11. BURNERS

These have been grouped according to the type of fuel used.

A. SOLID FUEL BURNERS

These are the simplest burners to make, and include candles as well as charcoal burners.

B. LIQUID FUEL BURNERS

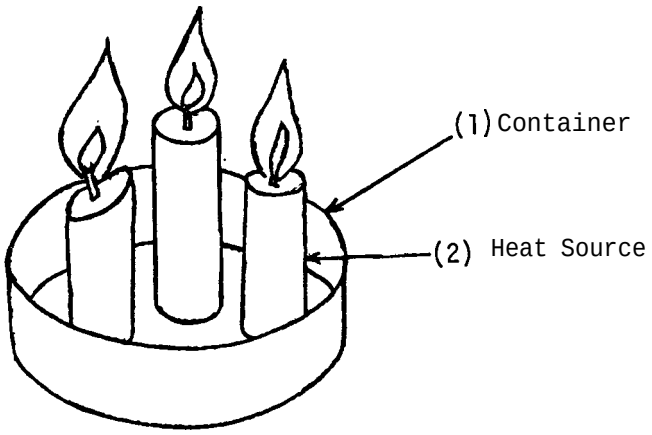
These include several types of alcohol burners.

C. GAS BURNERS AND SYSTEMS

These are functional items, providing the cleanest, most intense heat. However, they are somewhat more sophisticated for production purposes,

A. SOLID FUEL BURNERS

A1. Candle Burner



a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Container	1	Shallow Tin Can (A)	5 cm diameter or larger
(2) Heat Source	3	Household Candles (B)	Varies

b. Construction

(1) Container — Select a tin can (A) with low sides.

(2) Heat Source — Melt the wax at the base of the candles (B) and place them at equal intervals within the container.

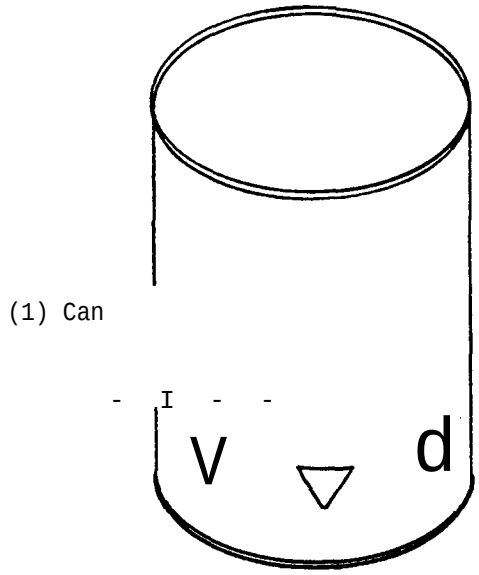
C. Notes

(i) The intensity of the heat produced may be increased by increasing the number of candles, but the total intensity is low.

(ii) The efficiency of a candle burner may be improved by collecting all the wax that melts into the container and using it again with new wicks made from soft string.

(iii) The candle flames tend to deposit soot on the surface of whatever is being heated.

A2. Charcoal Burner *

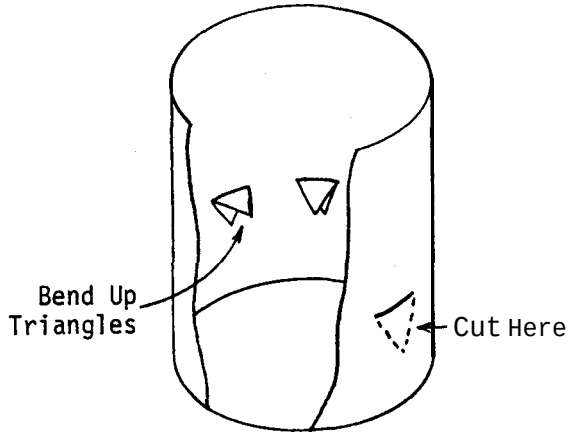


a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Can	1	Empty Metal Can (A)	10 cm diameter or larger

b. Construction

(1) Can



Remove top from can (A). Approximately 4 cm from the bottom of the can, mark off triangular windows all around.

With shears, cut along the sloping sides of each triangle to make the windows. Do not cut along the base line (horizontal edge) of the triangle.

Bend the triangles up to form a tray.

*Adapted from UNESCO, Source Book for Science Teaching, (Paris: UNESCO, 1967), pp 34-35.

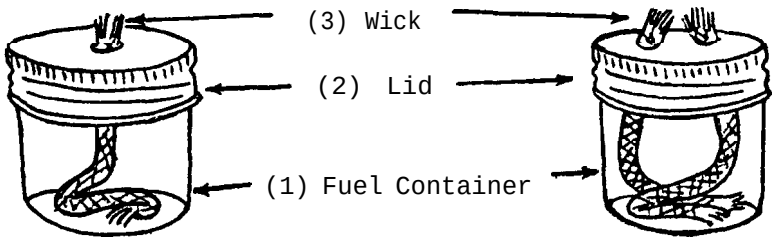
c. Notes

(i) The holes permit air to circulate freely to the burning charcoal.

(ii) Comments from users of the charcoal burners indicate that they are hard to start. Also, once started, they present a considerable fire and carbon monoxide risk.

B. LIQUID FUEL BURNERS

B1, Simple Alcohol Burner



a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Fuel Container	1	Glass or Metal Container (A)	150-200 ml, approximate capacity
(2) Lid	1	Screw Top (B)	To fit fuel container
(3) Wick	1	Soft Cotton Fiber Cord (C)	Long enough to extend to bottom of container and to cover it.

b. Construction

(1) Fuel Container — Make the fuel container from a glass or metal container (A) with a screw-on metal lid (B). Select a container with a wide base to insure stability.

(2) Lid — Punch a hole in the lid (B) with a nail, making it as round and smooth as possible, with a diameter smaller than that of the wick to be used.

(3) Wick — Select a piece of cord (C) with soft cotton fibers. The wick should protrude 0.5 cm above the surface of the lid.

c. Notes

(i) If a hotter, broader flame is required, punch two holes in the lid and use two wicks to produce a single, broad flame.

(ii) The wick should be soaked in alcohol before lighting the burner.

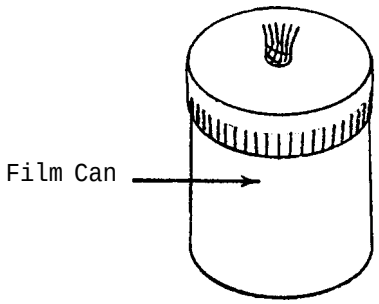
(iii) Methyl alcohol or denatured ethyl alcohol is the usual fuel used in the burner. Kerosene may also be used, but it tends to produce a smoky flame which blackens heated objects.

(iv) Important: Use a stable container. Otherwise, there is danger that the burner will tip over easily.

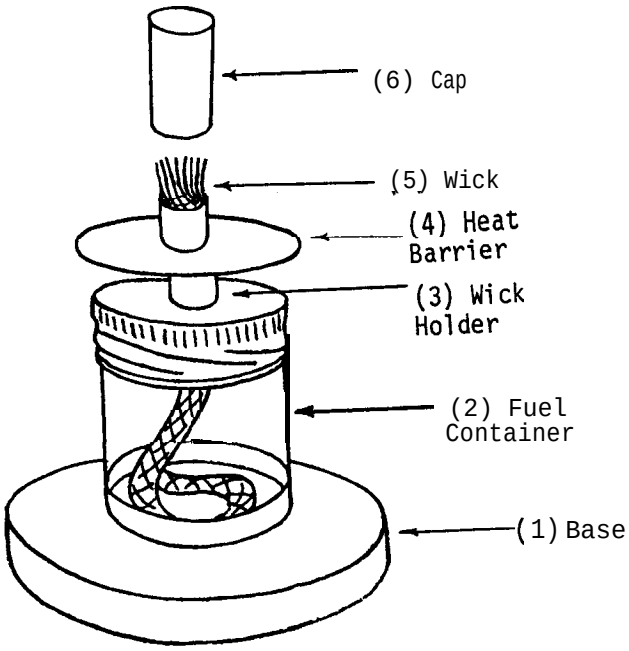
(v) If the burner is used for prolonged periods, overheating of the container, with build-up of internal pressure, is possible.

(vi) Make certain that the wick fits tightly into the hole in the lid. Otherwise, it is possible for the flame to climb down the wick into the container.

(vii) A user of alcohol burners notes that those made from 35 mm film cans have several advantages over larger ones made from glass containers. First, they are unbreakable. Second, if the inside is filled with cotton wadding (cotton wool) they are unspillable if knocked over. Also, these small film cans hold only enough for immediate use, so that evaporation losses are not serious.



B2. Modified Alcohol Burner

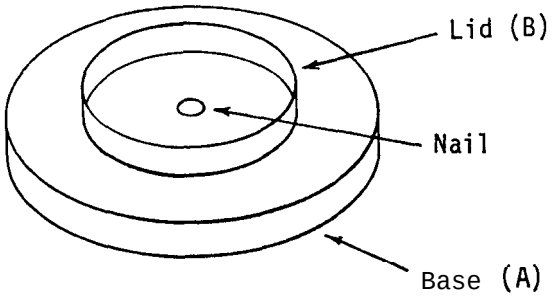


a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Base	1	Wooden Platform (A)	Approximately 10 cm diameter (round), or approximately 10 cm x 10 cm (square)
	1	Metal Lid (B)	To fit fuel container bottom
(2) Fuel Container	1	Glass or Metal Container (C)	100-200 ml capacity
	1	Metal Lid (D)	To fit fuel container top (C)
(3) Wick Holder	1	Metal Tube (E)	Approximately 4 cm long, 0.7 cm or 0.8 cm diameter
(4) Heat Barrier	1	Metal Disc (F)	5 cm diameter or larger
(5) Wick	1	Cord (G)	Approximately 10 cm long, 0.5 cm or more in diameter
(6) Cap	1	Ball Point Pen Top or Metal Tube (H)	To fit wick holder

b. Construction

(1) Base

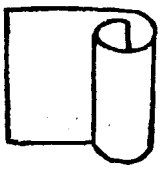


Nail the metal lid (B) (with a diameter equal to that of the fuel container) to the round or square wooden base (B).

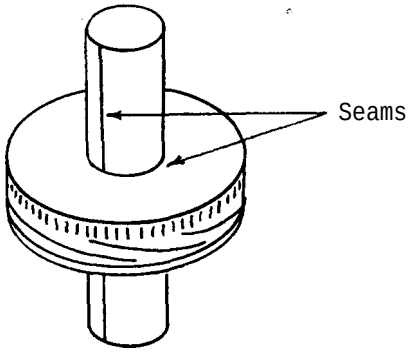
(2) Fuel Container

Select a glass or metal container (C) with a screw-on lid (D).

(3) Wick Holder

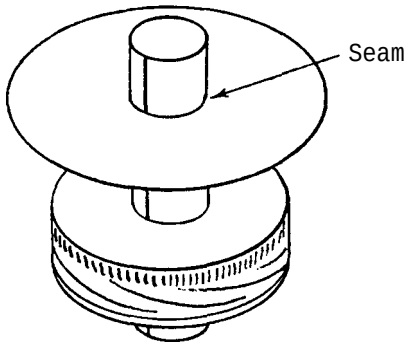


Make the wick holder from a metal tube (E) about 4 cm long x 0.7 or 0.8 cm internal diameter, or roll a piece of sheet metal (4 cm x 2.5 cm) into a tube.



Drill a hole in the fuel container lid (D) large enough to allow insertion of the wick holder. Insert the wick holder so that it penetrates about 1 cm into the container. Solder the seam along the tube and between the tube and the lid.

(4) Heat Barrier



Cut the metal disc (F) from metal sheeting, or use a tin can top. The disc should be slightly larger than the fuel container lid (D).

Drill a hole in the center of the disc large enough to allow insertion of the wick holder (E). Insert the wick holder so

that about 1.0 - 1.5 cm protrudes above the disc. Solder the seam between the heat barrier and wick holder.

(5) Wick

Make the wick from a piece of cord (G) or rope with soft cotton fibers. Insert the wick into the wick holder. Trim the wick with scissors so that about 0.4 - 0.5 cm protrudes above the top of the wick holder.

(6) Cap

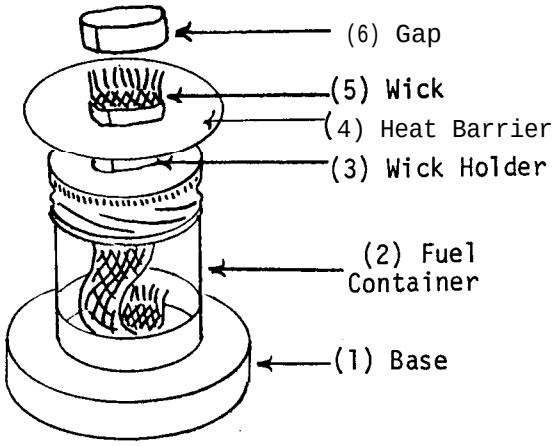
Use a ball point pen top (H) as a cap or make a metal cap large enough to fit snugly over the wick holder when the burner is not in use. The cap prevents evaporation of the alcohol.

C. Notes

(i) The design of this burner overcomes the major hazards of the simple alcohol burner (I I/Bl).

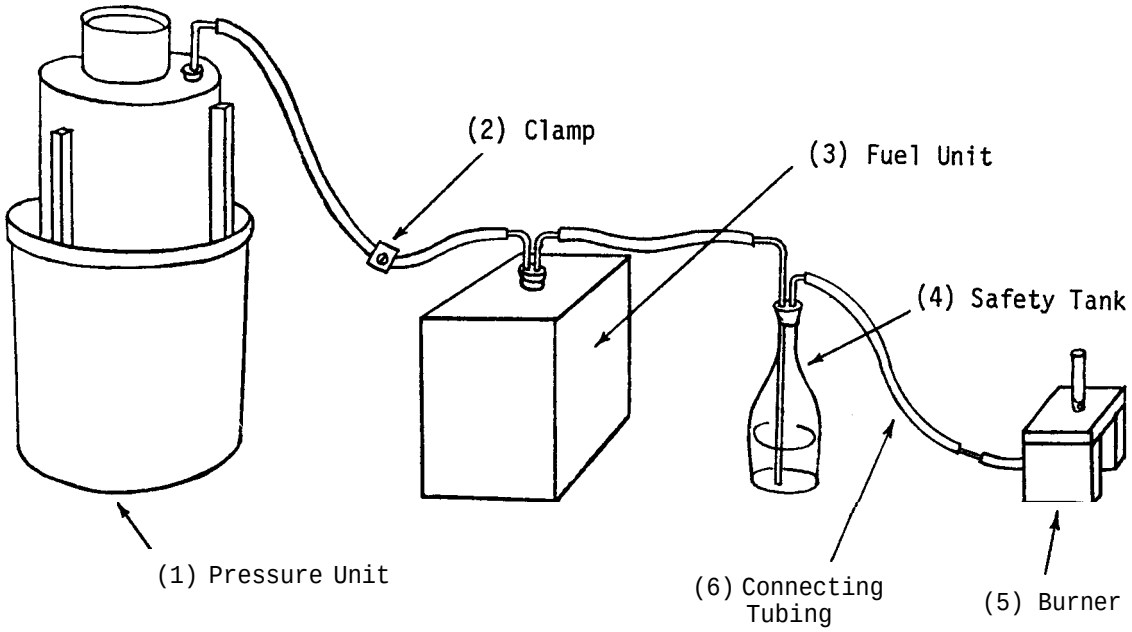
(ii) This 'design can be modified to produce a wide flame that is particularly useful for working with glass. All parts of the design are the same, except for the shape of the wick, wick holder, and cap.

For the wick holder, cut a piece of metal sheeting about 5 cm x 4 cm. Bend it into a flat tube about 2 cm wide and 0.5 cm deep. Solder the seam. Install this wick holder in the fuel container lid and heat barrier just as in the previous design. For the wick. use flat cotton webbing about 2 cm wide and 10 cm long, or braid (plait) a flat wick from six to ten strands of cotton cord or string. Make a cap from metal sheeting to fit snugly over the wick holder when the burner is not in use,



C. GAS BURNERS AND SYSTEMS

C1. Fuel System for Gas Burner *



a. Materials Required

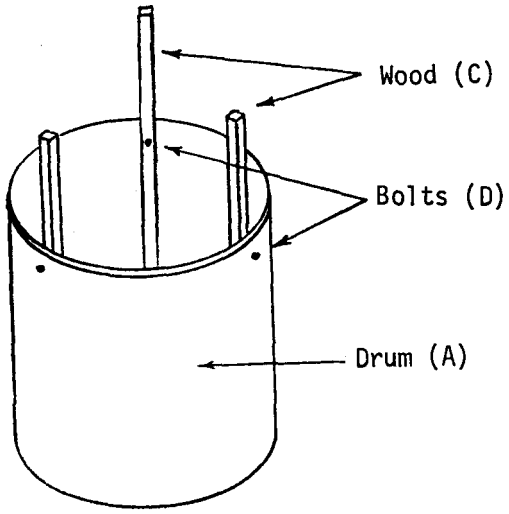
Components	Qu	Items Required	Dimensions
(1) Pressure Unit	1	Metal Drum (A)	Approximately 26 liter capacity
	1	Metal Drum (B)	Approximately 16 liter capacity
	3	Wood (C)	3 cm x 2 cm x 65 cm
	3	Bolts (D)	0.5 cm diameter, 4 cm long
	1	l-Hole Stopper (E)	Approximately 2.5 cm diameter (large end)
	1	Glass Tubing (F)	0.5-0.7 cm diameter, 10 cm long
	1	Container and Sand (G)	Approximately 6 kg
(2) Clamp	1	Screw Clamp (H)	IV/A5
(3) Fuel Unit	1	Metal Can (I)	4 liter capacity, approximately
	1	2-Hole Rubber Stopper (J)	To fit opening in can

*Adapted from C. S. Rao (Editor), Science Teachers' Handbook, (Hyderabad, India: American Peace Corps, 1968), pp 140-141.

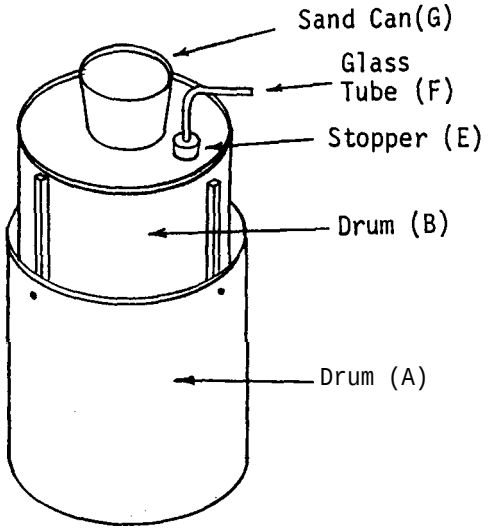
	1	Glass Tubing (K)	0.5 cm diameter, 10 cm longer than height of can
	1	Glass Tubing (L)	0.5 cm diameter, 10 cm long
(4) Safety Tank	1	Narrow-neck Bottle (M)	500 ml capacity, approximately
	1	2-Hole Rubber Stopper (N)	To fit bottle
	1	Glass Tubing (0)	0.5 cm diameter, 10 cm longer than height of bottle
	1	Glass Tubing (P)	0.5 cm diameter, 10 cm long
(5) Burner	1	Gas Burner (Q)	II/C2
(6) Connecting Tube	3	Plastic or Rubber Tubing (R)	Approximately 1 cm diameter, and approximately 1 meter long

b. Construction

(1)Pressure Unit



Select two metal drums (A,B) of approximately the same depths, but different diameters, so that one drum (B) will fit inside the other (A). Each drum should have one end open. Bolt the three pieces of wood (C) to the larger drum (A) with the bolts (D) so that the space between them is just sufficient to allow the smaller drum (B) to slide down easily between them.



Use an alcohol lamp to make a 90' bend in the middle of the glass tubing (F), or cut a shorter piece of straight tubing. Fit the glass tube into the stopper (E). Bore a hole near one side in the bottom of the smaller drum (B). Insert the stopper into this hole.

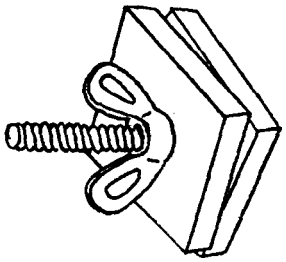
Fill the larger drum (A) with water equal to the volume of the smaller drum.

Fit the smaller drum, open side down, between the wooden uprights of the larger drum.

Push down on the upper (air) drum (B). It should slide down into the lower drum (A). Air should be felt escaping from the glass tubing (F).

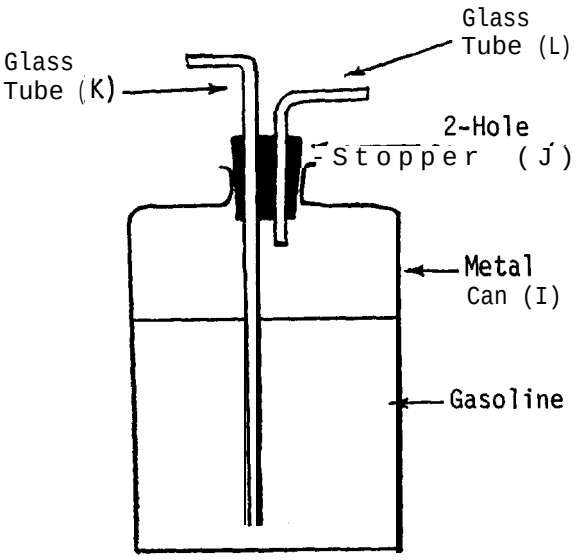
Place a can or bucket filled with sand (G) on the air drum, as a weight.

(2) Clamp



Use the screw-type clamp (H) or any standard screw-type clamp to control the air pressure from the fuel tank.

(3) Fuel Unit



Fuel Unit
(Cross-section)

Make the fuel container from a metal drum (I) or can with a single outlet, rather than a lid. Fit the drum with a two-hole rubber stopper (J).

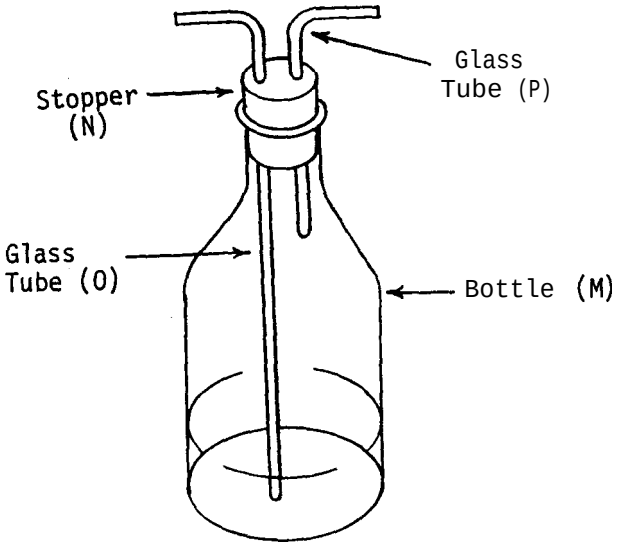
Make a 90' bend about 5 cm from one end of the longer piece of glass tubing (K), or use a slightly shorter piece of straight tubing.

Make a 90" bend in the middle of the short piece of glass tubing (L).

Insert both pieces of tubing into the stopper as illustrated.

Fill the can about 3/4 full of gasoline (petrol).

(4) Safety Tank



Select a glass or metal container (M) with a narrow neck. Fit the container with the two-hole rubber stopper (N).

Bend both, pieces of glass tubing (0,P) as described above, and insert each into the stopper as illustrated.

Fill this container about 1/3 full of water.

(5) Burner

Construct a Bunsen burner (Q) as described in the next section (II/C2).

(6) Connecting Tubing

Use flexible tubing (R) (rubber or plastic) to connect the

apparatus as illustrated.

Connect the tubing from the Pressure Unit (1) with the long glass tube of the Fuel Unit (3).

Connect the tubing from the short glass tube of the Fuel Unit (3) with the long glass tube of the Safety Tank (4).

Attach the connecting tubing from the short glass tube of the Safety Tank (4) to the Bunsen burner (5). Take care to see that the tubing is not kinked anywhere.

When all components are assembled and correctly connected, remove the weight and stopper from the upper (air) drum. Lift the drum until its lower edge is just below the water level in the lower drum. Replace the stopper and check to see that it is tight, and replace the weight on top of the drum.

c. Notes

(i) As the air drum sinks into the water of the lower drum under its own weight and the pressure of the weight on top, the air thus displaced is driven into the fuel drum and bubbles up through the petrol. The petrol evaporates as the air passes through it, and the air-gas mixture is driven through the water in the safety tank to the burner.

(ii) This system is potentially dangerous because the petrol-air mixture present from the fuel tank is an explosive mixture, but several safety precautions have been incorporated into the design.

The greatest safety factor is the needle valve in the burner; even when the burner occasionally "backfires" (the flame jumps down from the end of the burner tube to the needle opening) the flame is very unlikely to move back through the needle's narrow opening. In the unlikely event that a flame should move back down

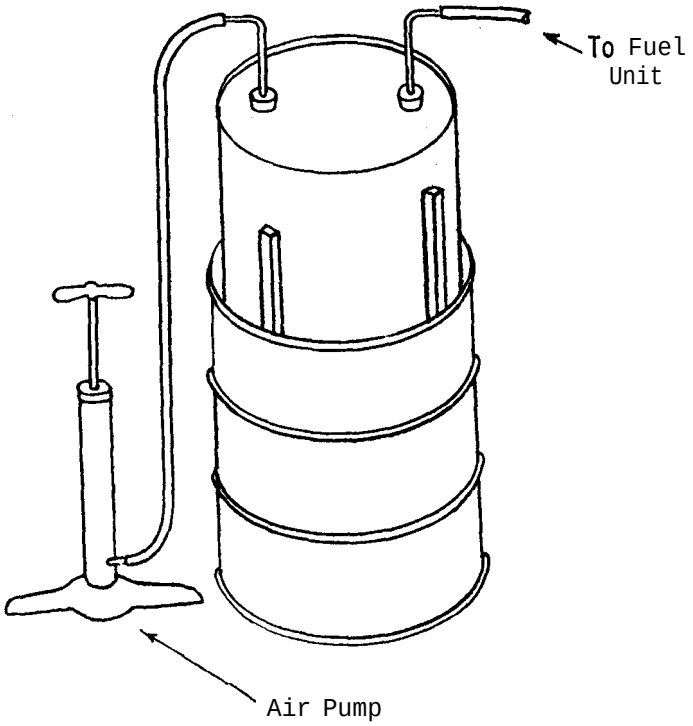
the tubing, the safety tank prevents it from reaching the fuel drum. As a further safety measure in the safety tank, the stopper should be snug, but not jammed tightly into the neck of the container. Thus, should the flame move back into the safety tank, it will be more likely to blow the stopper out of the tank than to blow the tank apart.

Despite the built-in safety precautions, however, feedback comments suggest extreme care in the use of this system.

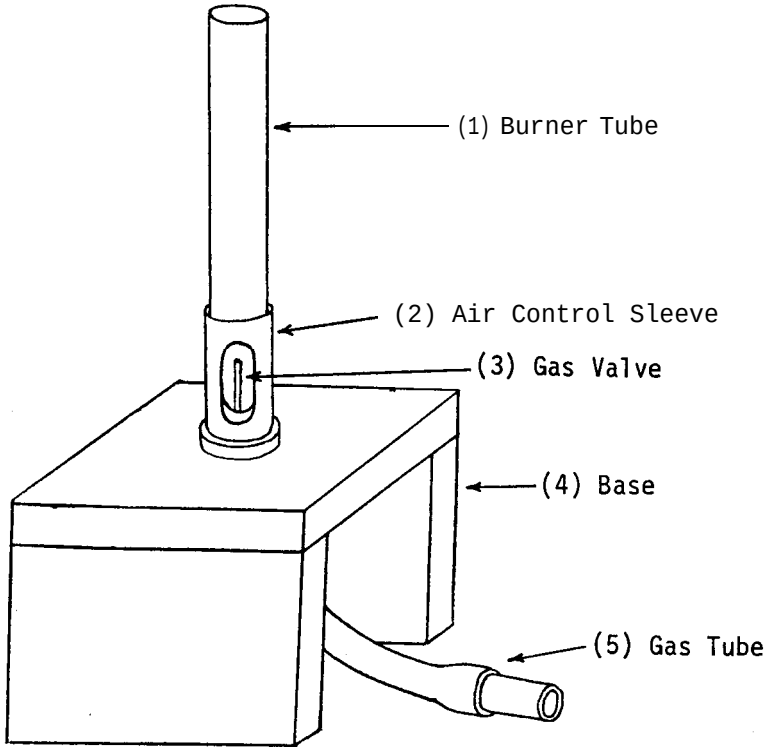
(iii) In the system described here, a glass bottle, encased in a cage of wire mesh for additional safety, was used as a water tank. This made it possible to observe the rate of bubbles in the water, an indicator of the pressure in the system. A fairly rapid rate of bubbles, about 100 or more per minute, was necessary to produce a burner flame 3 - 4 cm high. It is recommended, however, that once the bubbling rate is established, a metal safety tank of similar size be substituted for the glass bottle.

(iv) A weight of approximately 5.5 kg on an air drum with an area of 490 cm^2 (diameter 25 cm) provided 11 g/cm^2 pressure to run the Bunsen burner described in the following section (II/C2) for about a half-hour.

(v) The system and dimensions described here constitute a small, laboratory version suitable for running one Bunsen burner. For a larger system, the same components and principles apply, but experimentation on the details of construction will be necessary. For example, a larger pressure system, with a large, heavy oil drum for the upper drum would provide pressure for a longer period of time and might not require a weight on top. An air pump could be added to fill the drum with air without lifting it.



C2. Gas Burner *



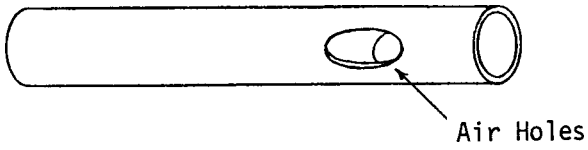
a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Burner Tube	1	Copper Tubing (A)	10.5 cm long, 1 cm diameter
(2) Air Control Sleeve	1	Metal Sheet (B)	3 cm x 3.5 cm
(3) Gas Valve	1	Hypodermic Needle (C)	18 gauge (0.125 cm outside diameter)
	1	Adhesive Tape or Electrical Tape (D)	Approximately 1 cm wide, 15-30 cm long
(4) Base	1	Wooden Block (E)	10 cm x 10 cm x 2 cm
	2	Wooden Block (F)	10 cm x 5 cm x 2 cm
(5) Gas Tubing	1	Rubber or Plastic Tubing (G)	Approximately 15-20 cm long, approximately 0.6 cm internal diameter
	1	Metal Tube (H)	3 cm long, 1 cm diameter

*Adapted from C. S. Rao (Editor), Science Teachers' Handbook, (Hyderabad, India: American Peace Corps, 1968), pp 138, 141.

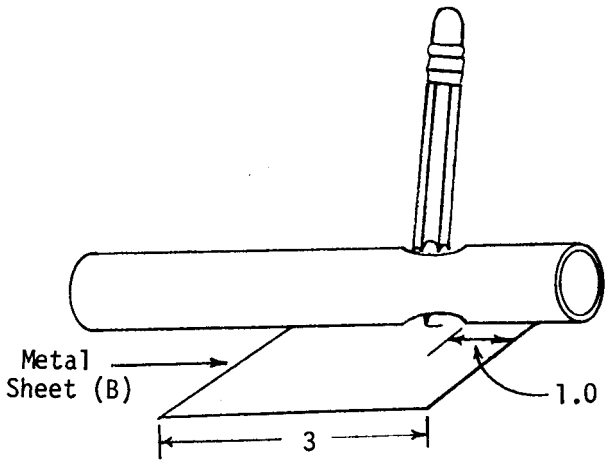
b. Construction

(1) Burner Tube



Drill two holes on opposite sides of the copper tube (A) about 2 - 2.5 cm from one end. Enlarge the holes to an oval shape, about 1 cm long x 0.6 cm wide.

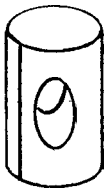
(2) Air Control Sleeve



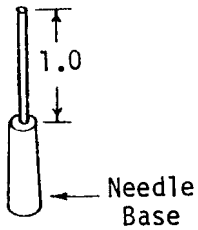
Lay the metal sheet (B) flat on a table. Lay the burner tube on it with the end of the tube with the holes in it about 1.0 cm from the 3.5 cm edge. Actually, the holes themselves should be 1.0 cm from the 3.5 cm edge.

Use a pencil to trace the outline of one of the holes in the tube onto the metal sheet. Cut this hole out. lineWrap the metal sheet around the burner tube until it forms a cylinder. Align the hole in the metal sheet with one of those in the tube. lineTrace the outline of the other hole in the tube onto the metal sheet. Remove the metal sheet, and cut out the second hole.

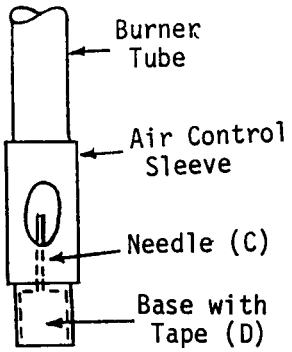
Reroll the air control sleeve and place it in position on the burner tube.



(3) Gas Valve



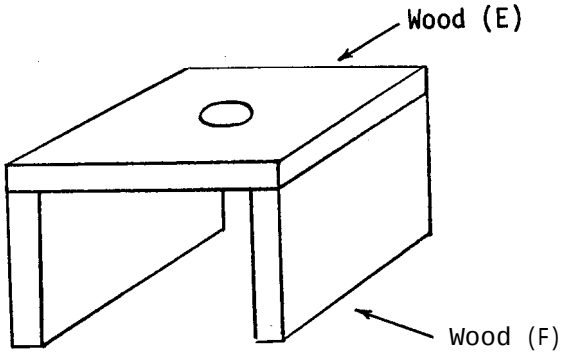
Cut the top off the hypodermic needle (C) so that about 1 cm of the needle remains. File the linecut end of the needle open.



Side View

Wrap the adhesive tape (D) or electrical tape around the needle holder until the base of the needle will fit tightly into the bottom of the burner tube. The open end of the needle should be near the middle of the air holes.

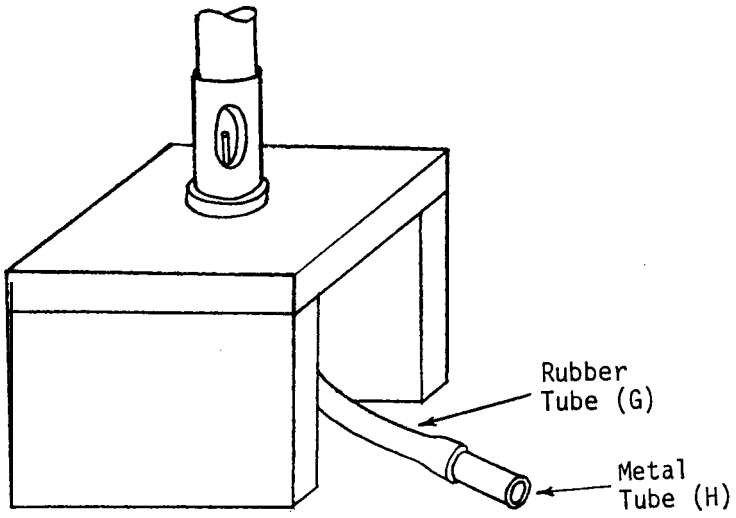
(4) Base



Drill a hole approximately 1.2 cm in diameter in the center of the square piece of wood (E). Enlarge the hole with a file to tightly hold the burner tube and gas tubing in place.

Nail the two rectangular pieces of wood (F) to the square to form the sides of the base.

(5) Gas Tubing



Connect one end of the plastic or rubber tubing (G) to the bottom of the burner tube. Then push the burner tube through the hole in the top of the base. It should fit snugly in place and should not wobble.

Pass the other end of the gas tubing through one open side of the base. Insert the small metal tube (H) into the open end of the gas tubing.

Connect tubing from the gas supply to this metal tube.

c. Notes

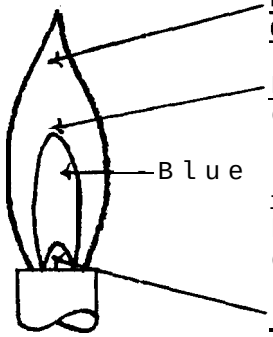
(i) This burner has been tested with both commercially supplied natural gas and with the gas generating system described in the previous section II/Cl.

(ii) When the burner is lit, the air control sleeve can be used to control the nature and intensity of the flame. The sleeve is closed when its holes and the holes in the burner tube.are not lined up with each other. No air enters the burner tube. The flame is smoky, yellow, and glowing. It gives little heat. The absence of air prevents the gas from being completely burned.

When the sleeve is turned so that its holes and those of the burner tube are partly lined up, some air enters the burner tube. The flame is almost colorless, and does not glow. It is quite hot. The gas is more completely burned in this flame because of the presence of some air.

When the holes of the air control sleeve completely match those in the burner tube, the maximum amount of air enters the burner tube.

This produces a very hot, roaring flame with a bright blue center cone. The gas is completely.burned, producing the hottest flame, because there is plenty of air entering the burner tube.



Purplish Cone - hot part of the flame, called the oxidizing flame. Combustion of the gas is most complete.

Hottest part of the flame just above the inner blue cone of flame.

Blue cone not as hot as the outer cone because there is insufficient oxygen mixed with the gas to completely burn it. Called the reducing flame because it can take oxygen away from some oxides.

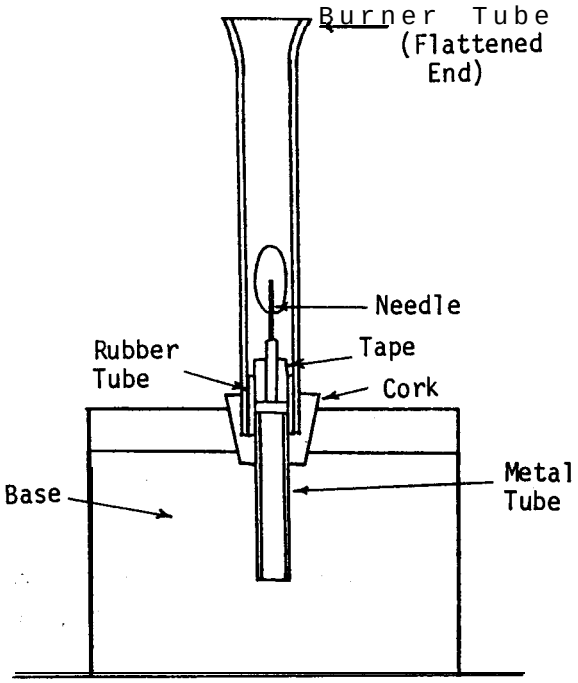
Dark cone - not a flame at all. It is filled with a mixture of unburned gas and air coming from the barrel.

Use a blue flame, about 4 cm high, for glass-working operations and most other heating operations. Adjust the gas supply and air control sleeve of the burner to produce a quiet blue flame with distinct cones.

(iii) In use this burner produced an excellent flame suitable for working soft glass and for blowing small bulbs in 0.3 cm and 0.5 cm soft glass tubing. However, the burner tube tended to heat up after a few minutes use. The larger diameter burner, of slightly more complex design, avoids this difficulty to some extent.

(iv) If a larger diameter tube (e.g., 1.5 cm diameter) is used for the burner tube, several alterations must be made to the design of the burner. First, a larger diameter syringe needle is needed (16 gauge, 0.15 cm outside diameter), and

it must be cut off shorter, i.e., 0.5 cm rather than 1.0. Secondly, the end of the burner tube must be flattened slightly to restrict the flow of air/gas mixture through it. Thirdly, the connection between burner tube, gas valve, and gas tube must be altered. One way in which this can be done is to drill a hole 1.0 cm in diameter through a cork. Enlarge the hole at one end to 1.5 cm diameter, and 1.5 cm deep. Insert a 1.0 cm diameter piece of metal tubing through the hole and place a short (1.0 cm) piece of rubber tubing on the end of it. Insert the needle into the rubber tube (the base may have to be built up with tape). Insert the burner tube into the enlarged hole in the cork. Make certain the fit is tight. Finally, insert the cork into the hole in the base, put the air control sleeve in place, and attach the gas tubing.

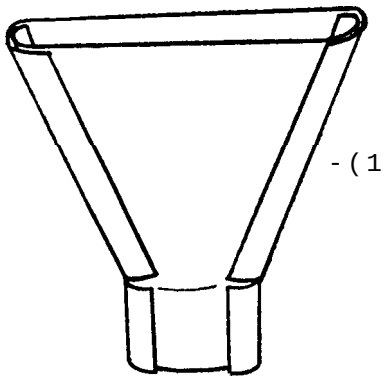


Cross Section

If, when this burner is in use, the flame should tend to blow itself out because the tube opening is too wide, decrease it further by pinching with pliers.

(v) It must be noted that various components of the burner design are dependent on the diameter of the burner tube. These include burner tube length, size of the air holes, gauge and length of the needle, width at the top of the tube, and various connecting devices such as metal and rubber or plastic tubing. For example, if the diameter of the burner tube is increased, the diameter of the needle used and the length of the tube must also be increased, but the size of the opening at the top of the tube must be decreased. Therefore, if tubing of a size different from those described here is used, experimentation with the other components will be necessary in order to construct a working Bunsen burner.

13. Wing Tip



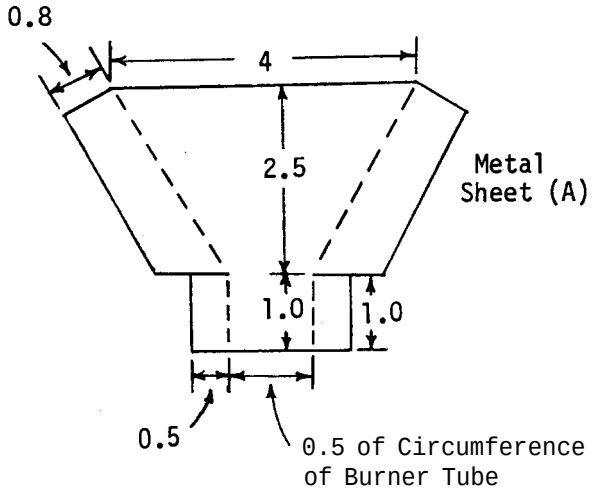
-(1) Wing Tip

a. Materials Required

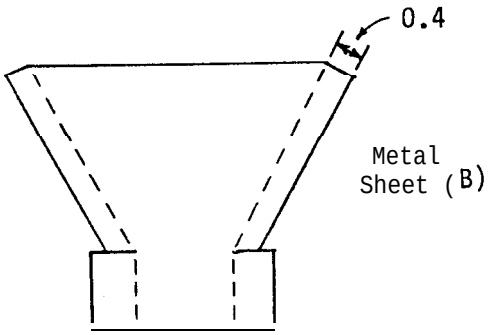
Components	Qu	Items Required	Dimensions
(1) Wing Tip	1	Metal Sheet (A)	6 cm x 4 cm
	1	Metal Sheet (B)	6 cm x 4 cm

b. Procedure

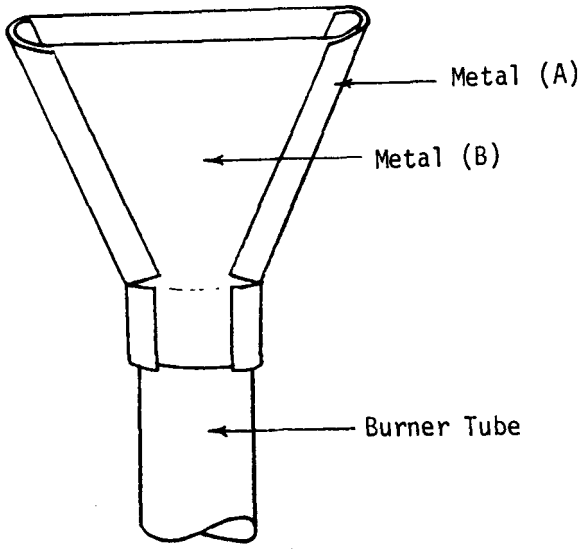
(1) Wing Tip



Measure the circumference of the burner tube. Draw and cut out a paper pattern as illustrated. Cut one piece of this pattern from the metal sheeting (A). Cut on the solid lines. Bend on the dotted lines.



Cut another piece from the metal sheeting (B), but trim the flaps on the wing to 0.4 cm. Cut on the solid lines. Bend on the dotted lines.



Bend the wing flaps on piece (B) at 90°. Bend the wing flaps of piece (A) around the outside of the flaps on (B). Pinch the flaps on (A) to hold (B) in place.

Place the wing tip on the burner tube, such that the wing extends above the burner tube.

Bend the support strip flaps of (B) and (A) to fit snugly around the burner tube. Small holes left at the corners of the flaps will not affect the wing tip's performance.

c. Notes

(i) The wing tip is an accessory used with the gas burner when a wide flame is desired. It is especially useful for working with glass.