VI. CAGES

A. GLASS CAGES

These cages, made wholly or largely of glass, can be used to house a large variety of small animals, from insects to small mammals.

B. WOODEN CAGES

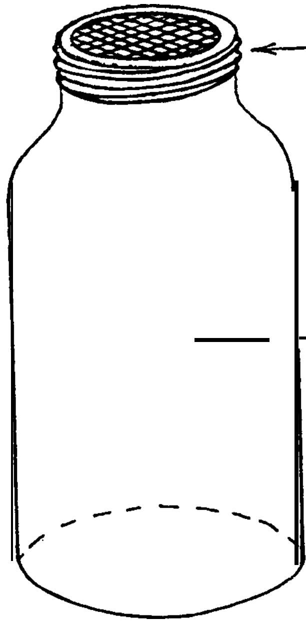
Two wooden cages are offered, one to house insects and the other designed for small mamals or birds. Both are somewhat more elaborate and permanent than their equivalent glass cages.

C. TEMPERATURE CONTROLLED CAGES

The vivarium and egg incubator are heated with light bulbs to serve the needs of animals and eggs which require relatively higher temperatures to live or hatch, respectively. Use a thermostat to control the internal temperature of heated cages and incubators, especially in classrooms which are not themselves thermostatically temperature controlled.

A. GLASS CAGES

Al. Glass Jar Cage



a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Jar	1	Glass Jar (A)	4 liters capacity or larger
(2) Top	1	Glass Jar Top (B)	To fit jar
	1	Wire Screening (C)	Same diameter as jar top

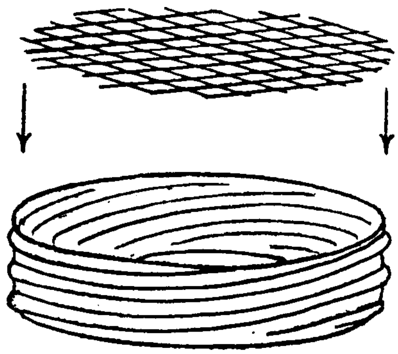
b. Constructi on

(1) Jar

Thoroughly clean the large glass jar (A). Select one with as large a mouth as possible.

(2) Top

Cut out a circular piece from the metal top (B) of the glass jar. The diameter of the hole in the top should be about 1 cm less than that of the top itself.



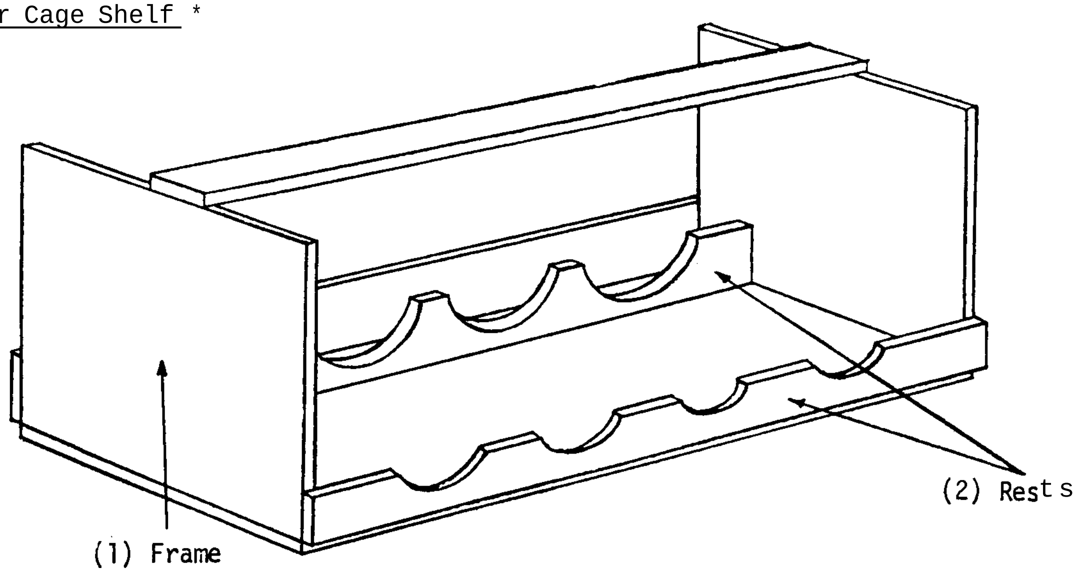
Next, cut out a circular piece of wire screen (C) the same diameter as the top. Insert this wire screen inside the top and glue it in place if it does not stay in place by itself.

C. Notes

(i) If the wire screening is cut to a diameter very slightly larger than that of the metal top, it will tend to stay in place within the top, and doesn't need to be cemented. In fact, once the top is screwed to the jar, the screen will be held tightly between the glass and top, and no cement is necessary.

(ii) Grass, sand, soil, twigs, etc., can be added to this cage depending on what type of animal is to be kept. If small amphibians are housed in it, lay it on its side and partially fill it with water. Most amphibians are best housed in shallow aquaria, however.

A2. Jar Cage Shelf *

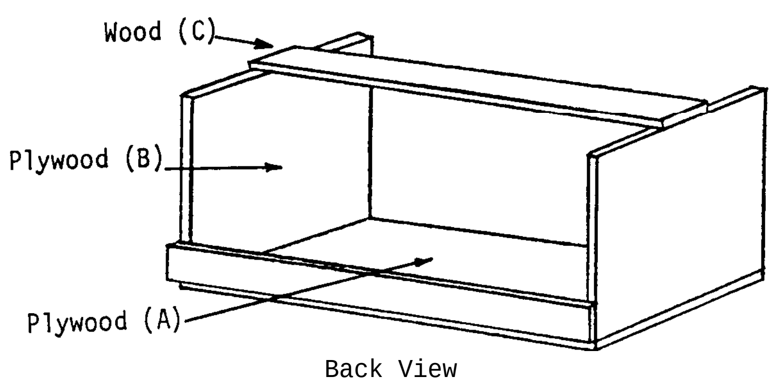


a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Frame	1	Plywood (A)	18 cm x 47 cm x 1.0 cm
	2	Plywood (B)	18 cm x 15 cm x 1.0 cm
	2	Wood (C)	4 cm x 47 cm x 1.0 cm
(2) Rests	1	Wood (D)	4 cm x 45 cm x 1.0 cm
	1	Wood (E)	2 cm x 47 cm x 1.0 cm

b. Construction

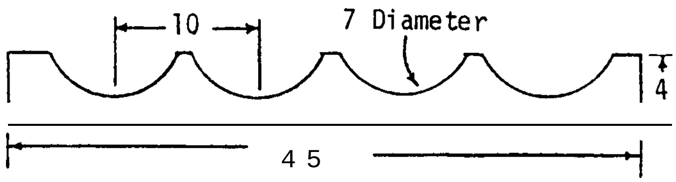
(1) Frame



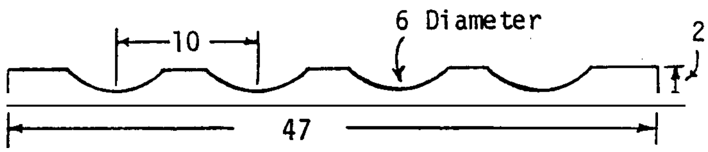
Nail or screw the two small pieces of plywood (B) to the ends of the large piece (A). Nail one of the wood strips (C) to the back with the lower edge even with the back. Screw the other strip (C) to the top to act as a carrying handle.

*Adapted from Richard E. Barthelemy, ~~et. al.,~~ Innovations in Equipment and Techniques for the Biology Teaching Laboratory, (Boston: D. C. Heath, 1964), p 28.

(2) Rests

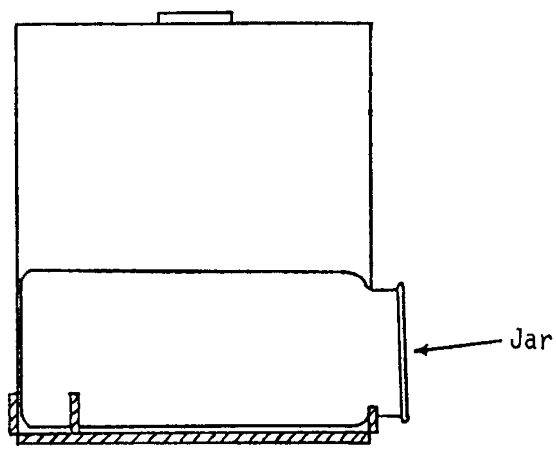


Wood Strip (D)



Wood Strip (E)

Wooden rests are needed to prevent the jar cages from rolling. Cut four arcs spaced 10 cm on center from the wide piece of wood (D). The diameter of the arcs should be the same as that of the body of the jar cages (in this description, the jars used had a body diameter of 7 cm and a neck diameter of 6 cm).



Side View
(Cross-section)

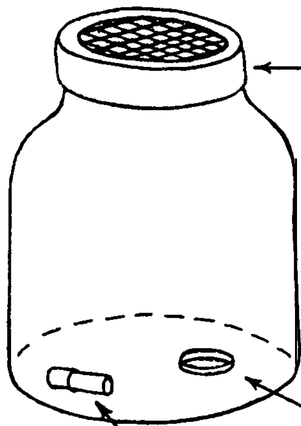
Similarly, cut four arcs of the same diameter as the neck of the bottle (in this case, 6 cm) from the narrow strip (E), also 10 cm on center. Nail the wide strip (D) to the sides and base about 3 cm from the back strip. Nail the narrow strip (E) to the front with its lower edge even with the base.

C. Notes

(i) Use this item as a storage rack for several jar cages (VI/Al). The handle permits several cages to be carried with little disturbance.

(ii) All dimensions given here are subject to change depending on the size, shape, and number of jar cages to be stored.

A3. Cockroach Cage *



a. Materials Required

Components		Items Required	Dimensions
(1) Cage	1	Glass Jar Cage (VI/Al) (A)	At least 1.0 liter capacity
(2) Food Container	1	Jar Top (B)	2-3 cm diameter, 1 cm deep
(3) Watering Device	1	Glass Vial (C)	4 cm long, 2 cm diameter
	1	Cotton (D)	Small plug

b. Construction

(1) Cage — Use the Glass Jar Cage (VI/Al) (A) as is.

(2) Food Container — A small jar top (B) will hold the small amount of food necessary for small insects like cockroaches.

(3) Watering Device — Insert the cotton plug (D) into the open end of the vial (C) containing a small amount of water. The cotton will stay

*Adapted from Richard E. Barthelemy, et. al., Innovations in Equipment and Techniques for the Biology Teaching Laboratory, (Boston: D. C. Heath, 1964), p 22-23.

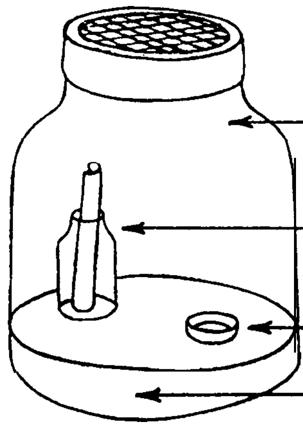
damp and provide water for the insects.

c. Notes

(i) If desired, the upper portion of the jar can be coated with talcum powder to prevent the insects from crawling out when the jar is open.

(ii) Providing small objects which the insects can climb on or conceal themselves in is recommended.

A4. Housefly Cage *



a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Cage	1	Glass Jar Cage (VI/A1) (A)	4 liters or larger
(2) Watering Device	1	Glass Jar (B)	Approximately 25 ml
	1	Absorbent Paper (C)	Approximately 10 cm x 3 cm
(3) Food Container	1	Jar Top (D)	4 cm long, 2 cm diameter
(4) Culture Medium	1	Culture Medium (E)	50 ml or enough to fill the cage to a depth of approximately 2 cm

b. Construction

(1) Cage

Use the Glass Jar Cage (VI/Al) (A) as is. Be sure to select a glass jar with as wide a mouth as possible.

(2) Water Device

This is merely a small glass jar (B) or other small container which holds a "wick" of absorbent paper (C). Water in the jar will soak into the paper

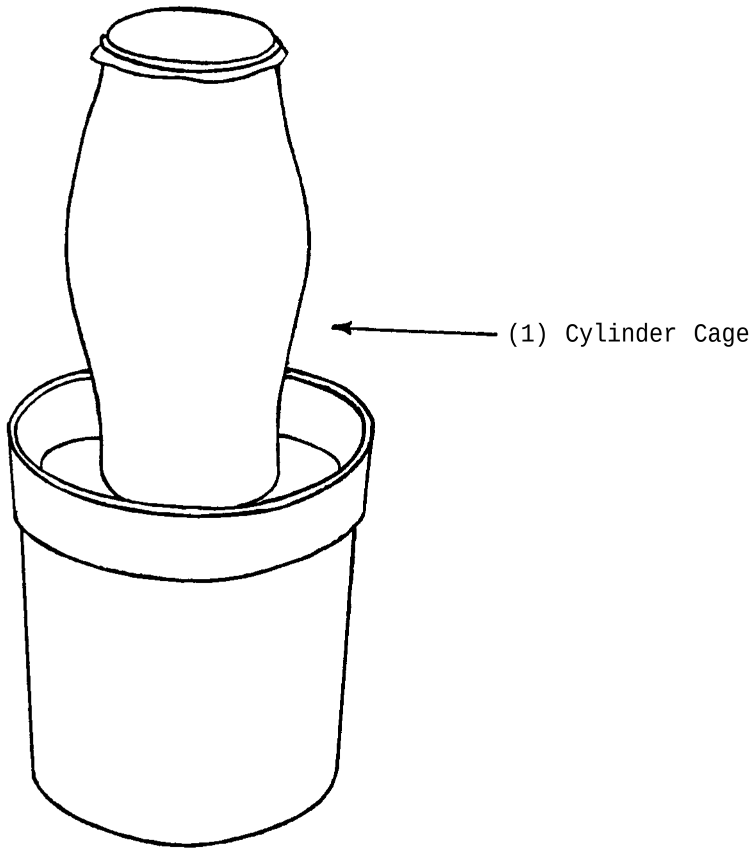
*Adapted from Richard E. Barthelemy, et. al., Innovations in Equipment and Techniques in the Biology Teaching Laboratory, (Boston: D. C. Heath, 1964), p 23.

	where it can be obtained by flies and other flying insects.
(3) Food Container	A small jar top (D) will suffice as a container for food for the flies.
(4) Culture Medium	This is a growth medium (E) for the insect larvae, and should contain all the necessary growth ingredients.

c. Notes

(i) For suitable growth media for houseflies , see the following BSCS publications: Barthelemy et. al., Innovations in Equipment and Techniques for the Biology Teaching Laboratory; and Glenn, The Complementarity of Structure and Function (BSCS Laboratory Block).

A5. Cylinder Cage



a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Cylinder Cage	1	Potted Plant (A)	--
	1	Lamp Chimney (B)	8 cm diameter, 30 cm long
	1	Cloth Mesh (C)	10 cm diameter
	1	Rubber Band (D)	--

b. Construction

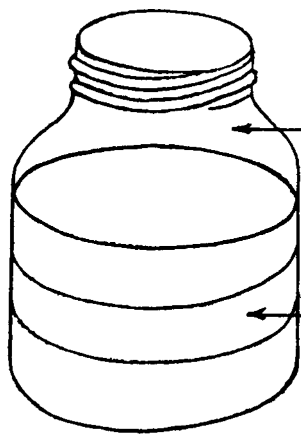
(1) Cylinder Cage

This is a quickly made cage. Simply put the lamp chimney (B) or other large diameter glass tube over the potted plant (A). Add the insects, and cover the top with cloth mesh (C) or gauze held in place with the rubber band (D).

c. Notes

(i) This is a good, simple cage in which to rear insects which feed on plants.

A6. Jar Wormery



a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Jar	1	Glass Jar (A)	1-4 liters
(2) Medium	1	Sand (B)	1/4-1 liter
	1	Leaf Mold (C)	1/4-1 liter
	1	Loam (D)	1/4-1 liter

b. Construction

(1) Jar

Thoroughly clean the glass jar (A).

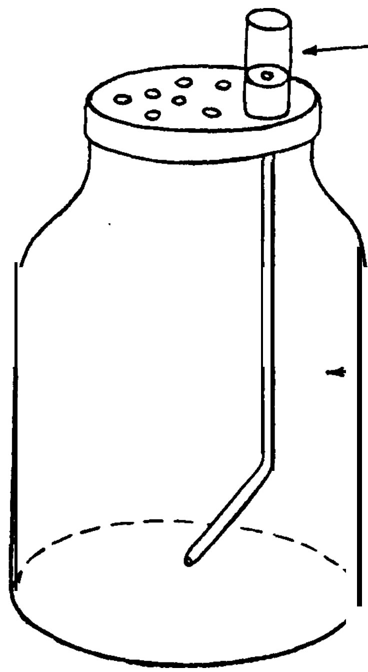
(2) Medium

Each layer of the medium should have a volume approximately one fourth that of the total for the jar. The bottom layer is sand (B), the middle is leaf mold (C), and the top layer is loam (D).

c. Notes

(i) Place the worms in the wormery along with some dead leaves, lettuce, carrots, etc. Keep the contents damp.

A7. Jar Cage



a. Materials Required

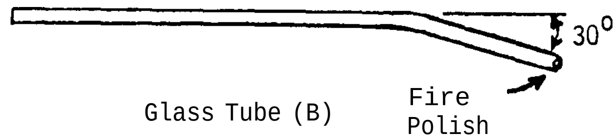
Components	Qu	Items Required	Dimensions
(1) Jar	1	Large Glass Jar (A)	4 liter capacity
(2) Water Bottle	1	Glass Tube (B)	25 cm long, 0.5 cm outside diameter
	1	Vial (C)	50-100 ml capacity
	1	l-Hole Stopper (D)	To fit vial

b. Construction

(1) Jar

Use a large capacity glass jar (A) with a metal or plastic lid. Punch several holes in the lid for ventilation. Make certain one of the holes is slightly larger in diameter than the glass tube (B) used in the water bottle.

(2) Water Bottle



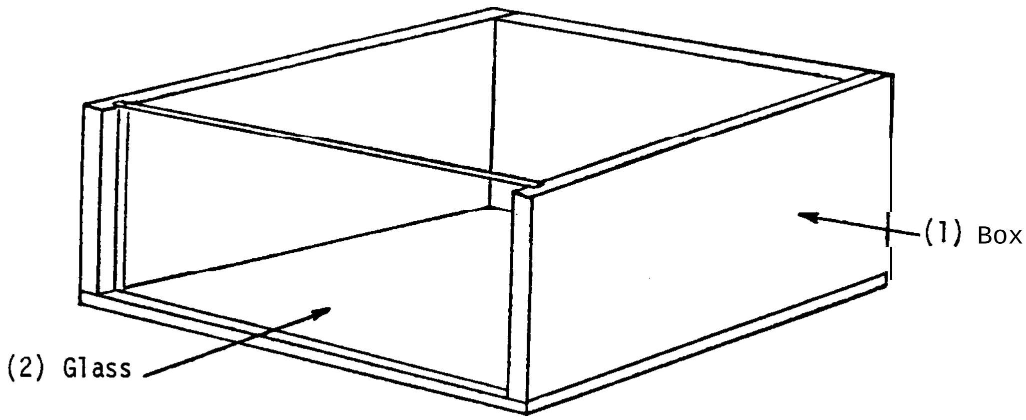
Heat the glass tube (B) about 7 cm from one end and make a slight bend in it (about 30°). Fire polish this end until the opening constricts very slightly. Insert the other end of the tube through the one-hole stopper (D), and plug the vial (C) with the stopper. Insert the completed water bottle through a hole in the lid of the jar. Be sure the tip of the glass tube is low enough for the animals to reach.

C. Notes

(i) This cage is designed for small mammals like mice or gerbils. Spread a layer of sawdust or newspaper shreds on the bottom to absorb wastes. Fill the water bottle and the animals soon learn to lick water from the end of the tube. Pieces of food can be dropped through the holes in the lid.

(ii) This cage is meant to be a temporary, not permanent, container for small mammals. Large jars of 4 liter capacity may be obtained from restaurants and other places which buy food in large quantities.

A8. Box Wormery

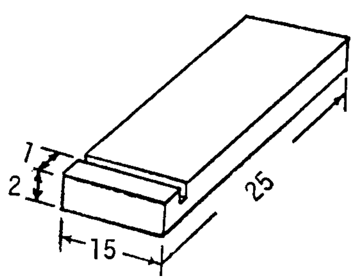


a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Box	1	Wood (A)	25 cm x 25 cm x 1 cm
	2	Wood (B)	25 cm x 2 cm x 15 cm
	1	Wood (C)	21 cm x 2 cm x 15 cm
(2) Glass	1	Window Glass (D)	23 cm x 15 cm x 0.3 cm

b. Construction

(1) Box



With a saw, cut a groove 1.0 cm deep and 1.0 cm from the end of the two pieces of wood (B). These grooves should be slightly wider (about 0.4 cm) than the glass (D) used. Nail these two pieces and the piece (C) to the base (D) to form an open-ended box with the two grooves facing each other,

(2) Glass

Insert the glass (D) into the grooves in the sides of the box. The box wormery is now complete.

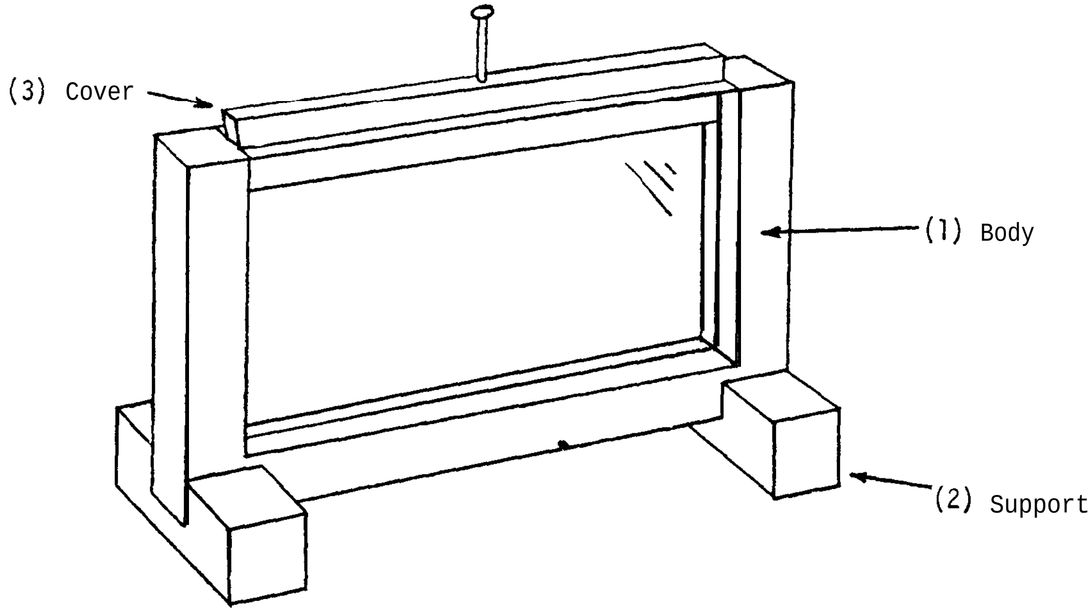
c. Notes

(i) Put a 5 cm deep layer of sand in the box, cover this with 5 cm of leaf mold, and finally cover this with about 5 cm of loam. Add worms, dead leaves, pieces of lettuce and carrots to the top. Cover the glass front with dark paper or cloth and keep the soil damp. After several days, worms and tunnels should be visible when the paper or cloth is removed.

(ii) There is no real need for the glass plate to be removable so all the joints between the wood and glass can be sealed with waterproof sealant (e.g., pitch, caulk).

(iii) If it is desired to simply raise worms rather than observe them, then the glass may be omitted and any suitable box can be used for the wormery.

A9. Ant Observation Cage

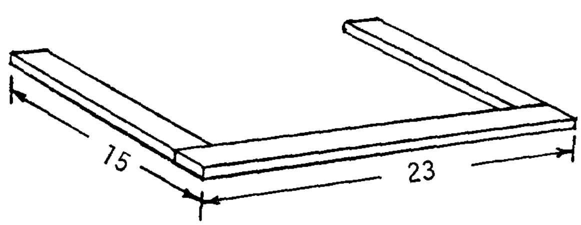


a. Materials Required

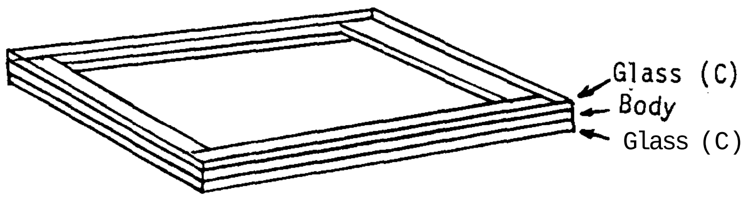
Components	Qu	Items Required	Dimensions
(1) Body	2	Wood (A)	13 cm x 2 cm x 0.7 cm
	1	Wood (B)	23 cm x 2 cm x 0.7 cm
	2	Glass Plates (C)	23 cm x 15 cm x 0.3 cm
	6	Tape (D)	19 cm x 2 cm
	3	Tape (E)	27 cm x 2 cm
(2) Support	2	Wood (F)	7 cm x 2 cm x 2 cm
(3) Cover	1	Wood (G)	19 cm x 2 cm x 0.7 cm
	1	Nail (H)	4 cm long, 0.3 cm diameter

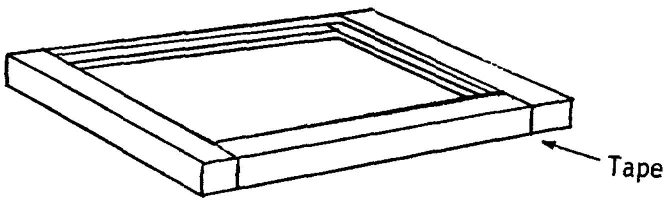
b. Construction

(1) Body



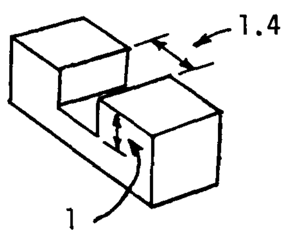
Glue, nail, screw or otherwise fasten the two short pieces of wood (A) to the ends of the longer piece (B). When the glue has dried, place the wood frame between the two pieces of glass (C) forming a "sand-wich". Use the six short pieces of tape (D) to tape each end together and use the three long pieces of tape (E) to tape the bottom.





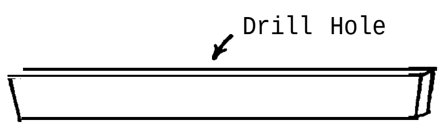
(2) Support

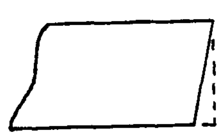
Cut a notch 1.4 cm wide and 1.0 cm deep into the center of each wooden support (F). Set the body into place.



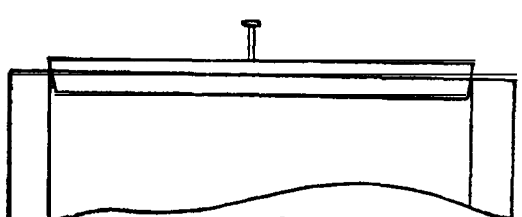
(3) Cover

Drill a hole approximately 0.3 cm in diameter through the middle of the piece of wood (G). Cut off a small portion of each end so that the ends are slightly tapered. This cover should now effectively seal the body, and the wedge shape of the cover insures that it need not be perfectly accurate in order to seal the cage. Complete the ant observation cage by sticking the nail (H) in the hole.





Detail



Detail

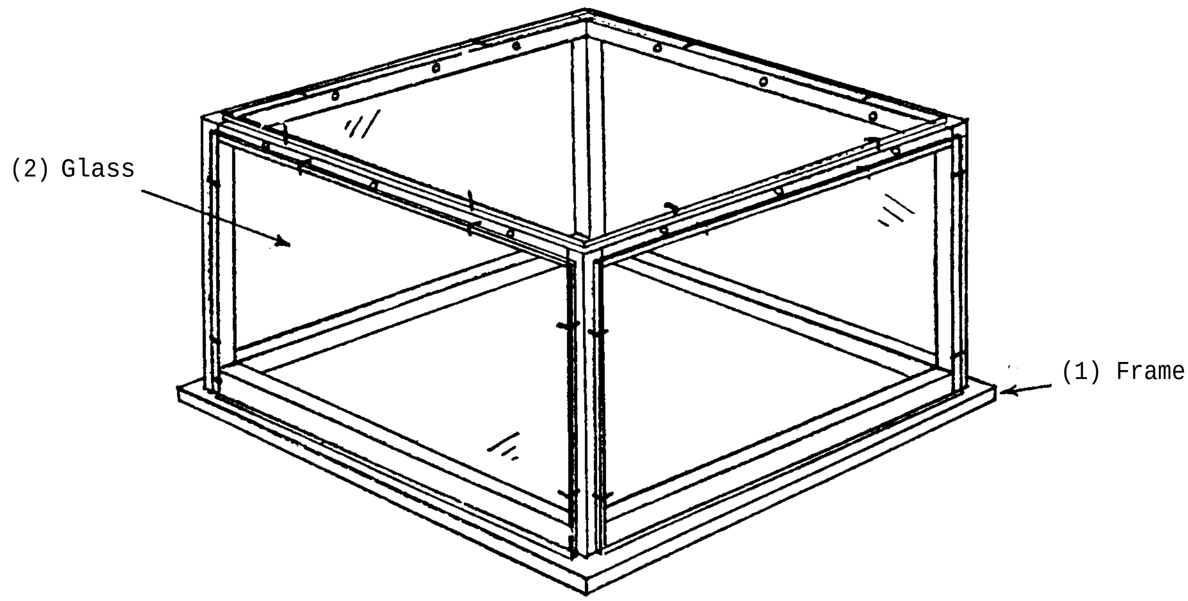
c. Notes

(i) Prepare the cage for use by filling it to within 2 - 3 cm of the top with soil. The soil should be firm, but not tightly packed. Add the ants (include a "queen" ant), and feed them by dropping moistened sugar, bread crumbs, etc., through the hole in the cover. Keep the cage covered when not actually observing the ants as this will encourage their tunneling activity.

(ii) The soil ought to be kept moist, so the cage should be taped with waterproof tape. Taping allows the cage to be easily dismantled, cleaned and reassembled.

(iii) Ant observation cages of different dimensions from those given here can be made, but the basic design need not be altered.

A10. Glass Cage

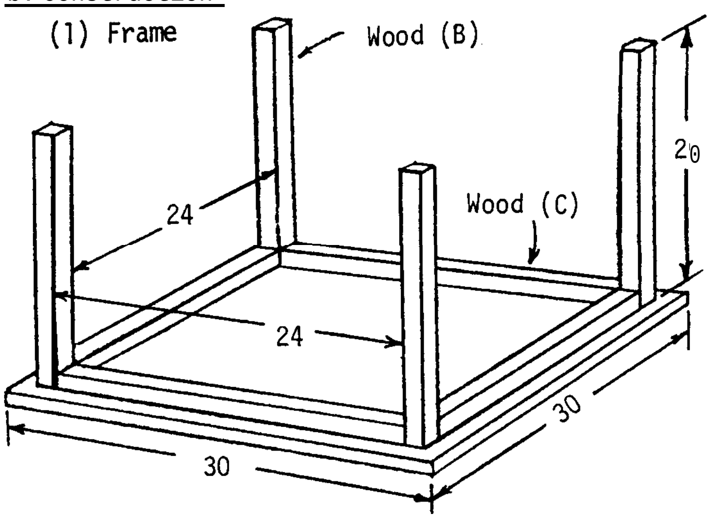


a. Materials Required

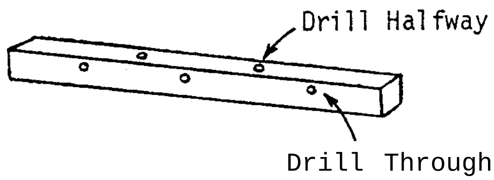
Components	Qu	Items Required	Dimensions
(1) Frame	1	Plywood (A)	30 cm x 30 cm x 1.0 cm
	4	Wood (B)	20 cm x 2 cm x 2 cm
	a	Wood (C)	24 cm x 2 cm x 2 cm
	32	Nails (D)	2.5 cm long
(2) Glass	4	Glass (E)	25.5 cm x 18.75 cm x 0.3 cm
	1	Glass (F)	25.5 cm x 25.5 cm x 0.3 cm

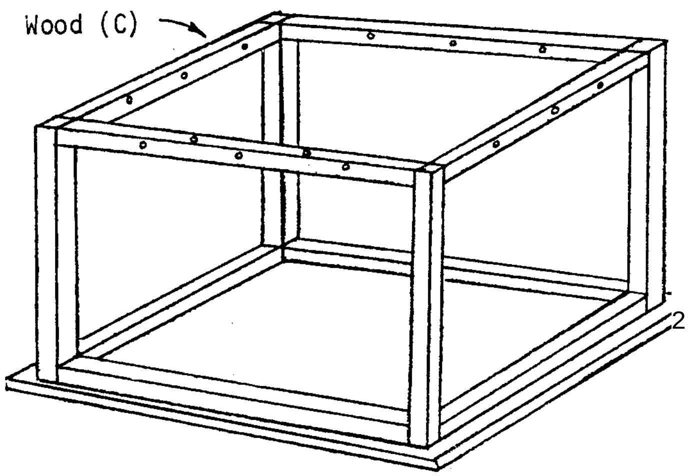
b. Construction

(1) Frame



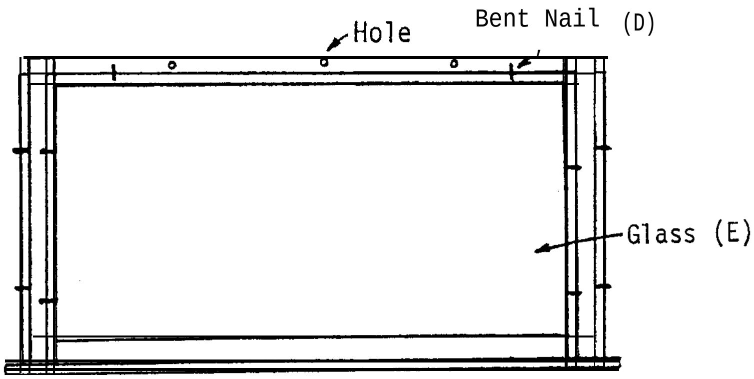
Use the plywood (A) as the cage base. Screw the four short pieces of wood (B) to the base from the back side of the base so that each of their edges is 1.0 cm from the edge of the base. Nail four of the remaining pieces (C) to the base (A) and uprights (B), between the uprights and 1.0 cm from the edge of the base.





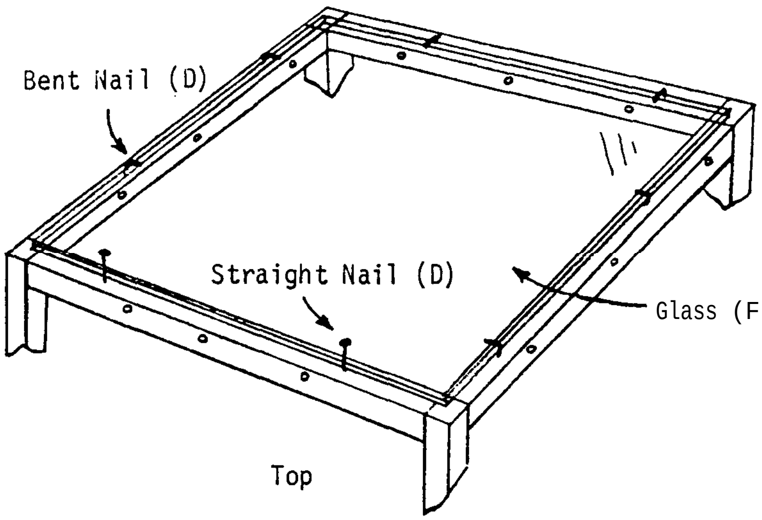
Drill three holes (0.2 cm in diameter) through each of the four remaining pieces of wood (C). Space the three holes about 6 cm apart and 0.5 cm from one edge. In one of these pieces of wood, drill two additional holes 0.2 cm in diameter. Drill them 0.5 cm from the same edge the other three holes are near, but only drill them halfway through the wood. Nail these four pieces to the uprights so that the holes are parallel to the base, and the holes must be closest to the top edge of the wood rather than the bottom. These three holes serve to ventilate the cage.

(2) Glass



Side View

Position one of the glass pieces (E) against the side of the frame so that it overlaps the edges of the frame by about 0.75 cm on all three sides. Drive four nails (D), two per vertical side, into the frame as close to the glass as possible. Only drive them in about halfway and remove the glass. Bend each nail over at right angles, and replace the glass. The nails should overlap the glass and hold it upright against the frame. Nail two more nails (D) above the glass and bend them down in a similar manner to keep the glass side firmly in place. Be



careful not to break the glass.

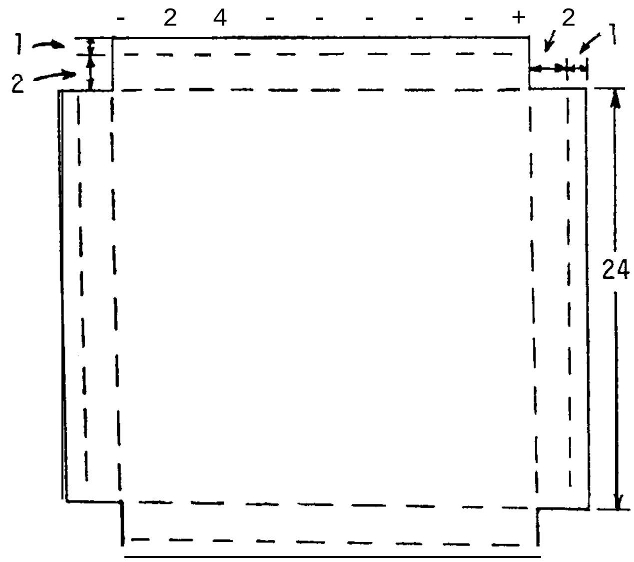
Fasten the remaining piece of glass (F) to the top in a similar manner as was done with the sides. Nail six nails (D), two per side, and bend them over to hold the glass in place. Put two nails in the holes in the remaining side of the frame. These two nails should slip easily in and out the holes so that they can be removed and the top glass plate removed by sliding it out from under the bent nails. Do not bend these last two nails.

c. Notes

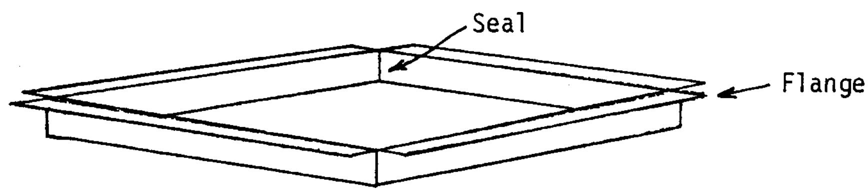
(i) This cage is designed primarily to house small reptiles (especially lizards and snakes) and other small, non-gnawing animals. The bottom of the cage can be filled with 1.5 - 2 cm of clean sand or gravel. If burrowing animals are to be kept, build the bottom of the frame higher so that the sand or gravel may be made deeper. Water may be provided in a jar lid and food simply dropped in from the top.

(ii) The dimensions of this cage can easily be altered depending on the number, size, and habits of the animals to be housed in it.

(iii) If it is so desired, a metal tray can be fashioned for the bottom of the cage to hold the sand or gravel. This makes the cage much easier to clean as the tray can simply be lifted out of the cage, the sand or gravel cleaned by running it through a seive, and replacing it. The tray prevents the wood from absorbing liquid wastes and spilled water and food. The pattern given here will fit the cage as described above. (See illustration on next page.)



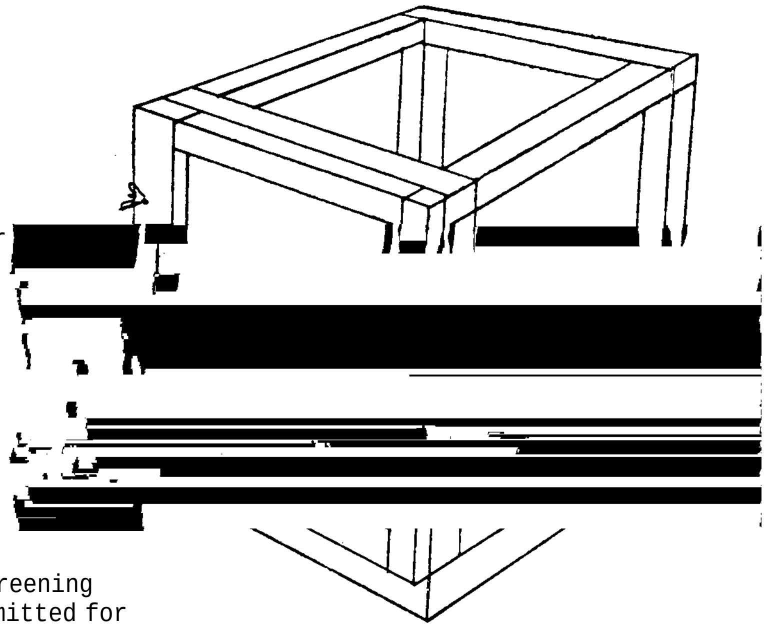
Fold the pattern along the dotted lines to the following shape.



Seal the inside corner joints with a waterproof sealant (e.g., pitch) and set the tray in place in the bottom of the cage. The flanges should overlap the bottom portion of the frame.

B. WOODEN CAGES

B1. Wooden Frame Cage

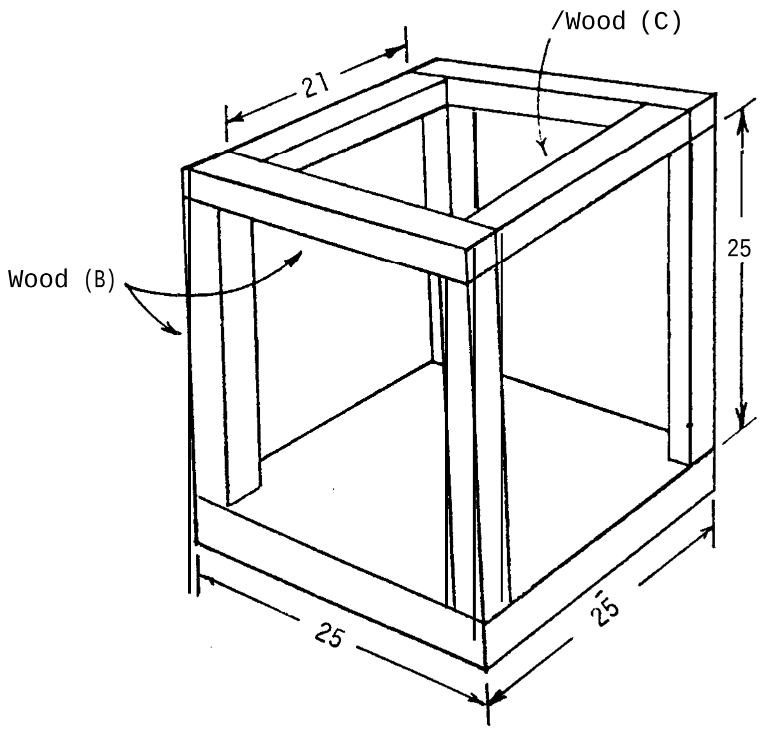


a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Frame	1	Wood (A)	25 cm x 25 cm x 1.0 cm
	6	Wood (B)	25 cm x 2 cm x 2 cm
	2	Wood (C)	21 cm x 2 cm x 2 cm
(2) Door	2	Wood (D)	27 cm x 3 cm x 1.0 cm
	2	Wood (E)	19 cm x 3 cm x 1.0 cm
	2	Hinges (F)	About 3 cm x 2 cm
	4	Nails (G)	2 cm long
	2	Rubber Bands (H)	--
(3) Screening	1	Wire Mesh (I)	24 cm x 24 cm
	3	Wire Mesh (J)	26 cm x 24 cm
	1	Cloth (K)	85 cm x 25 cm
	1	Rubber Band (L)	--

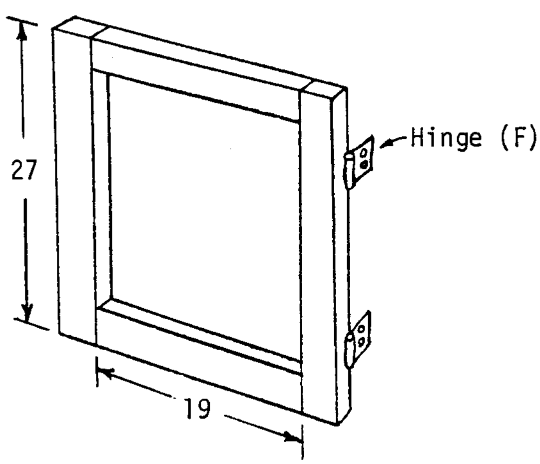
b. Construction

(i) Frame

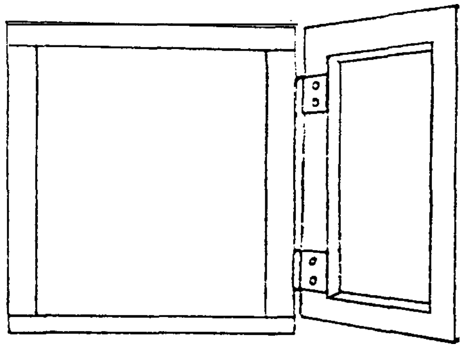


Glue, nail, or screw four of the long pieces of wood (B) to the four corners of the square piece (A) to form the uprights of the cage. Nail the two remaining long wooden pieces (B) to the tops of adjacent uprights. Then, nail the two short pieces (C) into place to complete the basic cage frame.

(2) Door

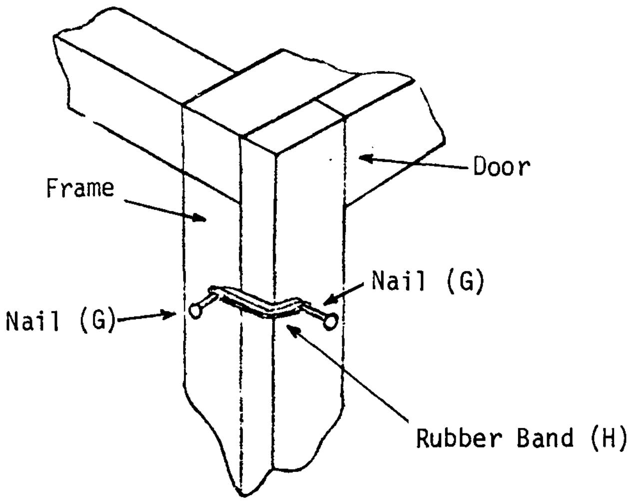


Glue, nail, or screw the short pieces of wood (E) between the long pieces (D) to form the frame for the door. Attach two small hinges (F) to the back of the door.



Front View

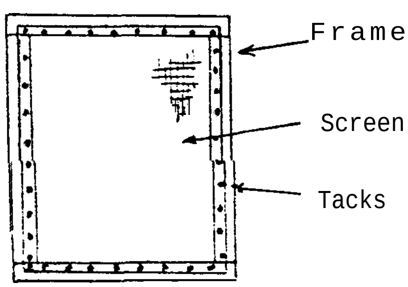
Next, fasten the door to the frame by use of the two hinges.



Detail

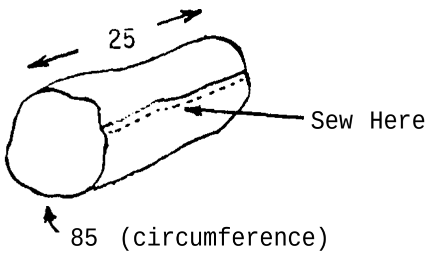
To keep the door shut, hammer nails (G) at both top and bottom of the door and frame. When the door is shut, wrap a strong rubber band (H) around each set of nails to keep the door shut.

(3) Screening

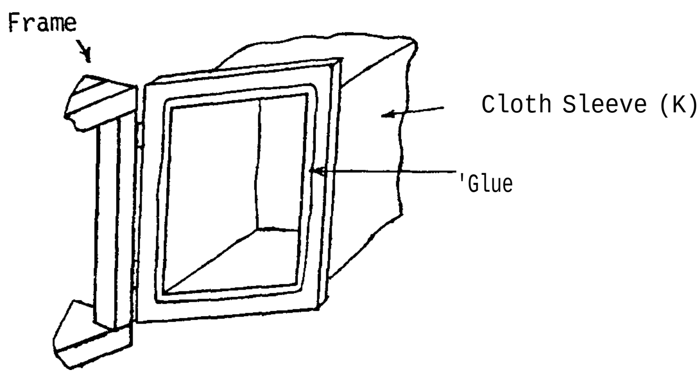


Side View

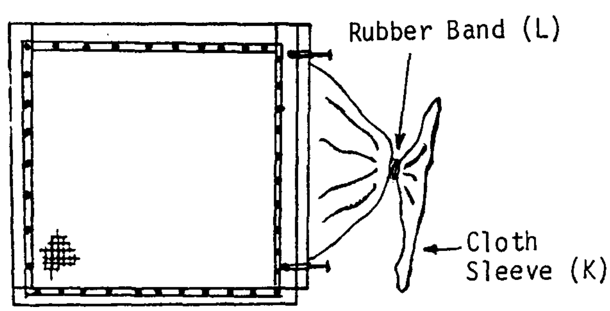
Attach the three pieces of screening (J) (cloth mesh may also be used) to the three sides and the fourth (I) to the top of the frame by gluing or tacking them in place. Liberal use of glue helps seal the joint between the screen and wood, especially if cloth mesh is used instead of wire mesh.



Sew the piece of cloth (K) along the <u>short</u> (25 cm) edge to make a kind of tube or "sleeve". Then, glue one end all around the inside edge of the door, making certain there are no gaps in the glue seam.



Detail



Side View

To complete the cage, close and latch the door, twist the protruding end of the cloth tube tight, and close it off with the rubber band,(L).

C. Notes

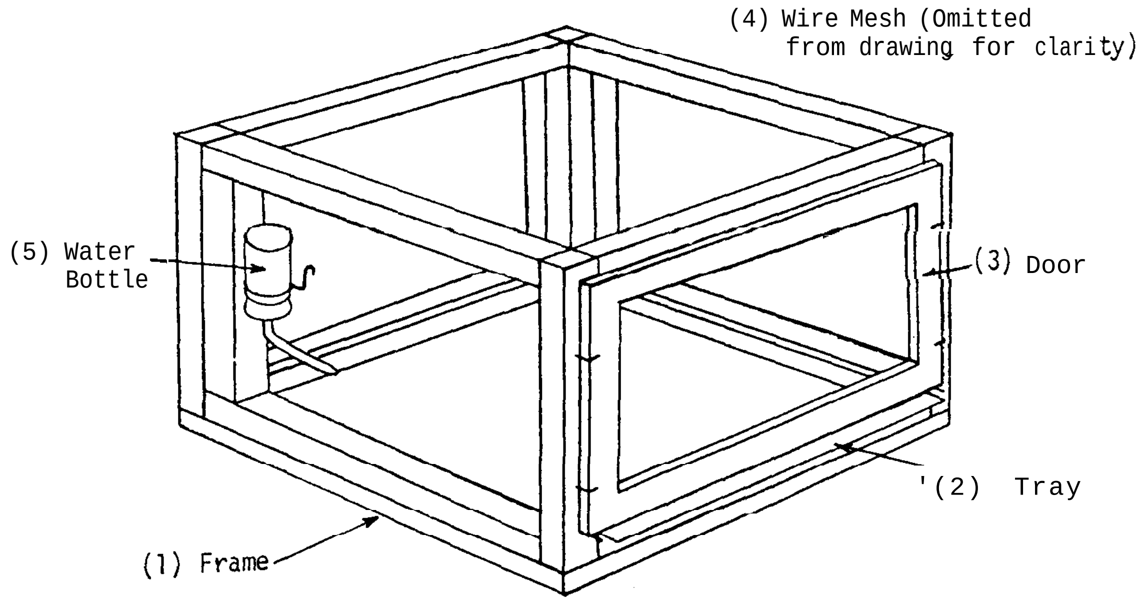
(i) The door can be opened to allow the cage to be cleaned, rearranged, etc. However, when the cage contains insects, items such as food, water, and the insects themselves can be put into and taken out of the cage by undoing the rubber band, slipping one hand through the cloth sleeve into the cage, and holding the cloth tightly around the arm in the sleeve with the other hand; this method prevents the insects from escaping.

(ii) See insect cages VI/A3 and VI/A4 for making watering and feeding devices for insects.

(iii) Since cloth is used for the sleeve and may be used for the sides, keep only insects or other small animals which are unable to chew their way through cloth in this cage.

I

B2. Wire Cage



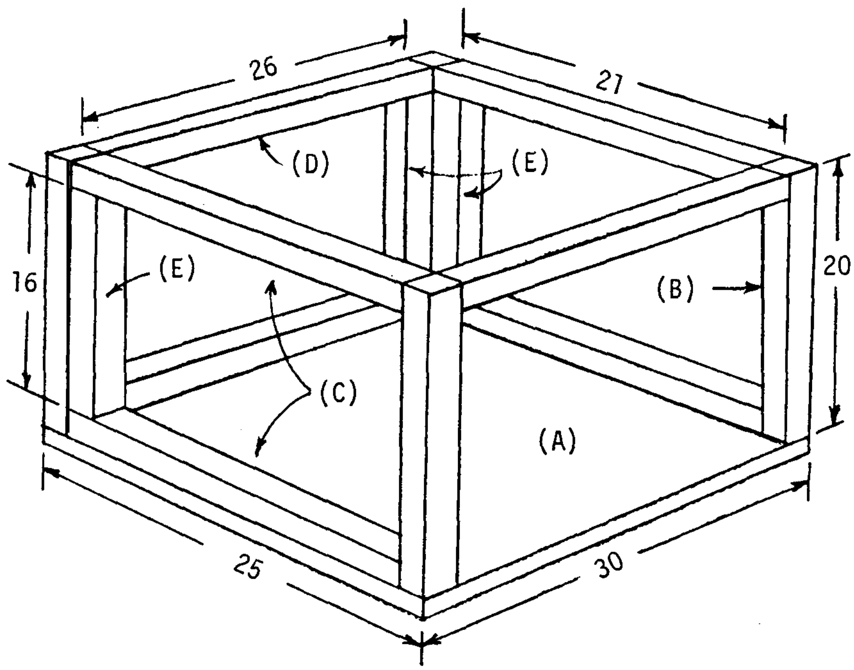
a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Frame	1	Plywood (A)	25 cm x 30 cm x 0.5 cm
	4	Wood (B)	20 cm x 2 cm x 2 cm
	4	Wood (C)	21 cm x 2 cm x 2 cm
	3	Wood (D)	26 cm x 2 cm x 2 cm
	4	Wood (E)	16 cm x 2 cm x 2 cm
(2) Tray	1	Sheet Metal (F)	30 cm x 30 cm x 0.05 cm
(3) Door	2	Wood (G)	28 cm x 3 cm x 1.0 cm
	2	Wood (H)	18 cm x 3 cm x 1.0 cm
	1	Wire Mesh (I)	28 cm X18 cm
	6	Nails (J)	2.5 cm long
(4) Wire Mesh	1	Wire Mesh (K)	23 cm x 62 cm
	1	Wire Mesh (L)	23 cm x 28 cm
	1	Wire Mesh (M)	20 cm x 26 cm
(5) Water Bottle	1	Vial (N)	50-100 ml capacity
	1	l-Hole Stopper (O)	To fit vial

1	Glass Tube (P)	10 cm long, 0.7 cm outside diameter, 0.5 cm inside diameter
1	Stiff Wire (Q)	About 20 cm long

b. Construction

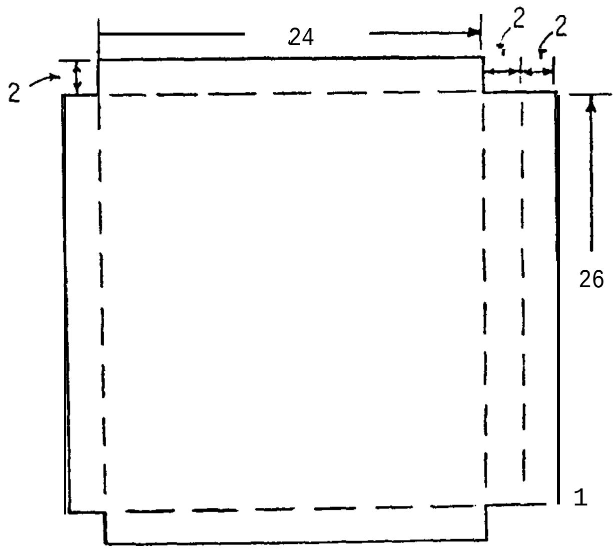
(1) Frame

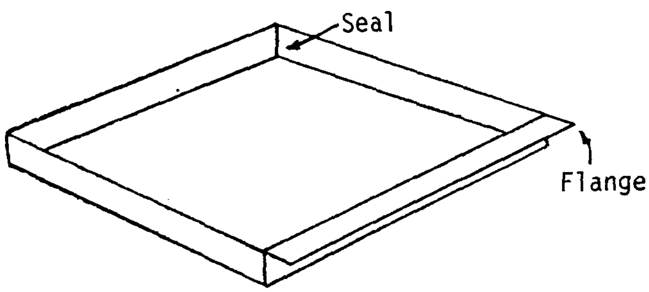


Nail or screw the four 20 cm pieces of wood (B) onto the four corners of the piece of plywood (A) used as the base. Make certain they are even with the edges of the base. Next, nail the four 21 cm pieces (C) into position between the.upright pieces, two at each side of the cage. Nail the lower ones to both the base and uprights. Nail the three 26 cm pieces (D) between the uprights, one at the top front, and two in the rear, top and bottom. Finally, nail the four 16 cm pieces (E) into position at the two back corners of the cage, one on each side of each upright.

(2) Tray

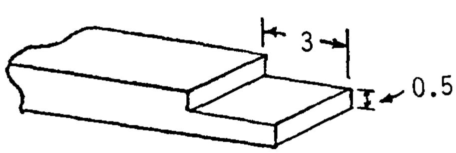
Cut the sheet metal (F) to the given pattern. Bend up the sides along the dotted lines and bend down the flange at the front. Seal the corners with a waterproof sealant (e.g., pitch). The tray should slide easily into the cage and protrude from the front for 1.0 cm.

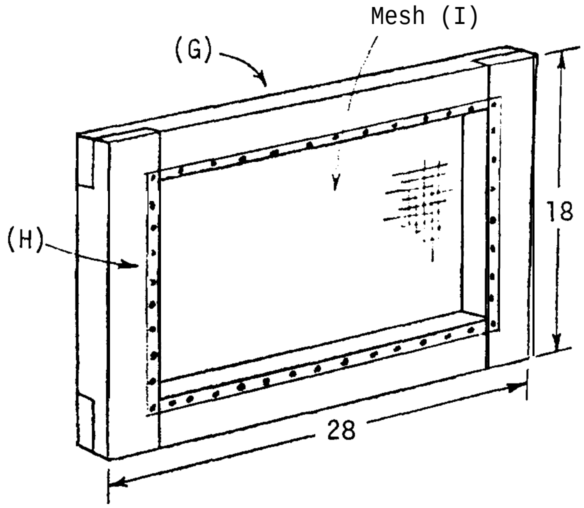




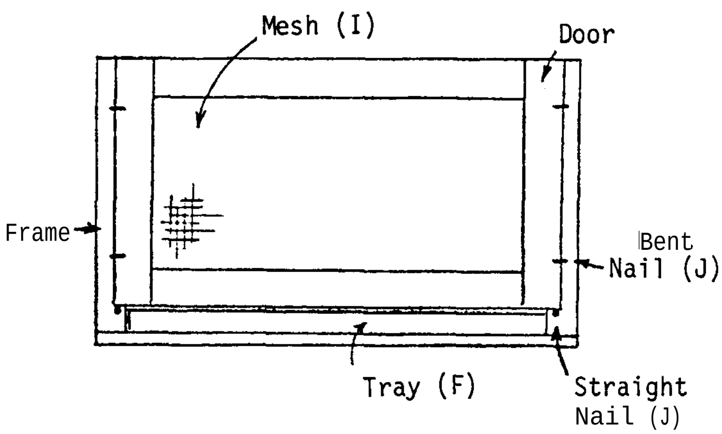
3) Door

Make the door from the four pieces of wood (G,H) by using half-lap joints. This simply involves cutting away half the piece of wood where the two pieces to be joined overlap.





Nail the wire mesh (I) to the back of the door making certain that it covers all wood portions completely to discourage gnawing animals like mice. If possible, use mesh with openings about 0.5 cm square rather than regular wire screening that is used in house screens.

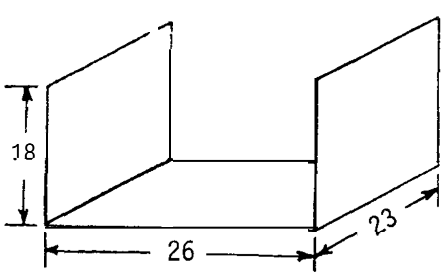


Front View

To form a holder for the door, first hammer two nails (J) into the front of the frame at a level even with the top of the tray. Drive. them in 1 - 1.5 cm but do not bend them. Set the door on these two nails and be certain that it completely covers the opening. Nail two nails (J) on each side of the door as close to it as possible and bend them over so that they hold the door in an upright position. The door should slide easily in and out of position. Remove the door while completing the cage construction.

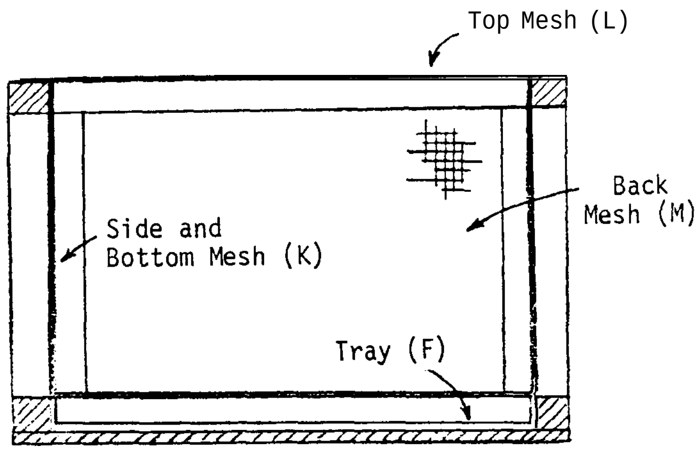
1

(4) Wire Mesh



Mesh (K)

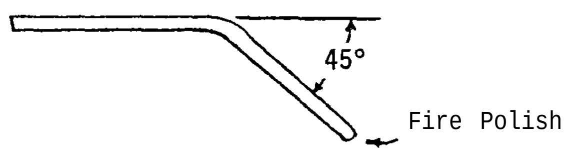
Fold the long piece of wire mesh (K) (again, use the 0.5 cm square size if possible) to the shape shown. Then, nail the 20 cm piece (M) into position to seal off the rear of the cage. Next, nail the folded piece (K) into position so that

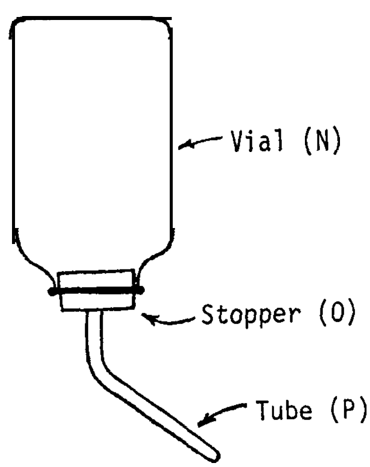


Cross Section View

the sidepieces cover the sides of the cage completely. The bottom of the screen will be 2 cm above the floor of the cage (actually, it will be level with the top edge of the tray). Properly done, wire mesh should cover the inside of the cage so that no wood is exposed. Finally, nail the remaining piece of mesh (L) onto the top of the cage.

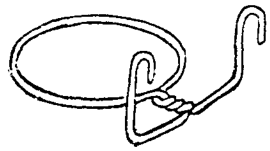
(5) Water Bottle





Begin the water bottle by bending the glass tube (P) in the middle to about a 45° angle. Fire polish one end until the opening constricts very slightly. Insert the other end of the tube into the stopper (0). Fill the vial (N) with water and seal the opening with the stopper.

When the vial is upside down water should flow down into the tube and stop at the end. One may have to tap the tube lightly with a finger to break up air bubbles in the tube.



Hanger (Q)
(Vial not shown
for clarity)

To make a hanger for the water bottle, use the piece of stiff wire (Q). Twist the wire around the stopper, then bend the loose ends as shown. The water bottle can then be hung on the outside of the cage with the glass tube sticking through the wire mesh. Animals such as mice and gerbils soon learn to lick the end of the tube to obtain water.

C. Notes

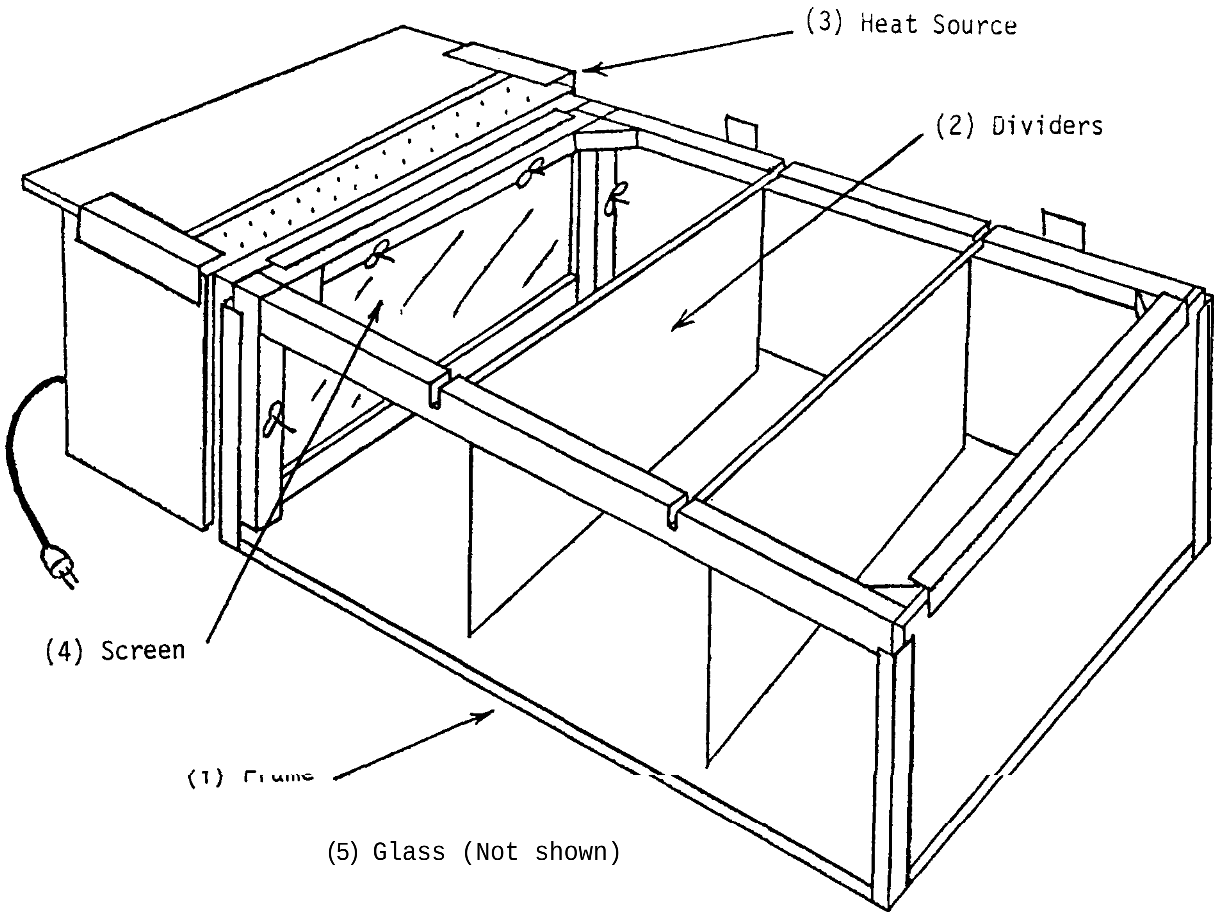
(i) This cage is intended for long-term housing of small mammals. Cover the screen floor with shredded newspaper or sawdust. Wastes fall through the screen floor onto the tray so they can easily be removed. Food can be simply put into a jar lid or shallow tin can.

(ii) The basic design of this cage can be retained and the dimensions altered to accomnodate other animals, especially birds. Remember to provide the basic requirements for each different type of animal (e.g., perches for birds).

(iii) If space is limited, these cages will stack one upon the other. However, the door must be hinged to swing open if it is undesirable to unstack them each time a lower cage is to be opened.

C. TEMPERATURE CONTROLLED CAGES

Cl. Vivarium



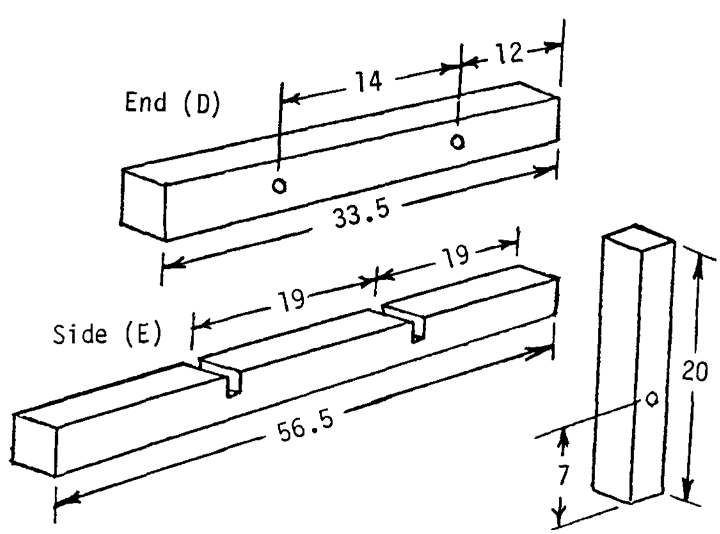
a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Frame	1	Plywood (A)	60 cm x 45 cm x 1.0 cm
	1	Plywood (8)	43.5 cm x 20 cm x 1.0 cm
	2	Wood (C)	20 cm x 2.5 cm x 2.5 cm
	1	Wood (D)	38.5 cm x 2.5 cm x 2.5 cm
	2	Wood (E)	56.5 cm x 2.5 cm x 2.5 cm
	2	Wood (F)	4 cm x 4 cm x 2 cm
	4	Sheet Metal (G)	5 cm x 21 cm x 0.05 cm
	2	Sheet Metal (H)	40 cm x 5 cm x 0.05 cm
(2) Dividers	2	Wood Dowels (I)	42 cm long, 0.75 cm diameter
	2	Cloth (Cotton) (J)	38 cm x 25 cm

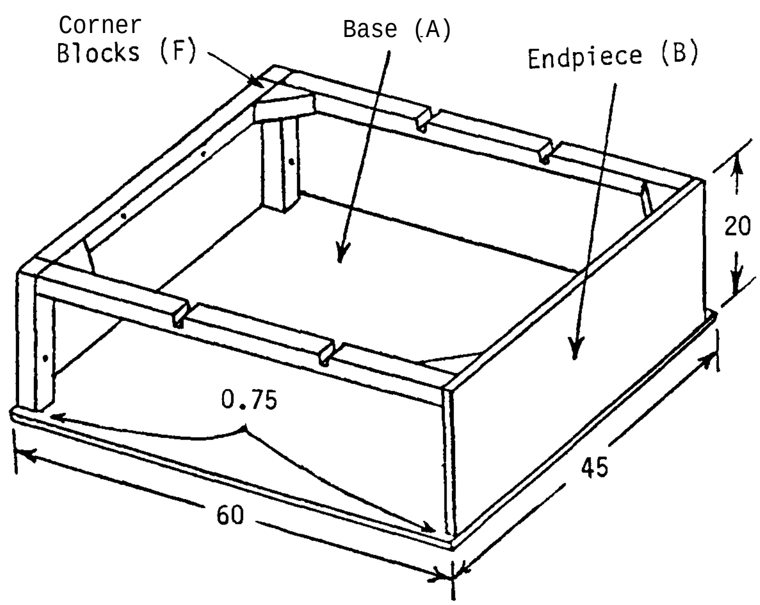
(3) Heat Source	1	Plywood (K)	44 cm x 16 cm x 1.0 cm
	1	Hardboard (L)	16.5 cm x 45 cm x 0.3 cm
	1	Plywood (M)	20 cm x 44 cm x 0.5 cm
	2	Plywood (N)	16.5 cm x 21 cm x 0.5 cm
	2	Wood (O)	20 cm x 4 cm x 1.0 cm
	1	Wood (P)	36 cm x 4 cm x 1.0 cm
	2	Sheet Metal (Q)	14 cm x 5 cm x 0.05 cm
	1	Plywood (R)	44 cm x 15 cm x 0.5 cm
	1	Light Bulb Socket (S)	Varies
	1	Light Bulb (T)	Varies
	1	Electric Cord (U)	150 cm long
		Plug (V)	Varies
(4) Screen	4	Bolts (W)	8 cm long, 0.5 cm diameter
	4	Wing Nuts (X)	0.5.cm inside diameter
	1	Wire Screen (Y)	20 cm x 45 cm
	2	Wood (Z)	21 cm x 3 cm x 0.5 cm
	2	Wood (AA)	39 cm x 3 cm x 0.5 cm
	2	Wood (BB)	45 cm x 3 cm x 0.5 cm
	2	Wood (CC)	15 cm x 3 cm x 0.5 cm
(5) Glass	1	Window Glass (DD)	59 cm x 44 cm x 0.25 cm
	2	Window Glass (EE)	19 cm x 59 cm x 0.25 cm
	2	Sheet Metal (FF)	12 cm x 4 cm x 0.05 cm

b. Construction

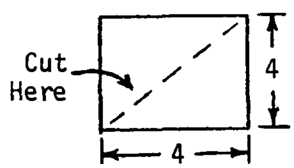
(1) Frame



Notches must be made in the two sidepieces (E) into which the dividers will be fit, Also, holes need to be drilled through the end (D) and the two uprights (C) through which the bolts hold the frame, screen, and heat source are put. However, these holes should be drilled when the three components (frame, screen, heat source) are held together in place with clamps in order to insure that the holes will be aligned.

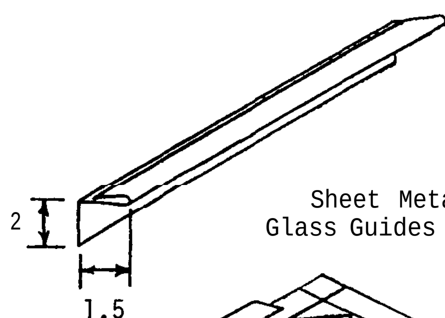


Nail, screw and/or glue the endpiece (B) to the base (A), flush to one edge and 0.75 cm from the other two edges. Nail two uprights (C) to the base, flush to the opposite end and each 0.75 cm from the outside edge. Nail the sidepieces (E) into position between the uprights and endpiece, and also nail the end (D) between the two uprights.

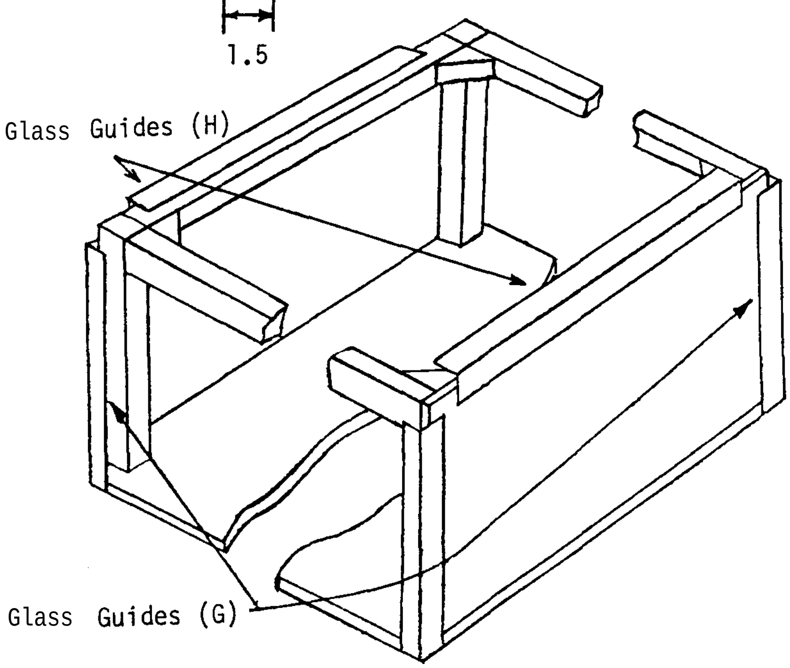


Corner Blocks (F)

Two square pieces of wood (F) cut into triangular shapes are used as corner blocks to provide additional support and strength.

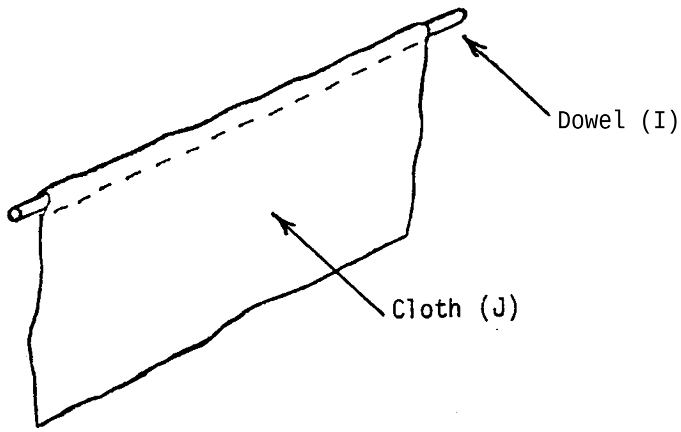


Sheet Metal
Glass Guides (G,H)



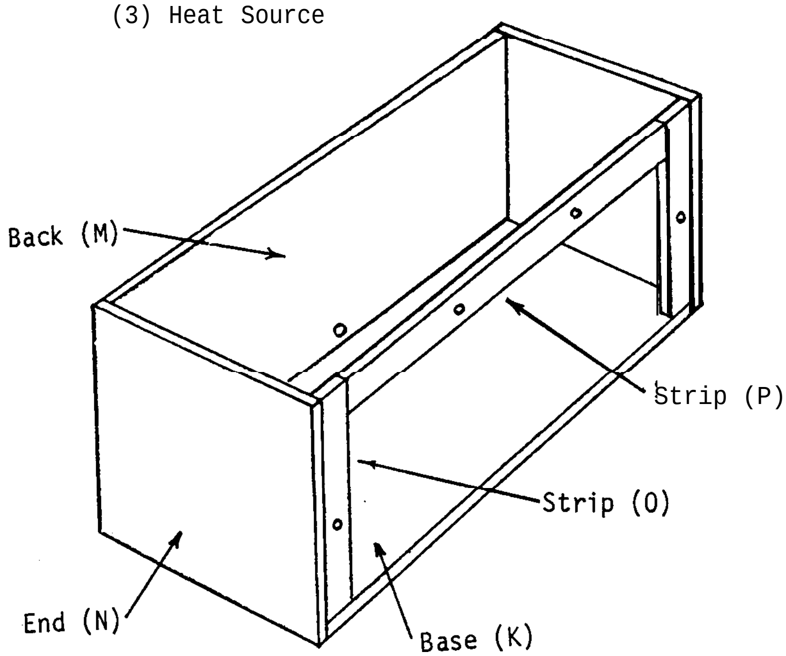
To provide guides for the glass, six rectangular pieces of aluminum sheeting (G, H) (0.05cm thick) are required. They are folded to the shape shown. Four (G) are nailed to the upright and endpiece. The remaining two (H) are nailed to the end and endpiece. These guides should be fastened in such a way as to provide approximately a 0.75 cm gap between wood and metal so that the glass can slide easily in and out.

(2) Dividers



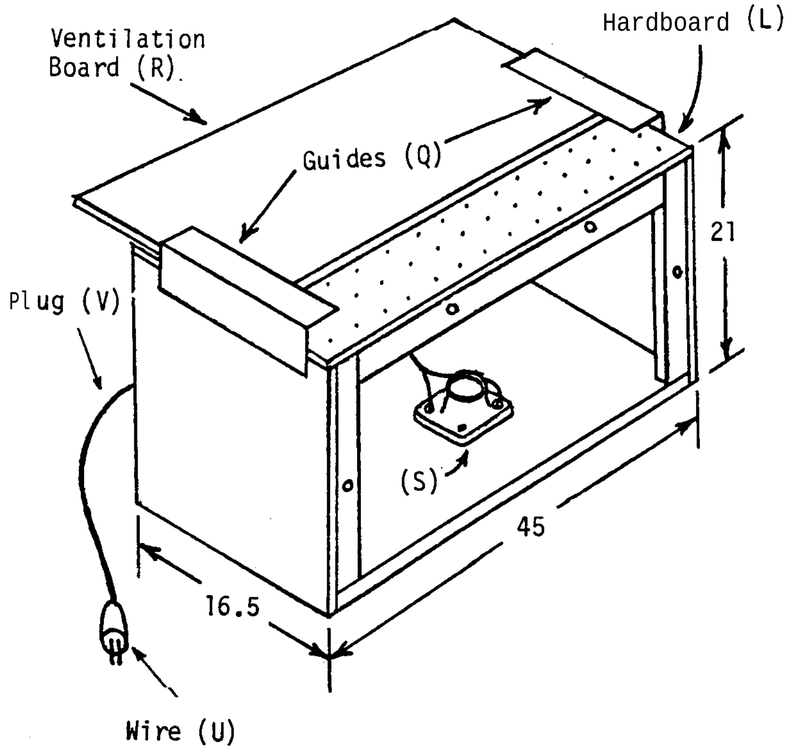
The dividers are simply made with wooden dowels (I). A piece of cotton cloth (J) is sewn around the dowel, and hangs down to within 1 or 2 cm of the base. The dividers (two are needed) are fit into the notches in the frame sides.

(3) Heat Source



Use the piece of plywood (K) as the base of the heat source. Fasten the two plywood pieces (N) to the ends of the base and the third plywood piece (M) to the back. Nail two of the wood strips (0) to the base and ends,and nail the remaining strip (P) between these two pieces (0).

Nail the piece of hardboard (L) to the top of the frame to enclose it. This hardboard should be the perforated type with 0.5 cm holes spaced every 2.5 - 3.0 cm. If such hard-board is not available, it can easily be made by making holes in regular board. Holes must also be made in the heat source, but again, these should be



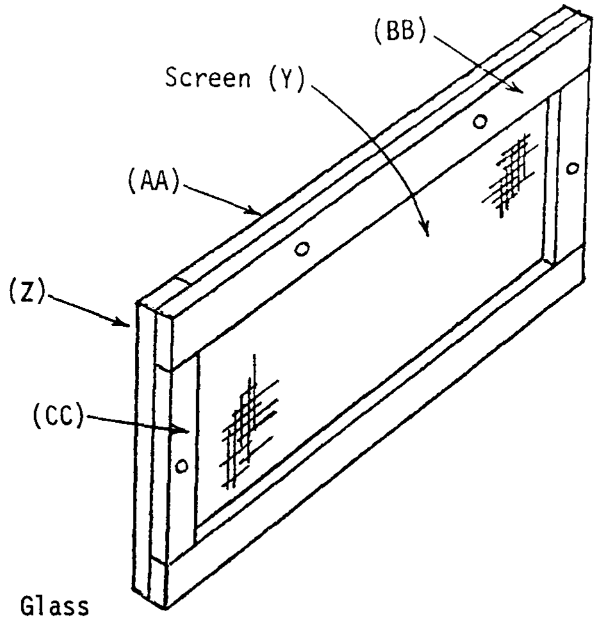
drilled when the frame, screen, and heat source can all be held together with clamps to insure alignment of the holes. Drill another hole in the back to allow the wire to the light bulb socket to run through.

Two guides (Q) are needed for the ventilation board, and are nailed to the sides of the heat source. Make these like the glass guides described in construction step (1). The ventilation board (R) is made of thin plywood slightly shorter in length and width than the top of the heat source. It should slide easily in and out between the guides (Q).

Finally, fasten a light bulb socket (S) in the middle of the heat source. Wire a plug (V) to the socket with the wire (U) and lead it out of the box through a small hole drilled in the back. Screw a bulb (T) in place.

(4) Screen

The screen is made with eight pieces of wood. Form two rectangular frames. Make one by nailing two pieces of wood (CC) between the two pieces (BB), and the second frame by nailing two pieces (AA) between the shorter pieces (Z). The aluminum screening (Y) (wire mesh) is fastened between the two frames with nails, and the frames are nailed and glued

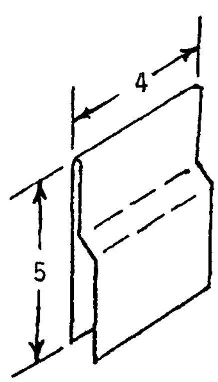


(5) Glass

together. The four holes for the connecting bolts (W) will be made when the three components (frame, screen, heat source) are clamped together, and the holes are drilled through all three parts at once.

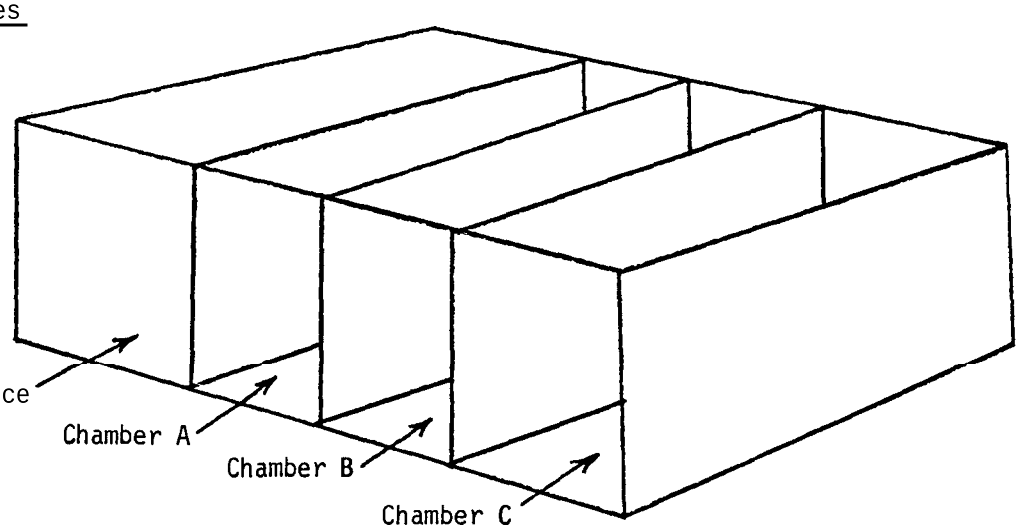
The heat source, screen, and frame are connected together with the bolts (W) and wing nuts (X).

Three glass plates are not shown in the main illustration in order to preserve clarity. However, the two side plates (EE) are made from standard window glass (0.2 cm in thickness). They fit between the glass guides on the frame sides. The top plate is also window glass (DD). The top plate of glass fits between the two glass guides on the top of the frame. Any of the three pieces of glass should slide easily in and out of place when the other two are in position. Additionally, air gaps should be kept to a minimum.



Finally, two pieces of aluminum sheeting (FF) can be folded to the shape shown and slipped over the top edge of one of the side pieces of glass (EE). These pieces of aluminum then act as stops to keep the top glass plate (DD) from sliding out.

C. Notes



(i) The vivarium is a cage in which the cloth dividers are used to loosely partition the interior into three chambers. The heat source employs light bulbs as the heating elements. A desirable result would be to maintain an even temperature gradient (i.e., 35°, 30°, 25° C) in the three chambers so that animals placed in the vivarium could seek their own optimal temperature level. For instance, the temperatures given above would imply that it was thought that the optimal environmental temperature for a given animal was 30°C (the temperature maintained in Chamber B). In this case, even if the vivarium were placed out-of-doors and subjected to temperature fluctuations of ± 5°C, one of the chambers would still maintain the 30°C level (e.g., temperatures in the vivarium might be depressed to <u>30</u>°, 25°, 20° or elevated to 40°, 35°, <u>30</u>° C). In order to insure that the desired temperature is maintained in at least one chamber, it may be necessary to increase the number of chambers from the three used in this experimentation, In fact, all the conclusions given here must be qualified by the limited nature of the experimentation.

(ii) Following construction of a vivarium, experimentation was carried out to determine which variables affect the establishment of the temperature gradient, and how these variables affect this gradient, both separately and in combination. Variables found to influence the temperature gradient included bulb size (wattage), divider material, height of the dividers above the floor of the cage, use of a reflector in the heat source and ambient (room) temperature.

(iii) Generally, increasing the bulb size (wattage) caused a marked increase in temperature in Chamber A, less so in Chamber B, and little or no change in temperature in Chamber C. The result was that the temperature gradient, rather than increasing in equal increments (i.e., 34°, 30°, 26° C), tended to increase in unequal increments (e.g., 36°, 26°, 23° C).

(iv) The material from which the dividers are made was found to have little effect on the temperature gradient maintained in the cage, but the amount of space left between the bottom of the dividers and the vivarium floor did have a compacting effect on the temperatures, i.e., bringing those in Chambers A and C closer to that in B.

(v) As might be expected, using a reflector in the heat source caused an overall rise in temperature in the vivarium. The last variable to be investigated, ambient (surrounding) temperature, was seen to have a profound influence on the internal temperatures in the vivarium, and is probably the most important variable to be considered. No doubt, the vivarium walls will have to be altered using better insulating materials (e.g., wood rather than glass) in order to reduce the influence of the ambient temperature,

(vi) Some other variables which were not investigated also may have an effect on temperature control. Among these is the material in the screen between the heat source and cage itself. It was aluminum screening for all the experimentation described here, but may well have different effects if it were made from steel rods or other materials. The type and amount of ventilation will also be an influence.

The dimensions of the vivarium are also important since a larger cage will obviously be harder to heat and maintain. The number and size of the chambers are variables to be reckoned with.

Finally, the most important factor will be the animals and their requirements. Testing must be done to see if a reasonable range of temperatures can be maintained for a variety of animals (e.g., baby chickens, mice, lizards, etc.). If experiments are to be run involving the determination of optimal temperature requirements for a particular animal, the range of temperatures provided must be narrow enough so that there will be some assurance that the animal has indeed chosen its favorite temperature, and not simply chosen the lesser of three evils. For example, if the optimal temperature for a certain lizard is thought to be 30°C, then the range should be 30°C plus or minus 2° or 3°C rather than plus or minus 6° or 8°.

(vii) Experimentation was also done with the cloth partitions removed, making the vivarium a single chamber. Three conditions were checked using three different bulb wattages (60, 100, 175). In the first condition, the vivarium was used as described above, only without the cloth partitions. In the second condition, one half of the glass top was removed and replaced by wood, and in the third case, the entire top was wood, leaving only the front piece of glass. In all three instances, the aluminum foil reflector was used, and the ventilated top of the heat source was fully closed. The results of this experimentation are tabulated below.

Table I

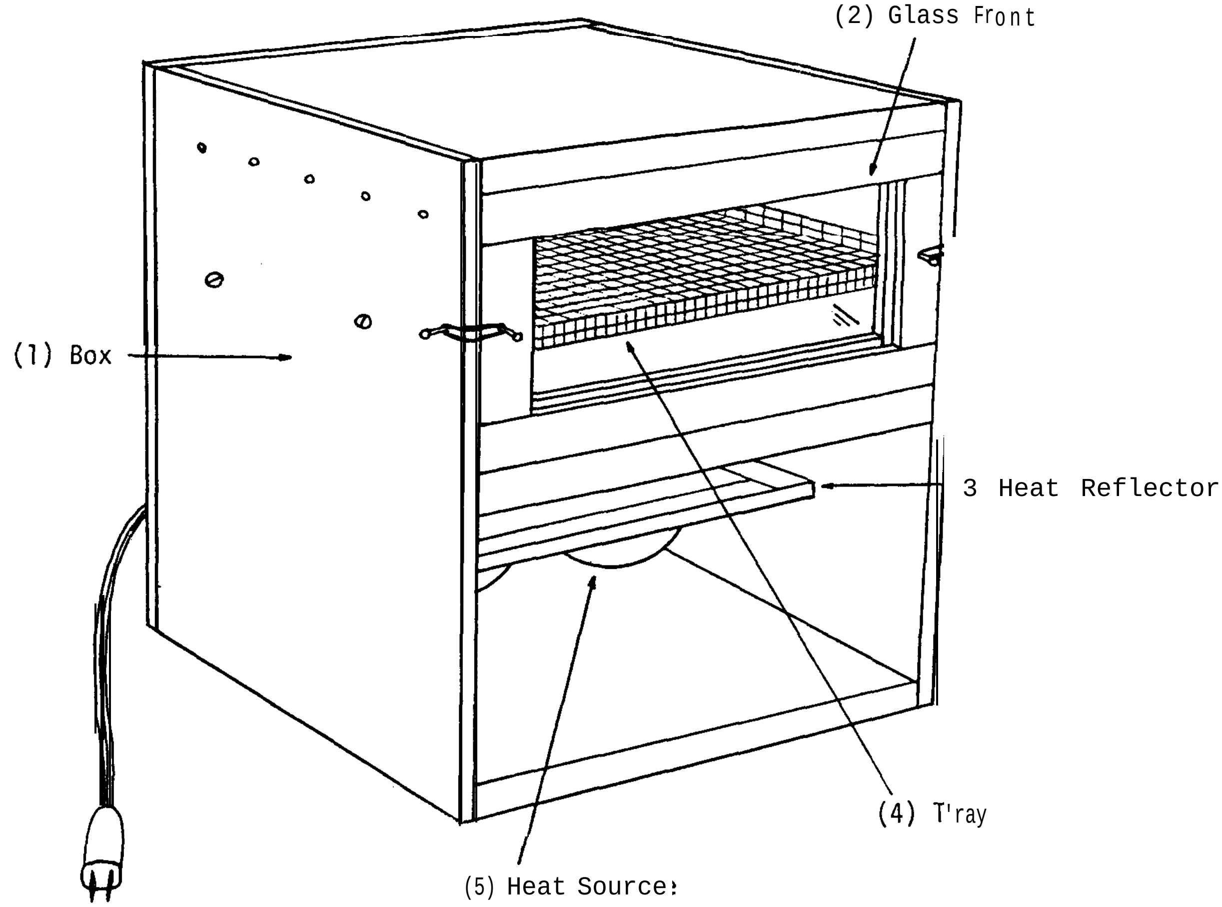
Condition	Wattage	Vivarium Temperature (°C)	Room Temperature (°C)
Top Completely Glass	60	26	22
	100	28	22
	175	33	22.5
Top One Half Glass, One Half Wood	60	26	22
	100	29	22.5
	175	38	24
Top Completely Wood	60	26	22
	100	30	22
	175	37	23

As the data show, there appears to be little significant difference in the various temperatures, although the additional wood does help hold the heat slightly better than the all glass top.

The vivarium will serve adequately as a controlled temperature environment as long as the ambient (room) temperature is kept relatively constant.

(viii) If the vivarium is to be used in a room where the outside temperature varies greatly, it is desirable to control its internal temperature more accurately. Therefore, use the thermostat, item VI/C3. Wire the heat source to the thermostat which should be mounted in the back panel of the vivarium if no wood is used in the top. Keep the thermostat as far from the heat source as possible. In addition, a screen or other protective device must be placed over the thermostat to prevent the animals (and students) from touching the exposed portions of the thermostat which carry current of 110 volts.

C2. Egg Incubator



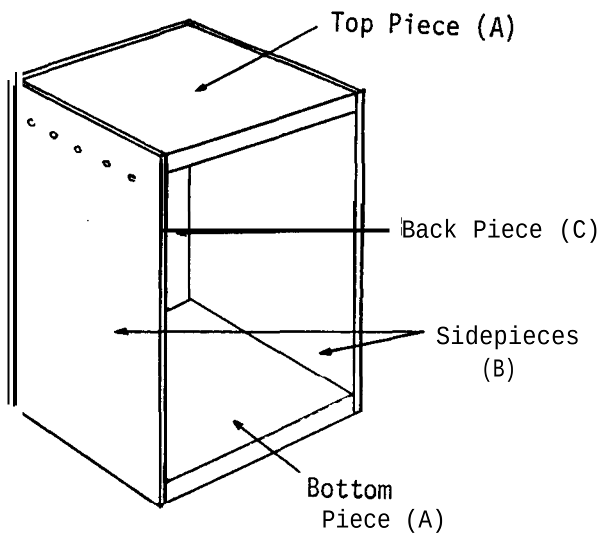
a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Box	2	Wood (A)	23 cm x 20 cm x 1.5 cm
	2	Plywood (B)	20 cm x 36 cm x 1.0 cm
	1	Plywood (C)	25 cm x 36 cm x 1.0 cm
	1	Wood (D)	23 cm x 2 cm x 2 cm
	2	Wood (E)	14 cm x 1.0 cm x 1.0 cm
	1	Wood (F)	23 cm x 1.0 cm x 1.0 cm
	1	Plywood (G)	19 cm x 25 cm x 1.0 cm
(2) Glass Front	2	Glass (H)	18 cm x 10 cm x 0.3 cm
	2	Wood Strips (I)	10 cm x 0.5 cm x 0.5 cm
	2	Wood Strips (J)	17 cm x 0.5 cm x 0.5 cm
	2	Wood (K)	23 cm x 2.5 cm x 2 cm
	2	Wood (L)	15 cm x 2.5 cm x 2 cm
	4	Screws (M)	Approximately 2 cm long
	2	Rubber Bands (N)	--

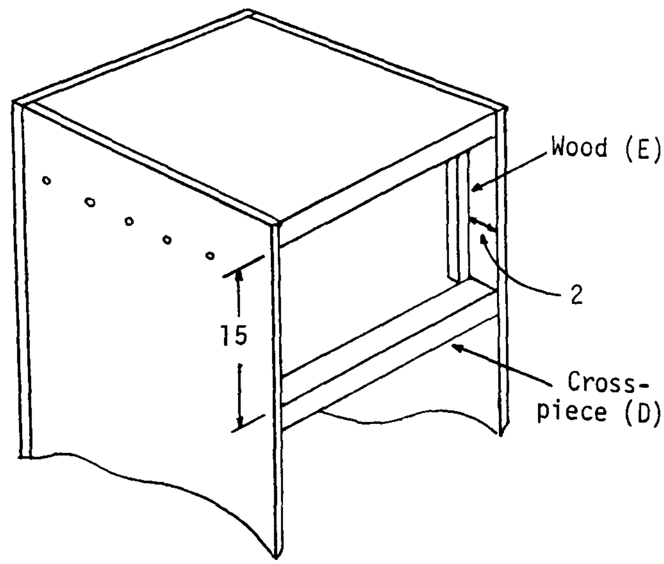
(3) Heat Reflector	1	Plywood (O)	23 cm x 15 cm x 1.0 cm
	1	Aluminum Foil (P)	28 cm x 20 cm
(4) Tray	1	Wire Mesh (Q)	26 cm x 20 cm
	4	Bolts (R)	Approximately 2 cm long
	4	Nuts (S)	To fit bolts
(5) Heat Source	2	Bulb Sockets (T)	10 cm diameter (base)
	4	Bolts (U)	Approximately 3 cm long
	4	Nuts (V)	To fit bolts
	1	Electrical Wire (W)	Approximately 100 cm
	1	Plug (X)	--
	2	Bulbs (Y)	--

b. Construction

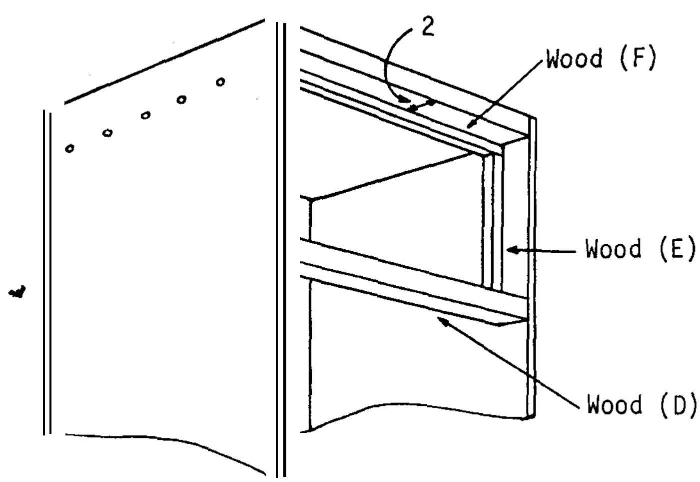
(1) Box

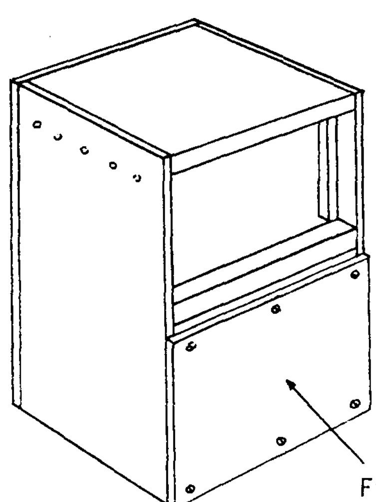


Nail or screw the two sidepieces of plywood (B) to the two pieces of wood (A) serving as the top and bottom of the box. Nail or screw the back (C) into position. Small ventilation holes (0.4 cm diameter) should be drilled along the tops of the sidepieces (B).



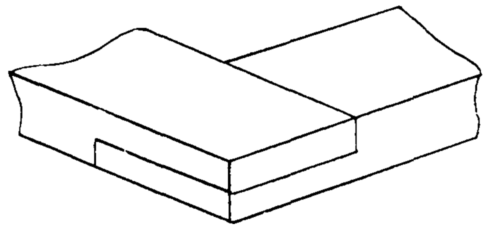
Make certain the crosspiece (D) fits very tightly, and nail or screw it into place. Nail or glue the wood strip (F) to the top (A), 2 cm from the front edge of the top. Likewise, nail or glue the other two wood strips (E) to the sidepieces (B), 2 cm from their front edges between the top (A) and cross-piece (D).



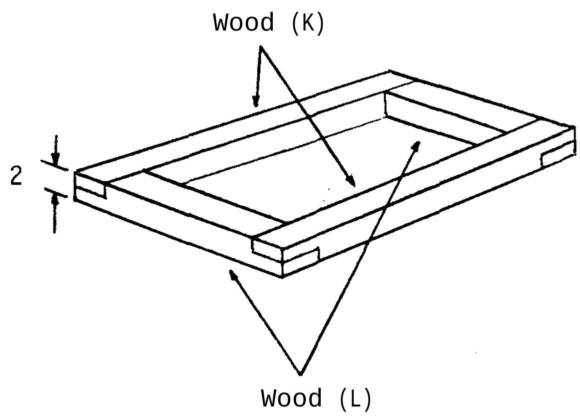


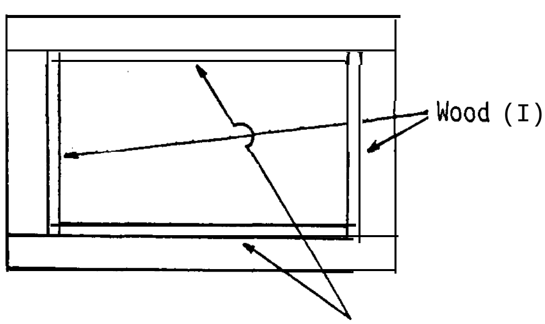
The front panel (G) is screwed into place so it may be easily removed to permit completing the construction of the incubator, and to permit changing the light bulb in the heat source.

(2) Glass Front

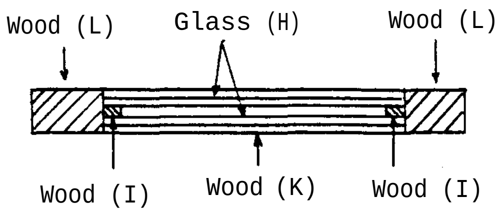


Half-lap Joint





Front View

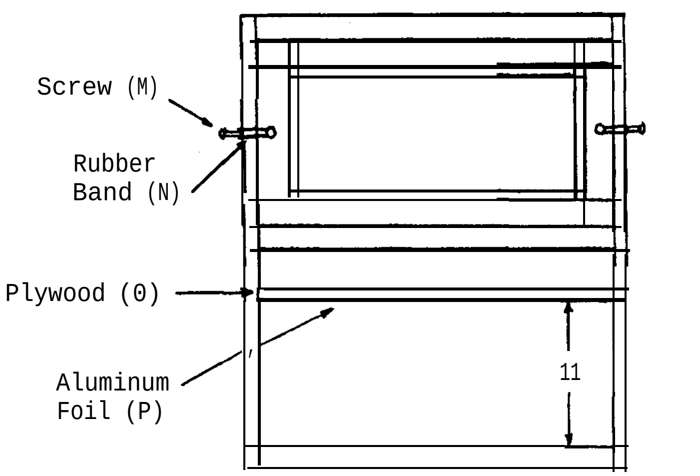


Cross Section

Make the frame for the glass front with half-lap joints (see drawing). Use this type of joint to connect the two short pieces of wood (L) to the two longer ones (K). Glue the two wood strips (I) down the center of the inner surface of the short wood pieces (L), and similarly, glue the longer strips (J) down the center of the inner surface of the long pieces (K). These thin strips serve to separate the two pieces of glass (H) which can now be glued into place with epoxy resin cement.

The glass front should fit tightly in the recess in the front of the box. To hold it in place, fasten one screw (M) on each side of the frame of the glass front and each side of the box adjacent to the glass front. Rubber bands (N) stretched tightly between adjacent screws should hold the glass front firmly in position.

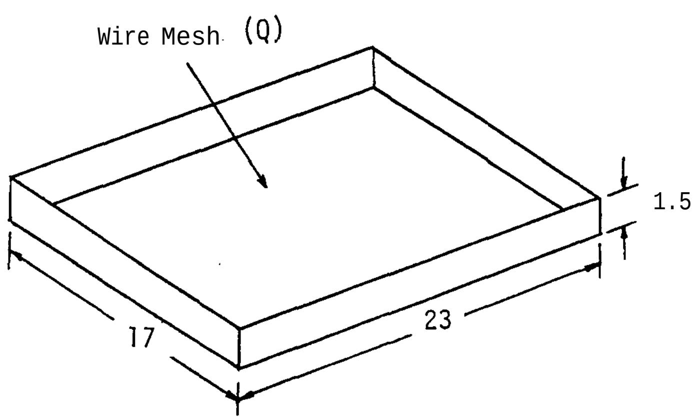
(3) Heat Reflector



Front View

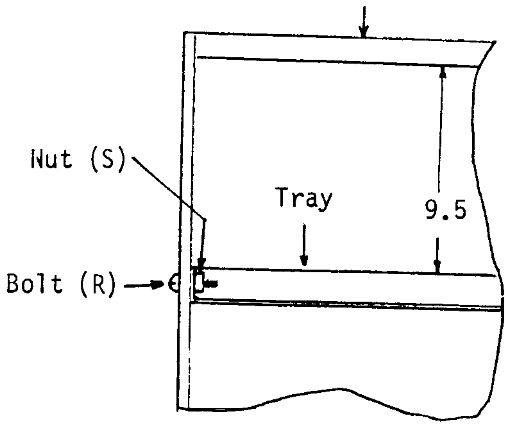
Cover the lower surface of the plywood (0) with the aluminum foil (P) and nail the heat reflector into position as shown. Be sure the rear edge is touching the back (C) of the box.

(4) Tray



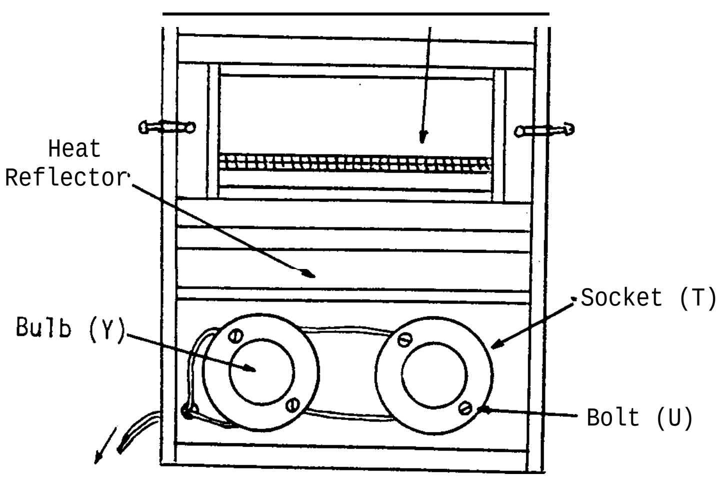
Tray (Diagram)

Use the wide (0.5 cm square) wire mesh (Q) for the tray and fold it so there is a 1.5 cm edge all around. Fasten it to the inside of the box by pinning the side edges of the mesh to the sides of the box with the nuts (S) and bolts (R). Obviously holes will have to be drilled through the sides of the box to permit passage of the bolts. The rear edge of the tray should touch the back (C) of the box.



Front View

(5) Heat Source



Front View

Drill four holes in the back of the box near the bottom through which the bolts (U) will be passed to hold the bulb sockets (T) in position. Wire the sockets together in parallel with short lengths of wire (W) and pass the remaining wire out of the box through a fifth hole drilled in the back. Wire the plug (X) in place, and tighten the nuts (V) onto the bolts (U) now that the bulb sockets are wired. Finally, place the desired number and power (wattage) of light bulbs (Y) in the sockets.

c. Notes

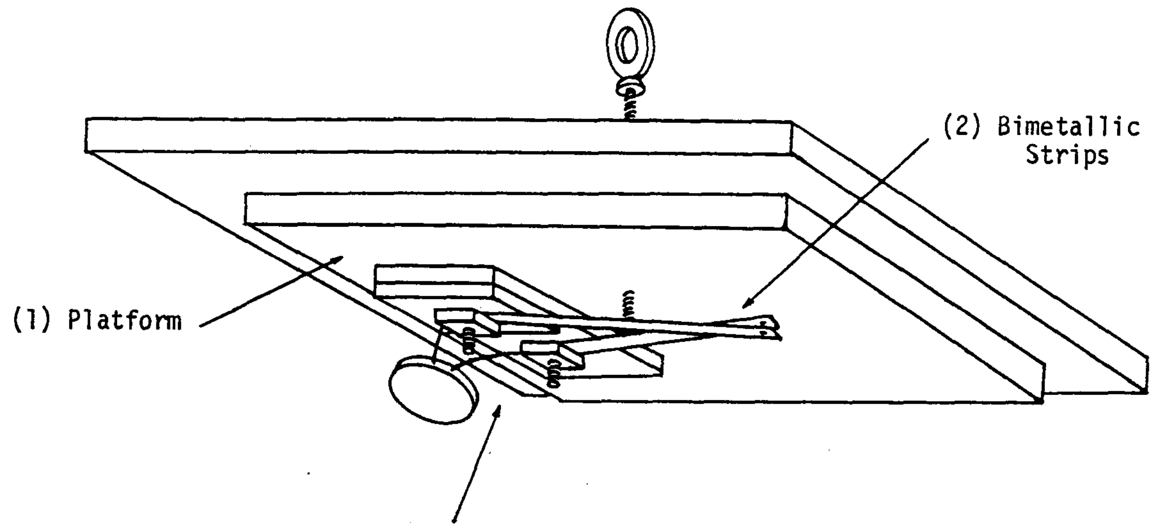
(i) Use the egg incubator in the study of the embryology of chicken or other eggs. The double glass front permits visual observation of the eggs on the tray without undue heat loss.

(ii) The temperature in the incubator will remain constant using varying wattages of light bulbs as long as the room temperature is relatively constant (see the table).

Watts	Incubator Temperature (°C)	Room Temperature (°C)
40	37.5	23.0
60	46.0	25.5
80	51.0	23.0
120	67.0	23.0

(iii) The thermostat (VI/C3) should be used with the incubator to insure that the internal temperature maintains itself at the correct level. Mount it in the top of the incubator, protected by a wire screen which will prevent hatchlings (and people) from touching the live wires. In fact, if the incubator is definitely to be used with the thermostat, increase the height of the top above the egg tray to insure that the hatchlings cannot touch the thermostat.

C3. Thermostat



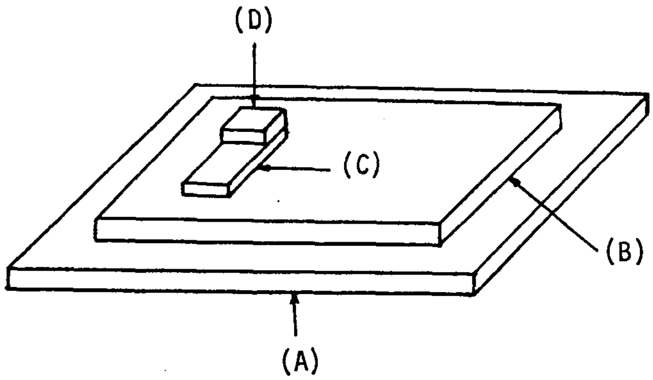
a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Platform	1	Wood (A)	10 cm x 10 cm x 1.0 cm
	1	Wood (B)	6 cm x 6 cm x 1.0 cm
	1	Wood Strip (C)	3 cm x 2 cm x 0.5 cm
	1	Wood Strip (D)	2 cm x 1.5 cm x 0.5 cm
(2) Bimetallic Strips	2	Bimetallic (Brass/Steel) Strips (E)	Approximately 3.5 cm x 0.5 cm
	1	Platinum Wire (F)	#20, 3 cm long
	2	Bolts (G)	0.2 cm diameter, 4 cm long
	2	Nuts (H)	0.2 cm internal diameter
	4	Washers (I)	--
	1	Bolt (J)	0.3 cm diameter, 5 cm long
	1	Nut (K)	0.3 cm internal diameter
	1	Washer (L)	1 cm external diameter
	1	Plastic Tube (M)	0.3 cm internal diameter, 0.5 cm long
	--	Insulation Tape (N)	--
(3) Electrical System	1	Capacitor (O)	0.01 microfarads
	1	Roll of Copper Wire (P)	#20

1	Bolt (Q)	0.3 cm diameter, 2.5 cm long
2	Nuts (R)	0.3 cm internal diameter
1	Double Electrical Cord (S)	300 cm long
1	Plug (T)	110 volt

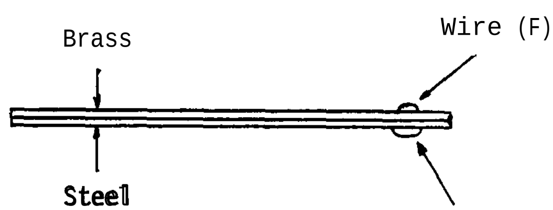
b. Construction

(1) Platform

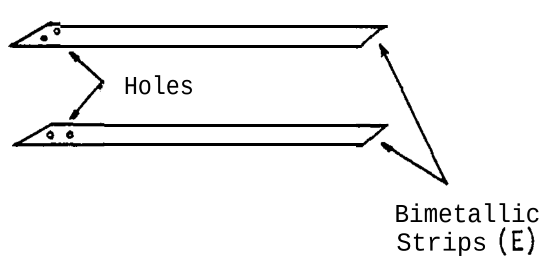


Glue the smaller wood piece (B) to the middle of the larger one (A). Next, glue wood strip (D) at one end of the other wood strip (E), and glue this resulting section near one edge of wood square (B).

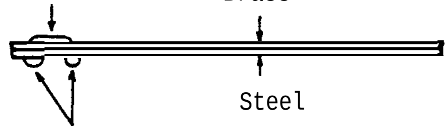
(2) Bimetallic Strips



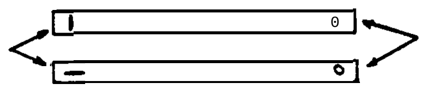
Side View



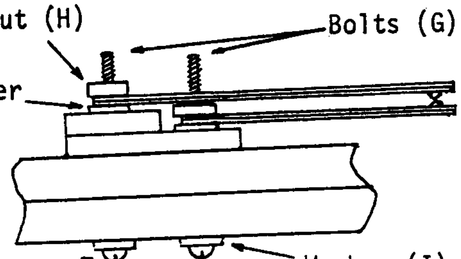
Drill a small hole (0.2 cm diameter or smaller) in one end of each bimetallic strip (E). Purchase these strips locally from a radio or electrical shop. Place a short piece of the platinum wire (F) through this hole and with a hammer, flatten each protruding piece of the wire flat as if the wire were a tiny rivet. Place a small drop of solder on the flattened portion of wire on the steel side of the bimetallic strip to insure good electrical contact. Alternatively, drill two very small holes in the end of each bimetallic strip, those in one strip in line with the short side of the strip and those in the other in line with the long side of the strip (see illustra-



Side View



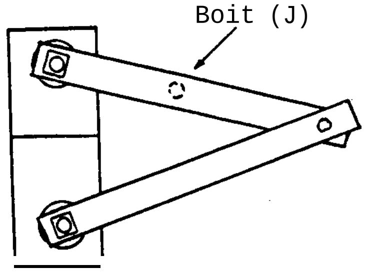
Top Views



Side View

tion). Place one end of a short piece of the platinum wire through each hole from the brass side of the strip and solder these ends to the steel side of the strip to provide good electrical contact. Flatten each wire slightly with a hammer to help make a greater surface area for electrical contact. Regardless of the manner in which the platinum is fixed to the end of the bimetallic strips, drill a small (0.2 cm diameter) hole in the opposite end of each strip. Also, make certain no solder is on the brass side of the bimetallic strips since this is likely to contaminate the surface of the platinum contacts.

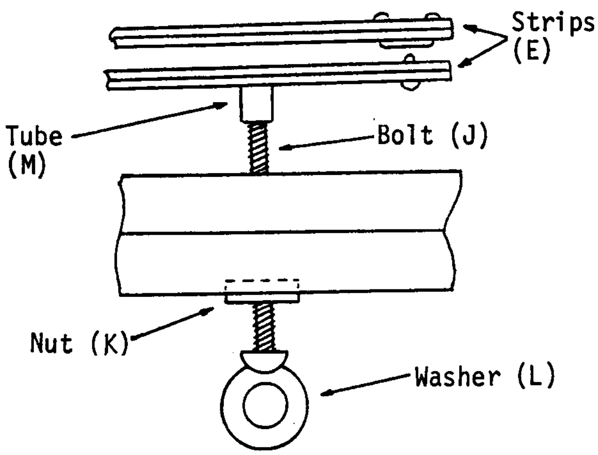
Next, drill two holes (0.2 cm diameter) through the platform, one through all four pieces of wood and the other through all but piece (D). Attach the bimetallic strips to the platform with the two bolts (G), two nuts (H), and four washers (I) as shown. The platinum contact point of the lower strip should face up while that of the upper strip should face down.



Top View

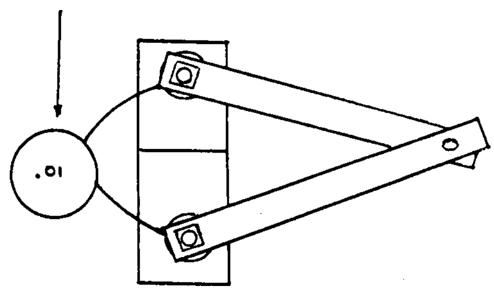
Pivot the free ends of the bimetallic strips toward one another so that the platinum contact points will touch one another when the strips are pressed together.

Side View



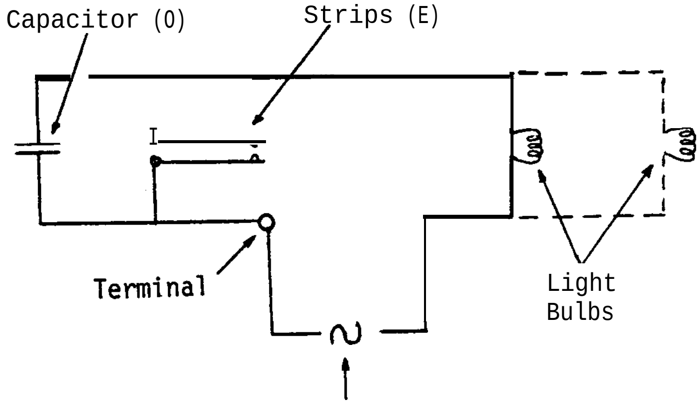
Drill a hole (0.3 cm diameter) through the platform directly below the middle of the lower bimetallic strip. Inset the nut (K) into the outside wood piece (A) directly over the hole. Thread the bolt (J) through the nut and hole. Place the piece of plastic tubing (M) on the end of the bolt (J) to prevent electrical contact between the bolt and metallic strip. Solder the washer (L) to the notch in the bolthead and cover both thoroughly with insulation tape (N). Make absolutely certain the bolt is completely insulated from the bimetallic strip as it will carry 110 volt current.

(3) Electrical System



Top View

Purchase the capacitor (0) locally, and connect it across the bimetallic strips. Cut a hole (6 cm x 6 cm) into the top of the container which is to be heated. The thermostat platform should fit firmly in the hole with the bimetallic strips beneath the platform.



Wiring Diagram

Use one piece of copper wire (P) to connect one of the bimetallic strips to one contact of the bulb socket of the heating source, and use another piece of the wire to connect the other bimetallic strip to a terminal [made from bolt (Q) and two nuts (R)] which must be put in the back of the cage or incubator which is to be heated. Then, connect the double electrical cord (S), with the plug (T) attached, to the terminal and the remaining contact on the bulb socket. The wiring circuit as shown in the diagram is now complete, and the thermostat is ready for use.

C. Notes

(i) It should be noted that due to lack of time the thermostat described here was tested out with the Microorganism Incubator (VII/A4) only. Care should therefore be taken to test the thermostat carefully when used in conjunction with either the Egg Incubator (VI/C2) or Vivarium (VI/Cl).

(ii) It was noted that using the thermostat the temperature of the Micro-organism Incubator took about 25 minutes to stabilize.

Time Minutes	Cage Temperature °C
0	40.5
5	39.0
10	38.5
15	38.0
20	38.0
25	37.0
30	37.0 stabilized

(iii) Do not permit direct radiation from the heat source to fall on the thermostat, otherwise the thermostat will switch itself off before the air temperature has risen to the desired level. Where there is a possibility of direct radiation falling on the bimetallic strips of the thermostat make an appropriate shield to stop the radiation without restricting the circulation of air around the bimetallic strips.