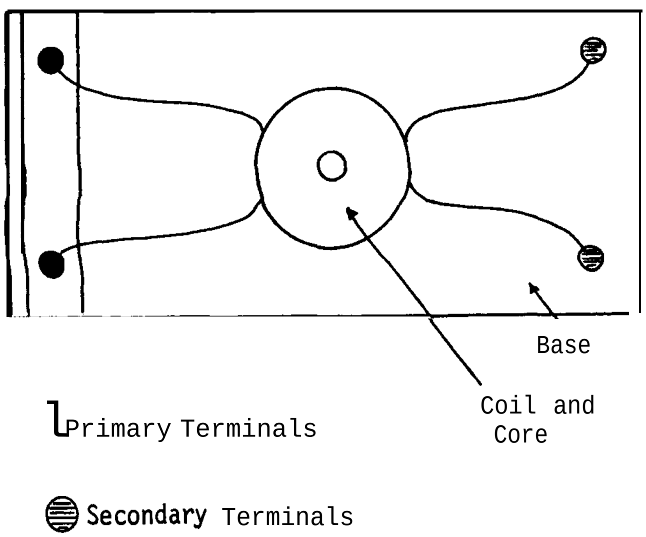


Slide bolt (G) through the middle of the iron wires. Washers (I) should be fitted on either end of the bolt, and the whole kept in position with a suitable nut (H).

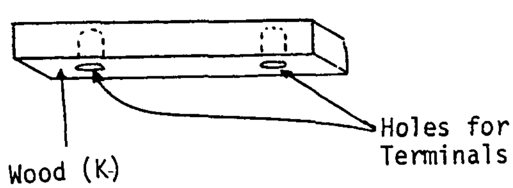
(3) Base



Make the base from wood (J). Drill a hole (diameter 0.5 cm) through the center, and attach the coil and core to the base with the help of the bolt (G) through the middle of the core. Make an inset in the bottom of the base to accommodate the bolt-head.

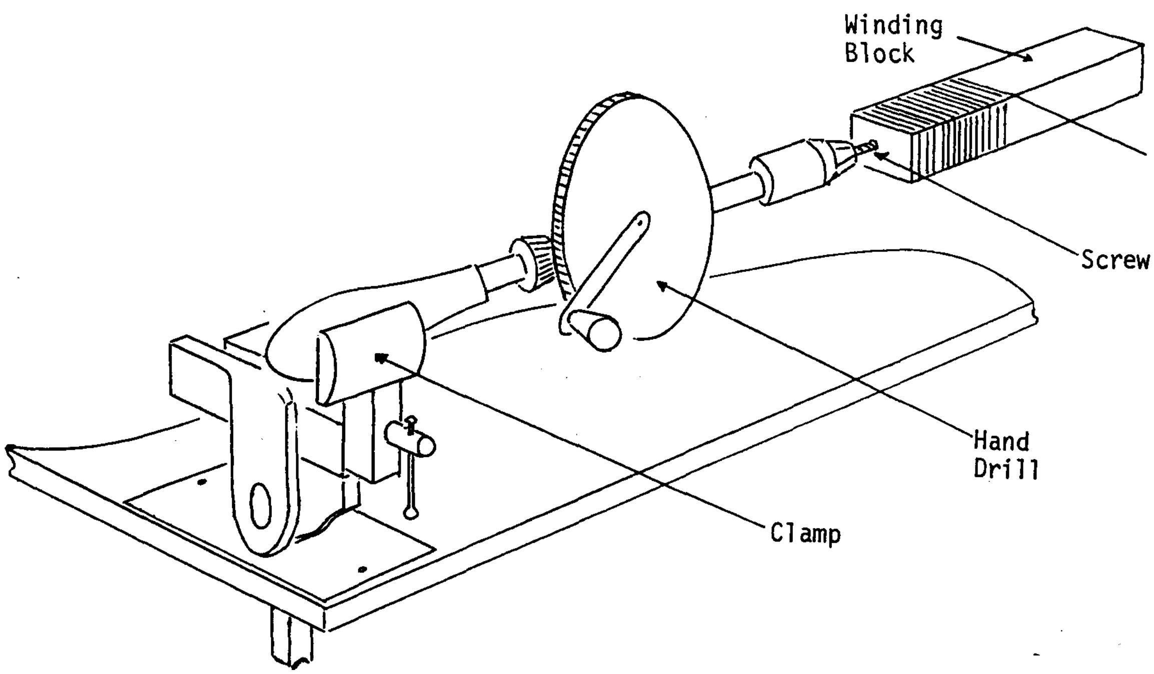


Use the bolts (L) and nuts (M) to make four terminals (as described under VIII/A2). Fit two at one end of the base to serve as secondary terminals, and attach the ends of the secondary coil to these, after cleaning the ends of the wire with sandpaper. Fit the other two terminals at the other end of the base to serve as the primary terminals. Attach the ends of the primary coil to the terminals after cleaning the ends of the wire with sandpaper. Remembering that the primary coil will be connected to the mains (120 volts) it is important to insure good insulation of all primary terminals and wires. Therefore, cover each of the wires from the primary coil to the relevant terminal with electrical insulation tape (N). In addition make a safety cover from wood (K). Simply cut holes (2 cm deep,



1 cm diameter) in the under-surface of the wood to accommodate the terminals, and set the wood on the base so that it covers the terminals.

C. Notes



(i) A convenient way of winding the coils is to use a hand drill and winding block. Clamp the tiand drill horizontally above the bench surface, and hold winding block horizontally in the drill chuck with the help of a screw fixed firmly in the end of the winding block. If a cardboard sleeve is fitted over the winding block, the wire may be wound on the sleeve, and the latter subsequently removed complete with newly wound coil.

(ii) The transformer made and tested here actually had 800 turns on the primary and 43 turns on the secondary. The voltage output was noted to be 6.6 volts when the current load was at a minimum, and that it fell to 5.5 volts as the load increased to 4 amps. At the same time the efficiency of the transformer increased from 32% at 6.6 volts to 45% at 5.5 volts.

(iii) Tested under a continuous load of 4 amps, the temperature of the core rose to 69°C over a period of 50 minutes, at which point the load was cut off to prevent serious overheating of the core. The data, indicated below, suggested that this transformer could be used continuously under a load of 3 amps, but with a load of 4 amps it should not be used for periods exceeding 30 minutes at any given time.

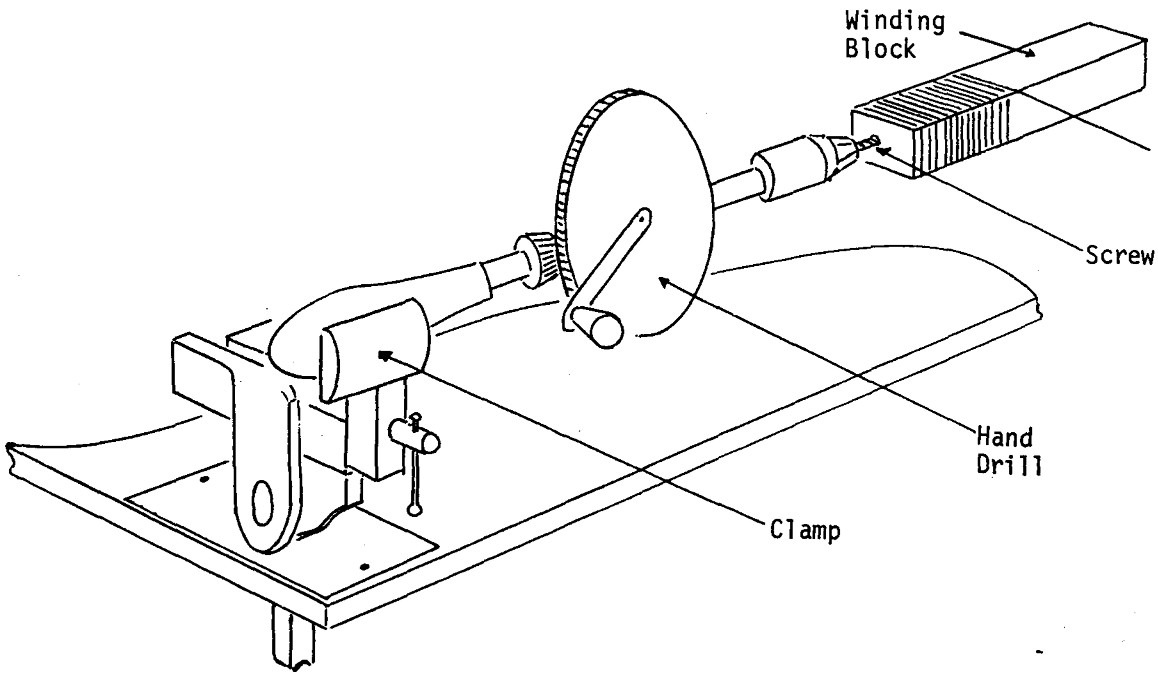
Room Temperature	output Voltage	output Amperage	Running Time	Core Temperature
°C	Volts	Amps	Minutes	°C
24	5.5	4	0	24
			20	50
			40	64
			50	68
			Testing stopped after 50 min	

Under the smaller load of 2.8 amps the core heated up more slowly, stabilizing at 62°C.

Room Temperature	output Voltage	output Amperage	Running Time	Core Temperature
°C	Volts	Amps	Minutes	°C
24	6.0	2.8	0	24
			20	46
			40	56
			60	62

1 cm diameter) in the under-surface of the wood to accommodate the terminals, and set the wood on the base so that it covers the terminals.

c.Notes



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			40	64
			50	68
			Testing stopped after 50 min	

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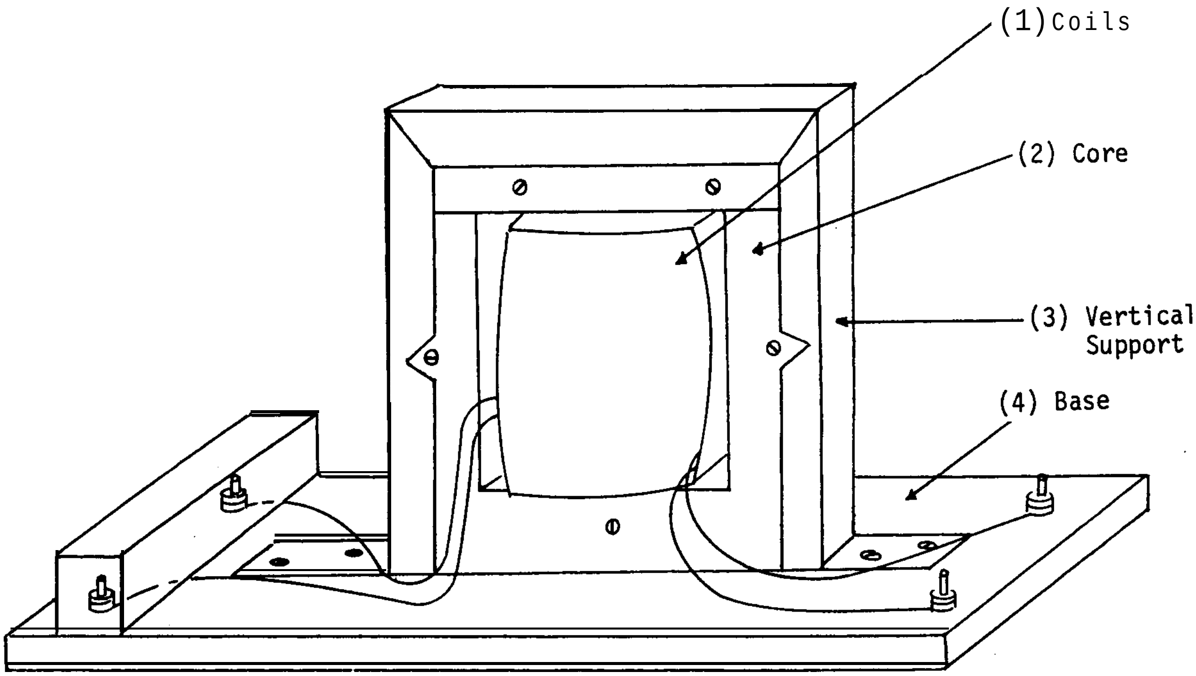
Room Temperature	output Voltage	output Amperage	Running Time	Core Temperature
°C	Volts	Amps	Minutes	°C
24	6.0	2.8	0	24
			20	46
			40	56
			60	62

A2. Transformer, Sheet Iron Core (12 volt output, 120 volt mains)



a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Coils	1	Sheet of Cardboard (A)	12 cm x 7.5 cm
	1	Roll of Magnet Wire (B)	#24, 250 g
	1	Roll of Magnet Wire (C)	#20, 100 g
	1	Roll of Masking Tape (D)	--
(2) Core	60	Galvanized Iron Sheets (E) (more sheets required if thinner sheeting is used)	13 cm x 10 cm x 0.05 an
	5	Bolts (F)	0.3 cm diameter, 3.5 cm long
	5	Nuts (G)	0.3 cm internal diameter
	--	Varnish (H)	--
(3) Vertical Support	1	Galvanized Iron or Aluminum Sheet (I)	47.5 x 5 x 0.02 all
(4) Base	1	Wood (J)	30 cm x 15 cm x 1.5 cm
	1	Wood (K)	15 cm x 3 cm x 2 cm
	4	Bolts (L)	2.5 cm long, 0.3 cm diameter
	8	Nuts (M)	0.3 cm internal diameter

-- Insulation Tape (N) --

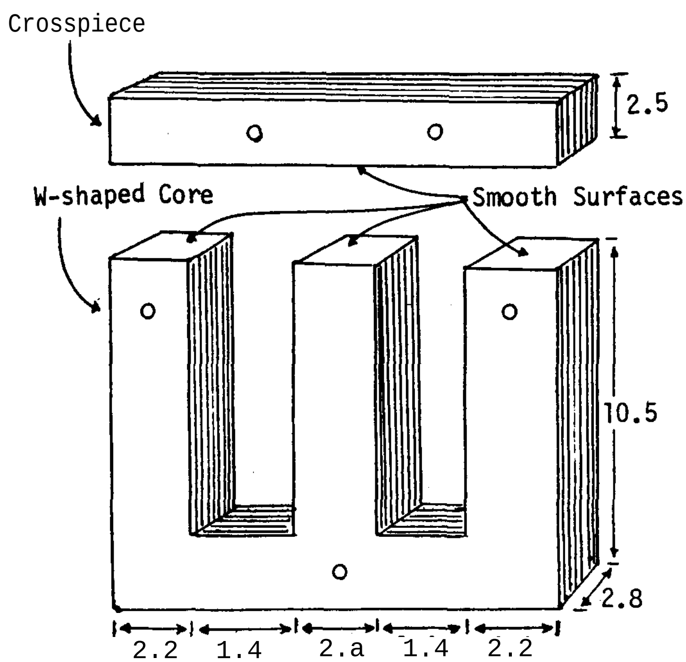
b. Construction

(1) Coils

Follow the instructions given with the foregoing transformer (VII/Al) for the construction of the coils. Make a form, on which to wind the coils, from the cardboard sheet (A), and wind BOO turns of magnet wire (B) on to the form to make the primary coil. Then wind BO turns (not 40) of magnet wire (C) on to the coil to make the secondary coil.

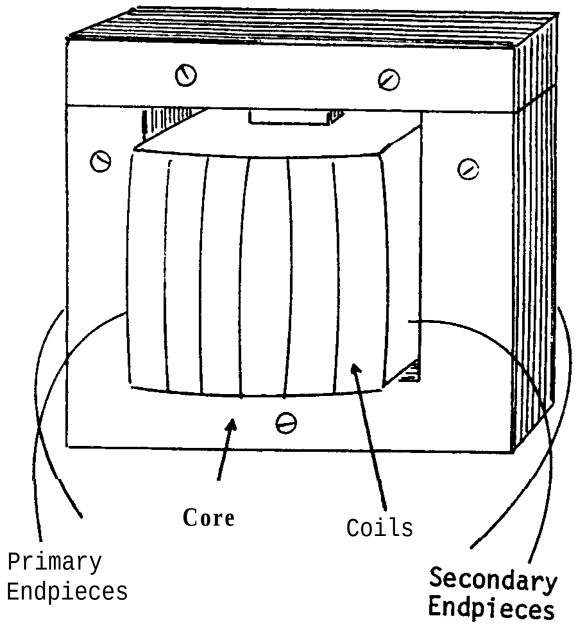
(2) Core

Stack the sheets of galvanized iron (E) one on top of the other, until they make a pile 2.B cm thick. This will require 55, or more, sheets, dependent on the thickness of each. Then cut each sheet as illustrated to form a W-shaped core piece and a rectangular crosspiece.



o Bolt Holes

Stack the newly cut plates back on top of each other, and drill five bolt holes (diameter 0.4 cm) through the plates. A drill press is preferred for this purpose, but it is possible to hand drill each plate separately. Use nuts (G) and bolts (F) to



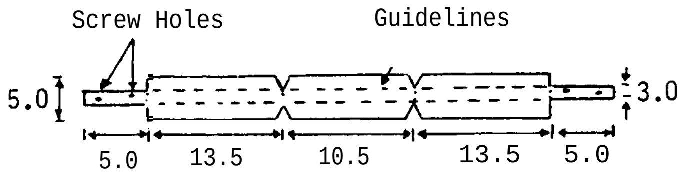
fasten the plates of the cross-piece and core together.

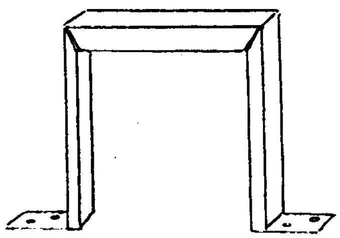
Take a file to smooth off the rough edges of the newly made core. It is important that the finished surfaces should insure good contact between the top of the W-shaped core and the crosspiece.

Now take the plates apart, paint varnish (H) on each in turn, reassembling the plates while still wet. The varnish acts as. an insulator, which reduces eddy currents, and hence heating effects, within the core. The core may take one or two days to dry.

Assemble the coils on the W-shaped core, using paper or wood wedges if necessary to insure the coil is held firmly on the central upright of the core.

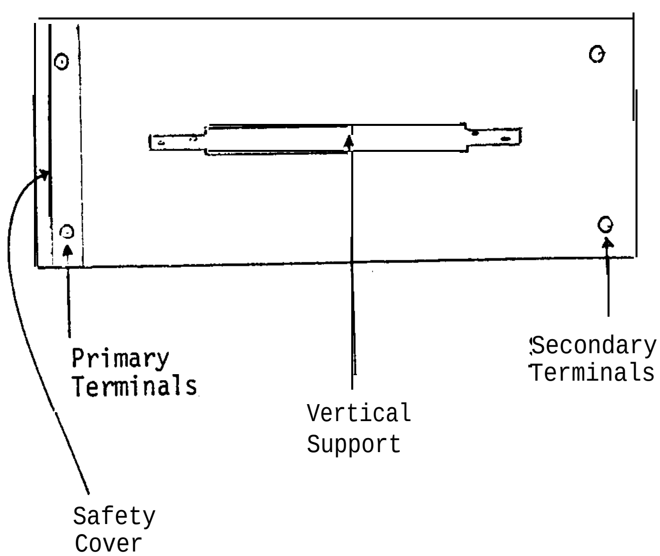
(3) Vertical Support





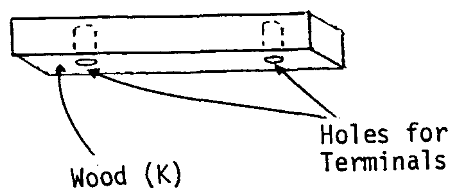
Use galvanized iron or aluminum sheeting (I) to make the vertical support. Cut it to the dimensions indicated, and bend it into the shape of a bridge. Drill two holes (diameter 0.3 cm) in either foot of the bridge so that the support may subsequently be attached to a base with screws.

(4) Base



Make a base for the transformer out of wood.(J). Fit the vertical support snugly over the core and coils, and attach the support to the middle of the base with screws.

Use bolts (L) and nuts (M) to make four terminals [as described under VIII/A2, Component (4)]. Fit two at one end of the base to serve as secondary terminals, and attach the ends of the secondary coil to these after cleaning the ends of the wire with sandpaper. Fit the other two terminals at the other end of the base to serve as the primary terminals. Attach the ends of the primary coil to the terminals after cleaning the ends of the wire with sandpaper. Remembering that the primary coil will be connected to the mains (120 volts),it is important to insure good insulation of all



primary terminals and wires. Therefore, cover each of the wires from the primary coil to the relevant terminal with electrical insulation tape (N).

In addition, make a safety cover for the primary terminals from wood (K). Simply cut holes (2 cm deep, 1 cm diameter) in the undersurface to accommodate the terminals, and set the wood on the base so that it covers the terminals.

c. Notes

(i) The voltage output of the secondary coil of the transformer will be at a maximum when the current load is at a minimum. In this case it was noted that the output voltage fell from 12 volts at 1 amp to 11 volts at 4 amps. At the same time the efficiency of the transformer increased from 47% at 12 volts to 62% at 11 volts.

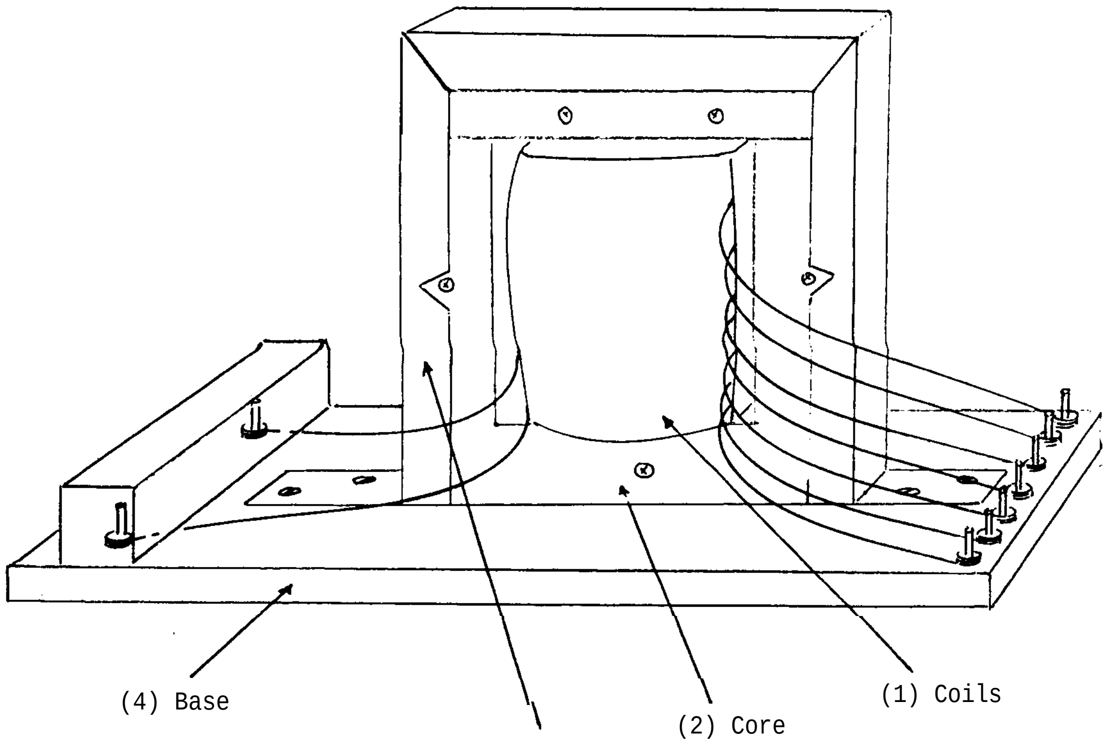
(ii) Tested over a period of 90 minutes under a continuous load of 4 amps, the temperature of the core remained well within acceptable limits. The following data indicates the degree of heating somewhat more explicitly.

Room Temperature	output Voltage	output Amperage	Running Time	core Temperature
°C	Volts	Amps	Minutes	°C
24	10.8	4	0	24
			20	52
			40	56
			60	59
			90	59

Under smaller loads the core heats up more slowly, but observations tended to suggest that the ultimate equilibrium temperature achieved (59°C) was the same as with the heavier load. (See table on next page.)

Room Temperature	output Voltage	output Amperage	Running Time	Core Temperature
°C	Volts	Amps	Minutes	°C
24	11	3	0	24
			20	44
			40	52
			60	59

A3. Transformer, Variable Output (120 volt mains)



a. Materials Required

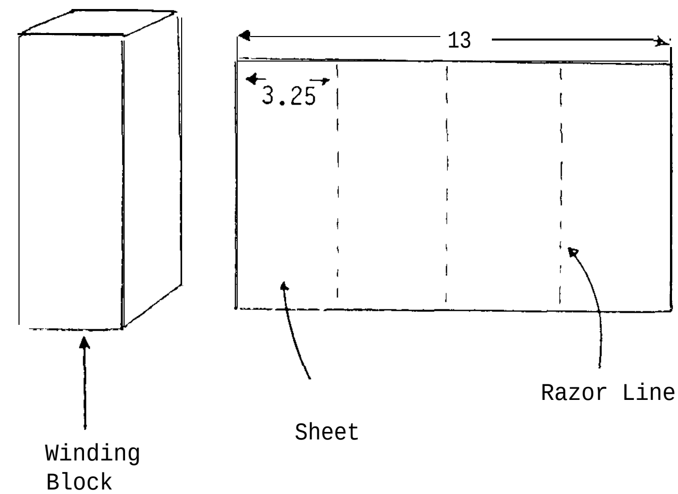
Components	Qu	Items Required	Dimensions
(1) Coils	1	Cardboard Sheet (A)	13.0 cm x 11.5 cm
	1	Roll of Magnet Wire (B)	#24, 250 g
	1	Roll of Magnet Wire (C)	#20, 250 g
	1	Masking Tape (D)	--
(2) Core	60	Galvanized Iron Sheets (E) (more sheets required if thinner sheeting is used)	17 cm x 10 cm x 0.05 cm
	5	Bolts (F)	0.3 cm diameter, 3.5 cm long
	5	Nuts (G)	0.3 cm internal diameter
	1	Can of Varnish (H)	--
(3) Vertical Support	1	Galvanized Iron or Aluminum Sheet	55.5 cm x 5 cm x 0.02 cm
(4) Base	1	Wood (J)	30 cm x 20 cm x 1.5 cm
	1	Wood (K)	20 cm x 3 cm x 2 cm

9	Bolts (L)	2.5 cm long, 0.3 cm diameter
18	Nuts (M)	0.3 cm internal diameter
1	Roll of Insulation Tape (N)	--

b. Construction

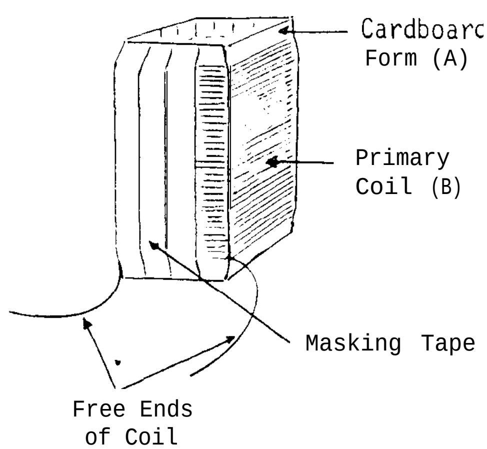
(1) Coils

Cut a piece of wood (14 cm x 3.2 cm x 3.2 cm) to serve as a winding block for the primary and secondary coils. Take the thin sheet of cardboard (A) and use a razor blade to score parallel lines on it at intervals of 3.25 cm, so that the cardboard may readily be bent around the wooden block.

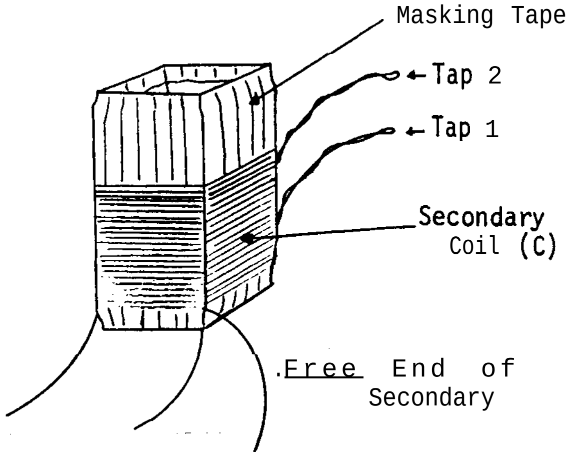


Wrap the cardboard sheet around the block, fastening the loose edges together with masking tape (D), thus producing a cardboard form on which to wind the primary and secondary coils.

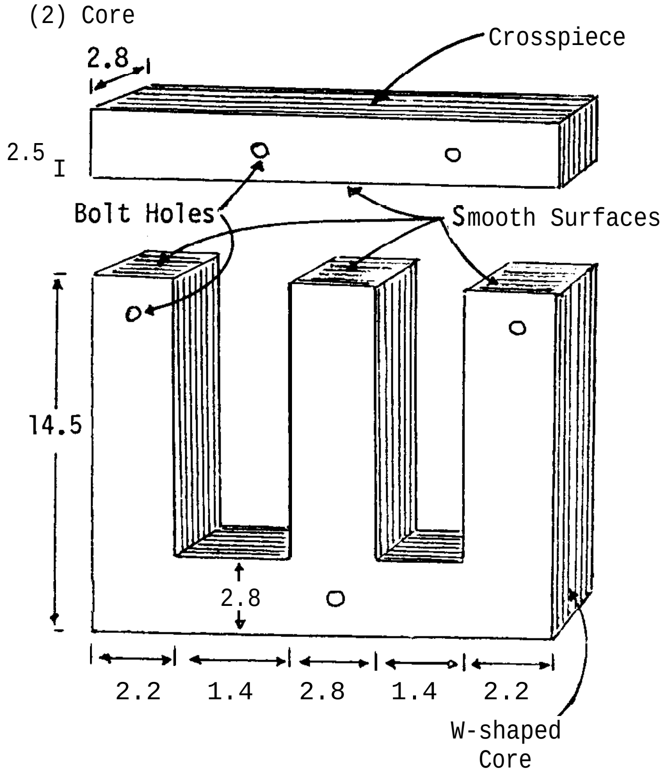
To make the primary coil, wind 720 turns (approximately 250 g) of magnet wire (B), onto the cardboard form. Each layer of turns will be 10 cm long. Place masking tape between each layer. The actual method of winding is described under VII/Al.



To make the secondary coil, wind 180 turns (approximately 250 g) of magnet wire (C) on top of the primary coil in the usual way (leaving a free end about 20 cm long at the start). However,



(2) Core



halt after every 30 turns to make a tap. (The latter is made by taking the next 40 cm of wire, folding it to make a double strand, and twisting it around itself.) Then continue for another 30 turns before making a further tap, again with a 40 cm length of wire. It is very important to make the taps at the corners of the secondary coil, otherwise they will interfere with the placement of the coil on the core. Each layer of turns should be covered in the usual way with masking tape to insulate it from the next layer. In all, there should be taps after 30, 60, 90, 120 and 150 turns, and a free end (20 cm long) after 180 turns.

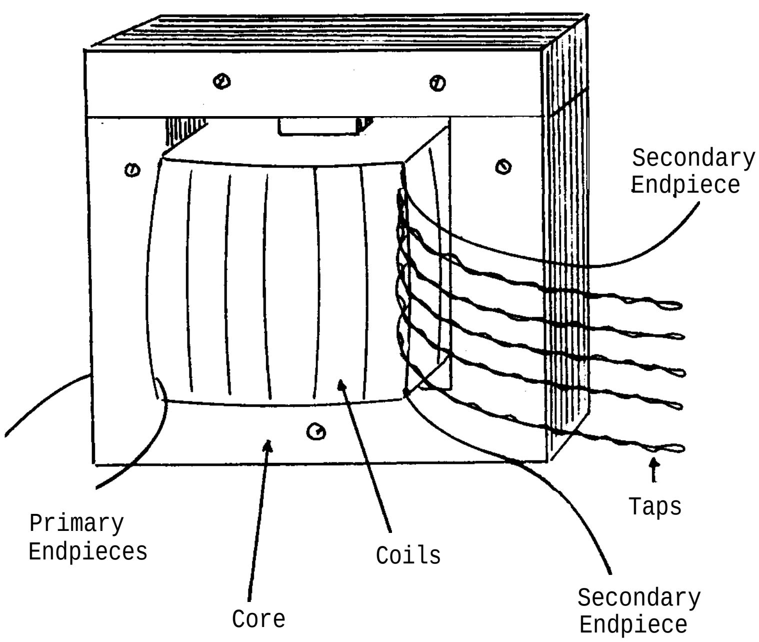
Stack the galvanized iron sheets (E) on top of the other until the pile is 2.8 cm thick. This will require 55, or more, plates, dependent on the thickness of the sheet. Then cut each of the sheets as illustrated to form a W-shaped plate and a rectangular crosspiece.

Stack the newly cut plates back on top of each other, and drill 5 bolt holes (diameter 0.4 cm) through the plates. A drill press is preferred for this purpose, but it is possible to hand drill each plate separately. Use nuts (G) and bolts (F) to fasten the plates of the crosspiece and core together.

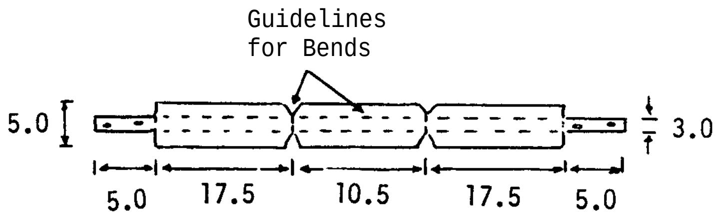
Take a file to smooth off the rough edges of the newly made core. It is important that the finished surfaces should insure good contact between the top of the W-shaped core and the crosspiece.

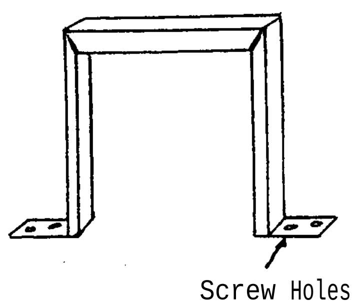
Now take the plates apart, and cover each in turn with varnish (H), reassembling the plates while still wet. The varnish acts as an insulator, which reduces eddy currents, and hence heating effects, within the core. The core may take one or two days to dry.

Assemble the coils on the W-shaped core, using paper or wood wedges if necessary to insure the coil is held firmly on the central upright of the core.

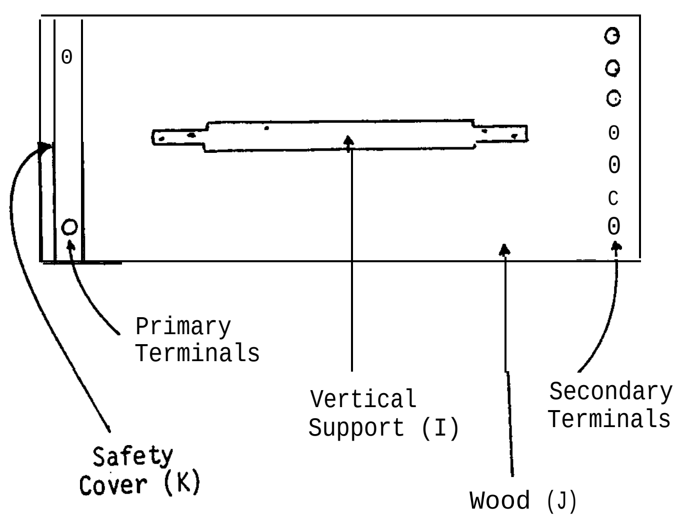


(3) Vertical Support

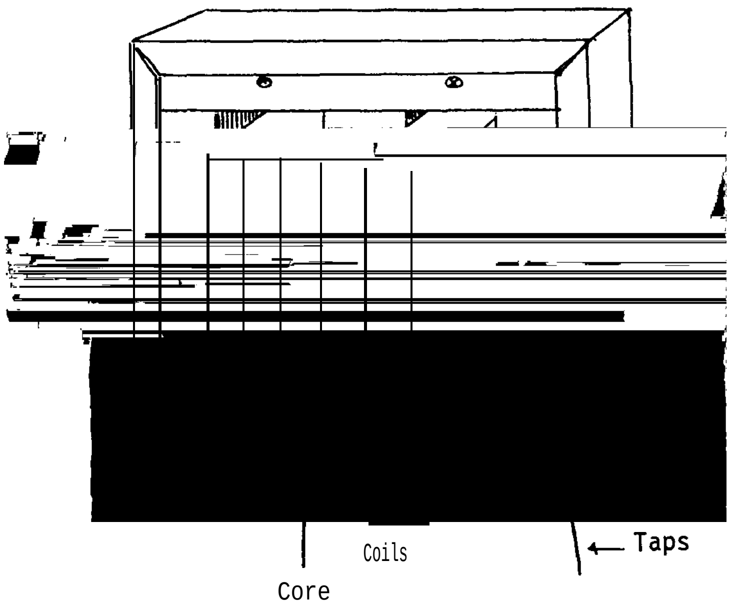




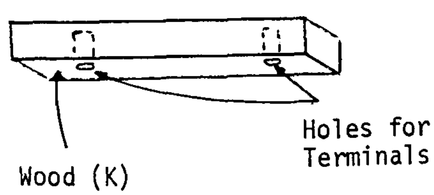
Use galvanized iron or aluminum sheeting (I) to make the vertical support. Cut it to the dimensions indicated, and bend it to the shape of a bridge. Drill two holes (diameter 0.3 cm) in either foot of the bridge so that the support may subsequently be attached to a base with screws.



Make a base for the transformer out of wood (J). Fit the vertical support snugly over the core and coils, and attach the support to the middle of the base with screws.



Use bolts (L) and nuts (M) to make nine terminals [as described under VII/AZ, Component (4)]. Fit seven at one end of the base to serve as secondary terminals, and attach the ends of the secondary coil and the taps to these after cleaning the ends of the wire and taps with sandpaper. Cover the wires with insulation tape (N) or tubing to prevent any possibility of a short. Fit the other two terminals at the other end of the base to serve as the primary terminals. Attach the ends of the primary coil to the terminals after cleaning the ends of the wire with sandpaper. Remembering that the primary coil will be connected to the mains (120 volts), it is important to insure good insulation of all primary terminals and wires. Therefore, cover each of the wires from the primary coil to the relevant terminal with electrical insulation tape.



In addition, make a safety cover for the primary terminals from wood (K). Simply cut holes (2 cm deep, 1 cm diameter) in the undersurface to accommodate the terminals, and set the wood on the base so that it covers the terminals.

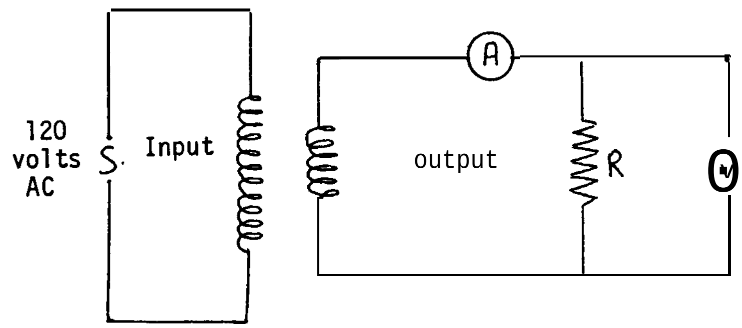
C. Notes

(i) Do not expect the output voltages to be exactly 5, 10, 15 volts and so on, With the apparatus produced and tested here the output voltages, observed by combining any one tap with the coil endpiece, were 4.5, 10.0, 15.0, 21.0, 26.3 and

31.0 volts when the primary voltage was 121 volts.

(ii) The transformer was tested using the 10, 20 and 30 volt outputs. As expected, it was noted that the transformer operated more efficiently at the higher voltages.

The voltage output from any given pair of terminals was observed to fall as the current output increased. Actual results are tabulated below.



Output Taps - 30 volts

Input	output				
*Power Watts	I Amps	V Volts	R Ohms	*Power Watts	Efficienc %
46	1.00	28.4	28.4	28.40	62
52	1.25	28.0	22.4	35.00	67
59	1.50	27.5	18.3	41.25	70
68	1.75	27.0	15.4	47.25	69
75	2.00	26.5	13.2	53.00	71
82	2.25	26.0	11.5	58.50	71
90	2.50	25.5	10.2	63.75	71
97	2.75	25.0	9.1	68.75	71
105	3.00	24.0	8.0	72.00	69

* Power was measured directly with wattmeters.

Output Taps = 20 volts

Input	output				
*Power Watts	I Amps	V Volts	R Ohms	*Power Watts	Efficiency %
33	0.75	19.5	26.0	14.6	44
3a	1.00	19.2	19.2	19.2	50
43	1.25	19.0	15.2	23.7	55
4a	1.50	la.5	12.3	27.7	5a
52	1.75	la.3	10.4	32.0	61
56	2.00	la.0	9.0	36.0	64
61	2.25	17.7	7.9	39.a	65
66	2.50	17.5	7.0	43.7	66
71	2.75	17.0	6.2	46.7	66
76	3.00	16.5	5.5	49.5	65

Output Taps = 10 volts

Input	output				
*Power Watts	I Amps	V Volts	R Ohms	*Power Watts	Efficiency %
22	0.50	9.0	18.0	4.5	20
24	0.75	a.a	11.7	6.6	27
26	1.00	a.7	a.7	a.7	33
29	1.25	8.6	6.9	10.7	37
31	1.50	a.4	5.6	12.6	41
34	1.75	a.3	4.7	14.5	43
36	2.00	a.1	4.0	16.2	45
3a	2.25	a.0	3.5	18.0	47
40	2.50	7.a	3.1	19.5	49
43	2.75	7.7	2.a	21.2	49
45	3.00	7.6	2.5	22.a	51

* Power was measured directly with wattmeters.

(iii) Some heating of the transformer was noted,but this appeared to be within acceptable limits. Hence, when a current of 3 amps was drawn from the maximum voltage taps (30 volts) the temperature of the transformer core did not rise beyond 60° Centigrade.

Output Taps = 30 volts

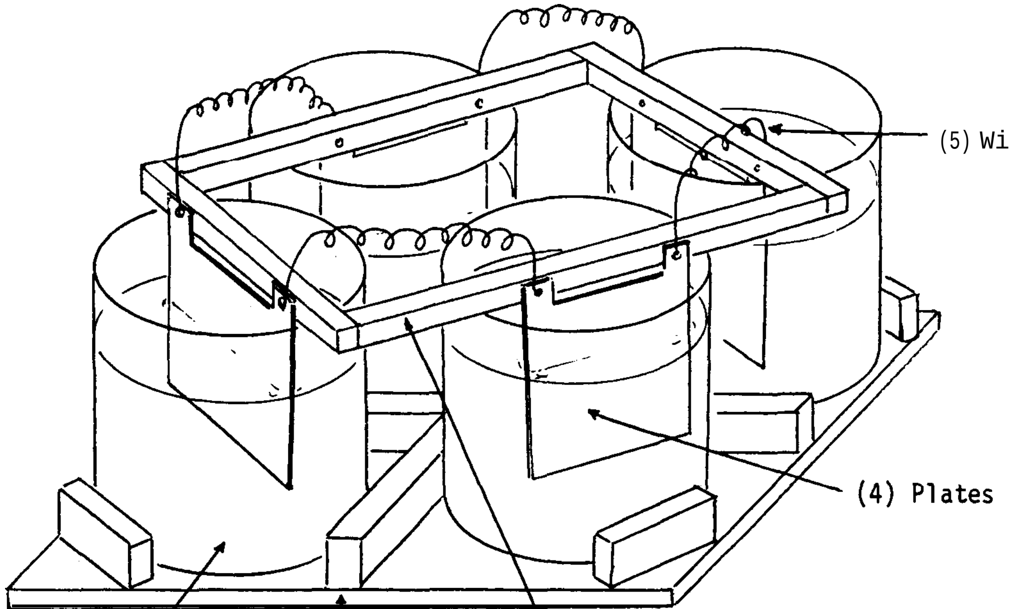
output = 3 amps at 24 volts

Room Temperature = 24°C

Running Time (Minutes)	Core Temperature (Degrees Centigrade)
0	27° C
5	38° C
10	48° C
15	49° C
20	51° C
25	53° C
40	56° C
50	58° C
60	59° C

B. RECTIFIERS

Bl. Sodium Bicarbonate Rectifier (2 Plate)



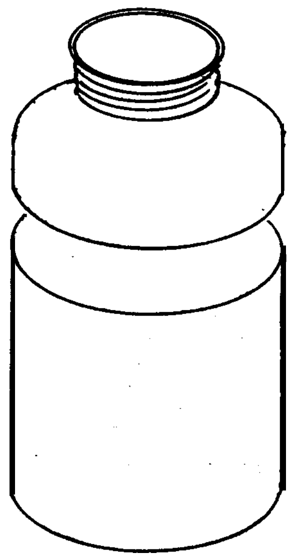
a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Cell Containers	4	Glass Jars (A)	Approximately 300 ml, 10 cm diameter
(2) Base	1	Plywood Sheet (B)	22 cm x 22 cm x 0.5 cm
	1	Wood Strip (C)	22 cm x 2 cm x 2 cm
	2	Wood Strips (D)	10 cm x 2 cm x 2 cm
	4	Wood (E)	2 cm x 2 cm x l cm
(3) Plates Support	2	Wood (F)	15 cm x 1.5 cm x 1.5 cm
	2	Wood (G)	12 cm x 1.5 cm x 1.5 cm
(4) Plates	4	Lead Sheets (H)	6.5 cm x 5.0 cm x 0.02 cm
	4	Aluminum Sheets (I)	6.5 cm x 5.0 cm x 0.02 cm
	8	Bolts (J)	0.3 cm diameter, 2.5 cm long
	a	Nuts (K)	0.3 cm internal diameter

	16	Washers (L)	0.3 cm internal diameter, approximately
	4	Filter Papers (M)	5.5 cm x 5.5 cm
	1	Saturated Solution of Sodium Bicarbonate (N)	1 liter
(5) Wiring	1	Roll of Magnet Wire (0)	#24

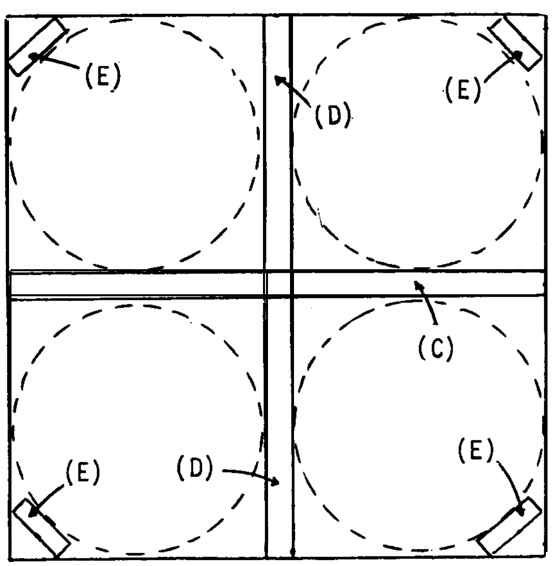
c. Construction

(1) Cell Containers



To make a cell container, take jar (A), and use a hot nichrome wire (CHEM/I/F2) to cut the top off the jar some 6 cm above the base. Repeat the process with three more jars.

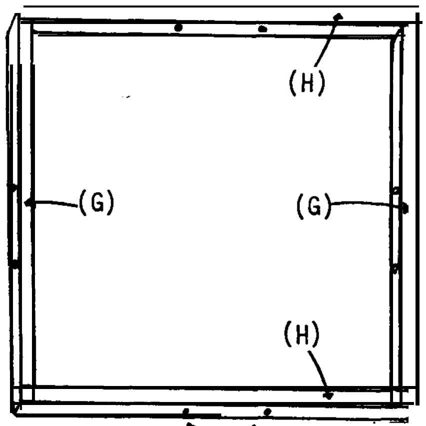
(2) Base



Plywood Base (B)

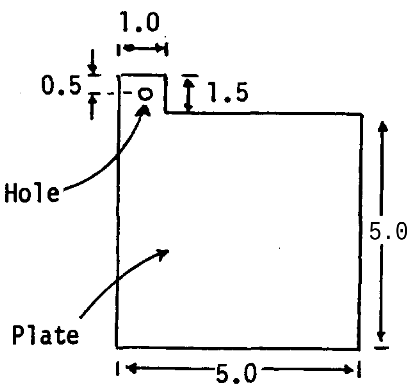
Nail wood strips (C,D) to the top of the plywood sheet (B) so as to divide it into four equal portions. Nail the wood strips (E) at the corners of the plywood in such a way that the four cell containers, placed in the appropriate quarters, will be held in position on the plywood base.

(3) Plates Support

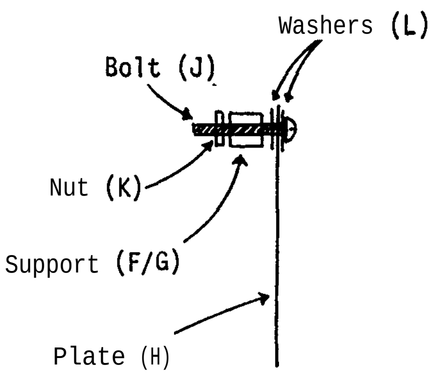


Use wood Strips (F) and (G) to make the frame of the plate support. Drill two bolt holes (0.3 cm diameter) in each side of the support, such that the holes in any one side are 4 cm apart, and are equidistant from the center of the side.

(4) Plates



Cut a plate out of lead sheeting (H) and another out of aluminum sheeting (I) to the dimensions shown. Drill a hole (0.3 cm diameter) in the projecting portion of each plate.



Attach the lead plate to the plate support with the help of bolt (J), nut (K) and washers (L) placed either side of the plate.

Attach the aluminum plate to the plate support in the same way, but so that the aluminum plate lies on top of the lead

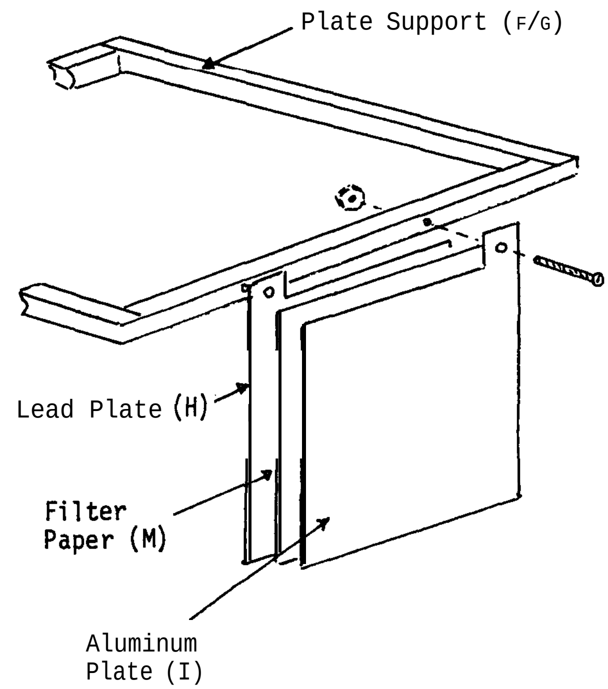


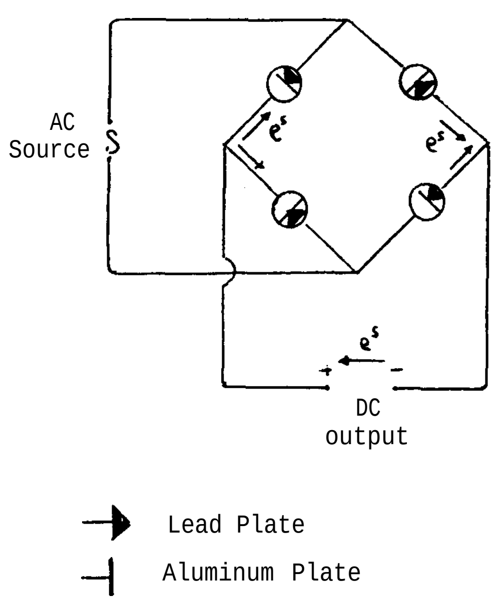
plate. Place the sheet of filter paper (M) between the two plates, thus insulating one from the other,

Cut three more lead plates and three more aluminum plates, and make identical plate pairs (insulated with filter paper) for the three remaining sides of the plate support.

Rest the plate support on the four cut jars, such that one pair of plates is suspended in each jar.

Almost fill each jar with a saturated solution of sodium bicarbonate (N),that is baking soda, and add a little extra sodium bicarbonate to each cell to insure that the solution remains saturated during use.

(5) Wiring

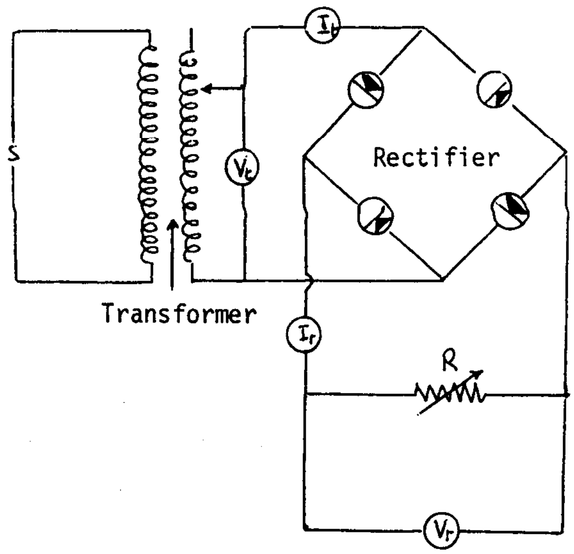


Use copper wire (O) to connect the plates of the four cells together, as indicated in the diagram. The cells have the simple property of permitting electrons to flow only in one direction, from aluminum to lead, and when connected as indicated to an AC source a rectified output is obtained. The type of output obatined with AC sources of 12 volts and 25 volts is indicated in the notes.

c. Notes

(i) The AC voltage supply may be taken from the transformer already described (VII/A3). A series of tests were conducted on the rectifier produced here, after it had been running for one hour. The results are tabulated below.

(ii) With a variable resistance (R) connected across the DC output it will be noted that the output voltage (V_r) fell off as the resistance decreased. [A very small proportion of the fall in voltage may be attributed to the drop in voltage (V_t) from the transformer.]



AC Supply = 15 volt taps

Load	Transformer Output			Rectifier Output			Efficiency
R Ohms	V_t Volts	I_t Amps	W_t Watts	V_r Volts	I_r Amps	W_r Watts	%
820	15.7	0.10	1.57	8.2	0.01	0.08	5.2
800	15.6	0.11	1.71	8.0	0.01	0.08	4.7
390	15.6	0.15	2.34	7.8	0.02	0.16	6.7
172	15.5	0.20	3.10	6.9	0.04	0.28	8.9
98	15.5	0.21	3.26	5.9	0.06	0.35	10.8
84	15.4	0.25	3.86	5.9	0.07	0.41	10.7
70	15.3	0.30	4.59	5.6	0.08	0.45	9.8
60	15.3	0.30	4.59	5.4	0.09	0.49	10.6
52	15.3	0.30	4.59	5.2	0.10	0.52	11.3
42	15.2	0.30	4.56	5.0	0.12	0.60	13.2
31	15.1	0.35	5.28	4.6	0.15	0.69	13.1
21	15.1	0.45	6.80	4.2	0.20	0.84	12.3
11	15.0	0.61	9.15	3.4	0.31	1.05	11.5
9	14.9	0.75	11.18	3.2	0.37	1.18	10.6
6	14.8	0.95	14.06	2.8	0.45	1.26	8.9
5	14.5	1.05	15.23	2.6	0.50	1.30	8.5
3	14.0	1.35	18.90	1.9	0.68	1.29	6.8

AC Supply = 25 volt taps

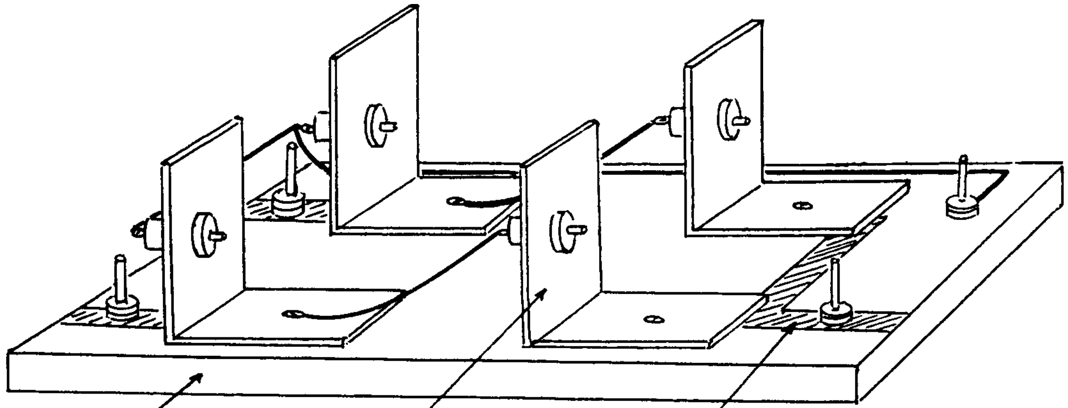
Load	Transformer Output			Rectifier Output			Efficiency
R Ohms	V_t Volts	I_t Amps	W_t Watts	V Volts	I_r Amps	W_r Watts	%
1,850	25.9	0.48	12.43	la.5	0.01	0.18	1.5
910	25.9	0.48	12.43	la.2	0.02	0.36	2.9
583	25.9	0.50	12.95	17.5	0.03	0.53	4.1
435	25.9	0.50	12.95	17.4	0.04	0.70	5.4
275	25.8	0.55	14.19	16.5	0.06	0.99	7.0
200	25.8	0.60	15.48	16.0	0.08	1.28	a.3
97	25.2	0.70	17.64	14.5	0.15	1.45	a.2
a9	25.1	0.75	la.82	14.2	0.16	2.27	12.1
78	25.1	0.78	19.58	14.0	0.18	2.52	12.9
69	25.0	0.80	20.00	13.8	0.20	2.76	13.8
61	25.0	0.85	21.25	13.5	0.22	2.97	14.0
50	24.8	0.95	23.56	13.0	0.26	3.38	14.4
39	24.5	1.05	25.73	12.5	0.32	5.00	19.4
30	24.0	1.22	29.28	12.0	0.40	4.80	16.4
20	23.5	1.52	35.72	11.0	0.55	6.05	16.9
10	22.2	2.15	47.73	9.0	0.88	7.82	16.4

(iii) The current output of the rectifier was very low, but was noted to increase when the voltage from the transformer was increased. Thus with a resistance of 10 ohms in the external circuit the DC current produced was 0.34 or 0.88 amps according to whether the rectifier was connected to the 15 or 25 volt taps on the transformers.

(iv) The rectifier was extremely inefficient in its use of power. The maximum efficiency on the 15 volt taps was noted to be 13% and on the 25 volt taps to be 19%.

(v) It was noted that not only did the output voltage (V_r) from the rectifier decrease with increasing resistance (R), but that there was also some variation of the voltage (V_r) at a fixed resistance (R) with the passage of time. These factors suggest that although the apparatus is capable of producing a DC current, the latter is not suitable for quantitative (as opposed to qualitative) experimentation.

B2. Silicon Rectifier



a. Materials Required

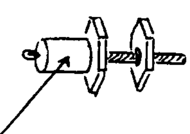
Components	Qu	Items Required	Dimensions
(1) Base	1	Wood (A)	15 cm x 10 cm x 2 cm
(2) Rectifiers and Supports	4	Silicon Rectifier Diodes (B)	1N1341
	4	Brass Bars (C)	7 cm x 2 cm x 0.3 cm
(3) Electrical Connections	2	Brass Strips (D)	5 cm x 1 cm x 0.5 cm
	1	Brass Strip (E)	5 cm x 3 cm x 0.5 cm
	4	Bolts (F)	0.3 cm diameter, 3.5 cm long
	8	Nuts (G)	0.3 cm internal diameter
	1	Copper Wire (H)	#20, 40 cm long

b. Construction

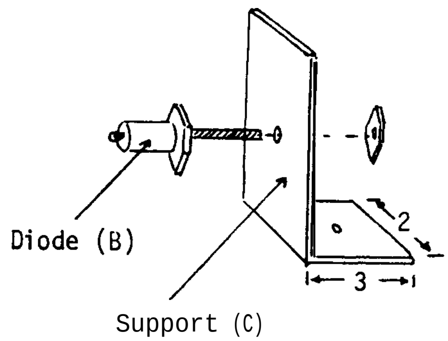
(1) Base

Use wood (A) as the base.

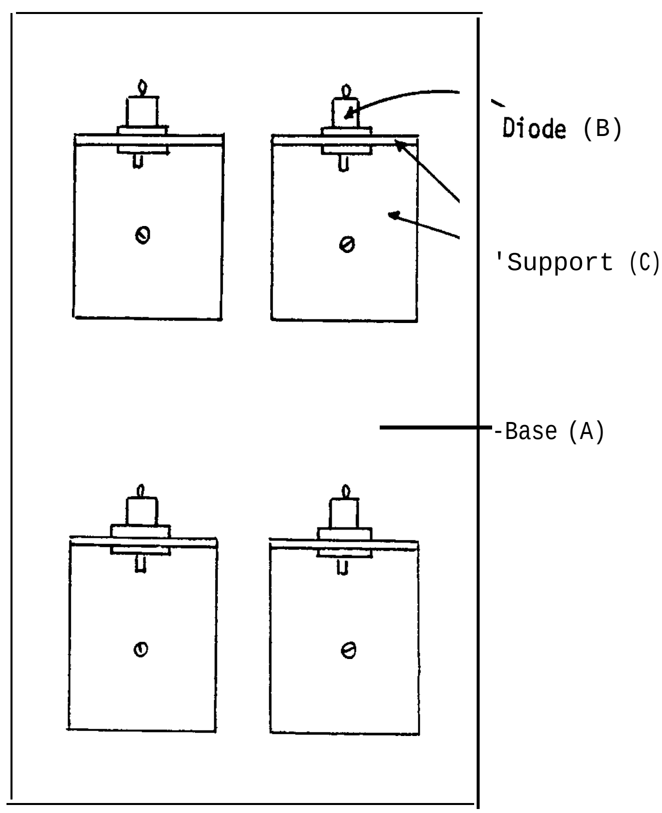
(2) Rectifiers and Supports



Purchase four silicon rectifier diodes (B) from a radio shop or electrical supply house. Ask for a rectifier identified as a 1N1341. This will be capable of handling a peak reverse

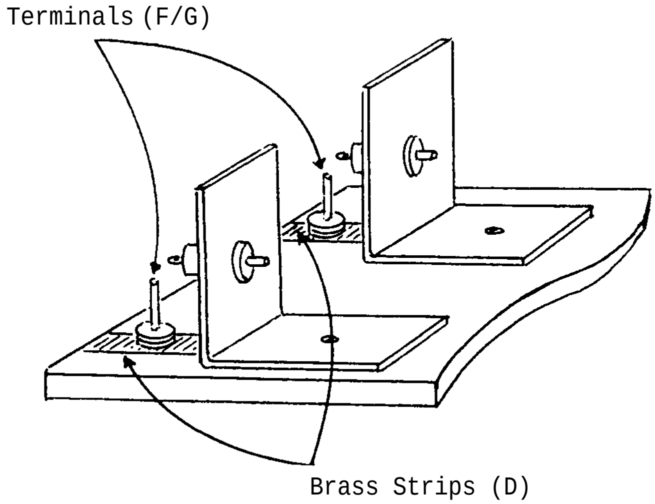


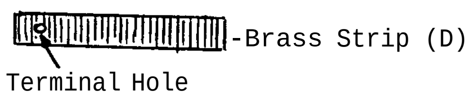
voltage of 50 volts, a continuous forward current of 6 amps and a maximum surge of 30 amps.



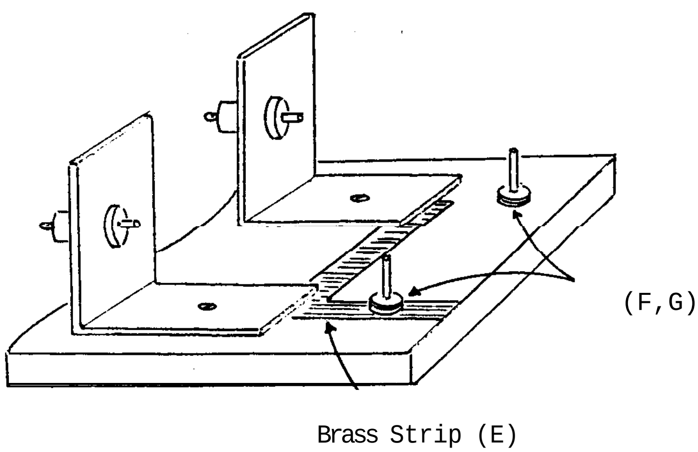
Take a brass bar (C) and bend it at right angles, 4 cm from one end, to form an L-shaped support. Drill a hole (0.5 cm diameter) in the middle of the long upright of the support and a hole (0.3 cm diameter) in the base of the support. Screw one of the rectifier diodes in the upright portion of the support. Attach the three remaining diodes (B) to three identical supports (C) in the same way. Attach the four supports to the base (A). It should be noted that the supports also act as heat sinks, removing heat that is generated within the diodes. It is for this reason that the support is made from a thick metal bar.

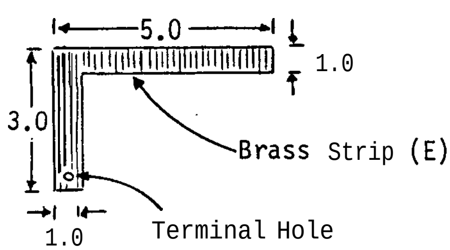
(3) Electrical Connections



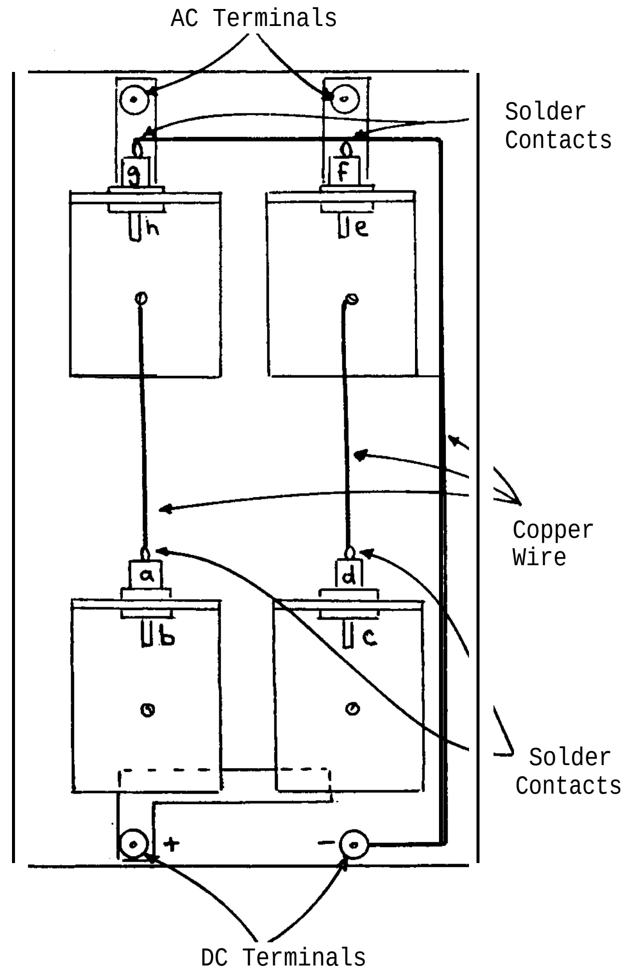


Take the two brass strips (D) and drill a hole (0.3 cm diameter) close to the end of each. Insert the strips under the supports (C) at one end of the base as indicated. Use bolts (F) and nuts (G) to make four terminals (F/G) as described under VIII/A2,Component (4). Fit two of the terminals on the base so that each is connected to a brass strip by means of the appropriate hole.





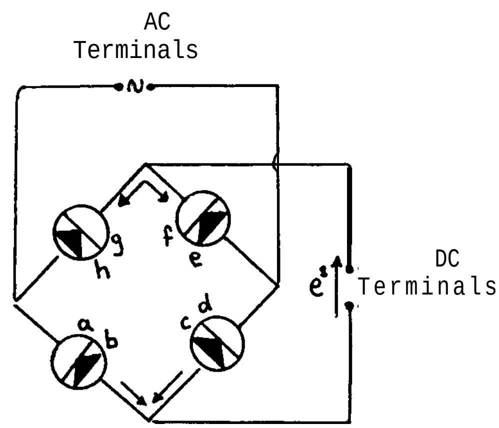
Cut an L-shaped strip out of brass sheet (E). Drill a hole (0.3 cm diameter) in the end of the shorter arm, and fit the longer arm beneath the two remaining supports so that they are connected electrically. Fit Terminals the two remaining term. **(F/G) to the end of the base,** so that one is connected to the L-shaped strip.



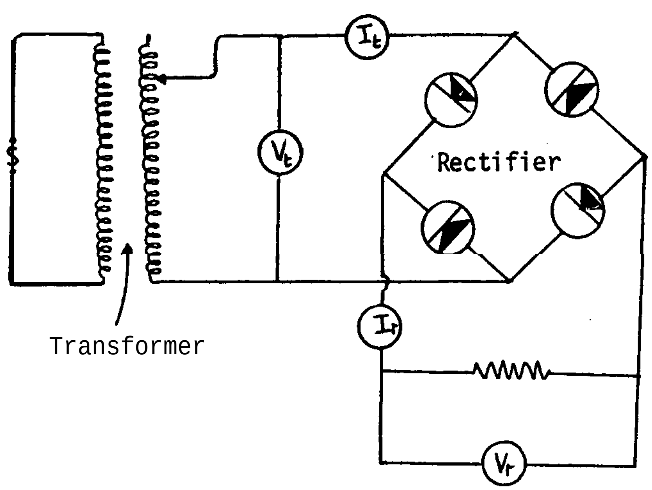
Take the copper wire (H) and connect the silicon diodes as illustrated. It will be necessary to solder the wire on to the ends of the diodes, and particular care should be taken to avoid overheating, since this can destroy the diodes.

C. Notes

(i) The rectifier produced is represented diagrammatically here. The reader should compare this with the previous diagram, noting the equivalent components marked by letters of the alphabet.



(ii) With a variable resistance R connected across the DC output it will be noted that the output voltage (V_r) falls off as the resistance decreases, even when the transformer is continuously monitored to keep the voltage (V_t) constant. This pattern of behavior is the same as for, the Sodium Bicarbonate Rectifier (VII/Bl). However, it will be noted that the efficiency of the Silicon Rectifier varies from 60% to 70% and the rectified current is as great as 3 amps at 5.5 volts. In this respect the Silicon Rectifier is a considerable improvement over the Sodium Bicarbonate Rectifier.



AC Supply = 10 volt taps

Load	Transformer Output			Rectifier Output			Efficiency
R Ohms	V_t Volts	I_t Amps	W_t Watts	V_r Volts	I_r Amps	W_r Watts	%
110	10.2	0.08	0.82	7.7	0.07	0.6	70.4
96	10.2	0.09	0.92	7.7	0.08	0.6	67.4
86	10.2	0.10	1.02	7.7	0.09	0.7	67.9
77	10.2	0.11	1.12	7.7	0.10	0.8	68.7
63	10.2	0.13	1.33	7.6	0.12	0.9	68.6
54	10.1	0.16	1.62	7.6	0.14	1.1	67.9
42	10.1	0.20	2.02	7.6	0.18	1.4	67.7
31	10.1	0.26	2.63	7.5	0.24	1.8	68.4
21	10.0	0.39	3.90	7.4	0.35	2.6	66.7
11	9.9	0.77	7.62	7.2	0.68	4.9	64.2
9	9.8	0.90	8.82	7.0	0.80	5.6	63.5
8	9.8	1.00	9.80	7.0	0.86	6.0	61.2
7	9.7	1.15	11.20	7.0	1.00	7.0	62.5
5	9.6	1.42	13.60	6.8	1.35	8.5	62.3
4	9.4	1.68	15.80	6.6	1.50	9.9	62.6
3	9.3	1.95	18.10	6.4	1.75	11.2	61.9
2	8.7	3.05	26.50	5.8	2.75	15.9	60.2
1	8.6	3.35	28.80	5.6	3.00	16.8	58.3

AC Supply = Held constant at 10 volts.

Load	Transformer Output			Rectifier Output			Efficiency
R Ohms	V_t Volts	I_t Amps	W_t Watts	V_r Volts	I_r Amps	W_r Watts	%
128	10.0	0.06	0.60	7.7	0.06	0.46	76.7
95	10.0	0.08	0.80	7.6	0.08	0.60	75.0
63	10.0	0.13	1.30	7.6	0.12	0.91	70.0
38	10.0	0.22	2.20	7.6	0.20	1.52	69.1
25	10.0	0.32	3.20	7.6	0.30	2.28	7.13
19	10.0	0.43	4.30	7.5	0.40	3.00	69.8
15	10.0	0.55	5.50	7.5	0.50	3.75	68.2
12	10.0	0.66	6.60	7.5	0.60	4.50	68.2
9	10.0	0.89	8.90	7.4	0.80	5.92	66.5
7	10.0	1.07	10.70	7.4	1.02	7.55	70.6
6	10.0	1.32	13.20	7.3	1.25	9.13	69.2
5	10.0	1.61	16.10	7.3	1.51	11.02	68.4
4	10.0	1.88	18.80	7.2	1.75	12.60	67.0
3	10.0	2.41	24.10	7.2	2.25	16.20	67.2
2	10.0	3.27	32.70	7.1	3.00	21.30	65.1

(iii) The output voltage (V_r) remains extremely steady with the passage of time, making this a much more suitable rectifier for quantitative experimentation than the Sodium Bicarbonate Rectifier.

AC Supply = 10 volt taps

Time	Transformer Output		Rectifier Output	
t Minutes	V_t Volts	I_t Amps	V_r Volts	I_r Amps
1	9.5	1.62	6.6	1.50
2	9.5	1.62	6.6	1.49
3	9.6	1.63	6.6	1.50
4	9.6	1.62	6.6	1.50
5	9.7	1.63	6.6	1.51
10	9.7	1.63	6.6	1.51
15	9.7	1.63	6.6	1.51
20	9.7	1.63	6.6	1.51
25	9.7	1.63	6.6	1.51
30	9.8	1.65	6.6	1.51