VI. OPTICS APPARATUS

The apparatus in this section has been grouped according to the concepts, and are identified as follows:

A. GENERAL APPARATUS

This apparatus is for use in studying all aspects of optics whether this might be reflection and refraction, or interference and diffraction.

B. REFLECTION APPARATUS

This apparatus is sufficient for a simple study of reflection. The electroplated mirrors are preferable to brass mirrors described, although the latter will be found adequate for most purposes.

C. REFRACTION APPARATUS

Apparatus for the study of refraction using plastic prisms.

D. LENS APPARATUS

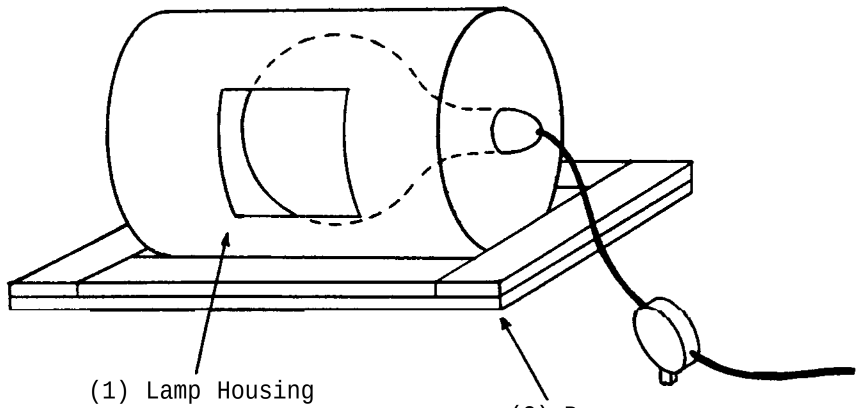
Apparatus to enable a study of the properties of lenses.

E. DIFFRACTION AND INTERFERENCE APPARATUS

A study of the basic phenomena of interference and diffraction is possible with this apparatus, using simple slits, holes and thin films.

A. GENERAL APPARATUS

Al. Light Source ©



a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Lamp Housing	1	Ripple Tank, Lamp Housing (A)	IV/Al, Component (5)
(2) Base	1	Plywood (B)	21 cm x 11 cm x 0.5 cm
	2	Wood Strips (C)	16 cm x 2.5 cm x 1 cm
	2	Wood Strips (D)	11 cm x 2.5 cm x 1 cm

b. Construction

(1) Lamp Housing

This lamp housing (A) is precisely the same as that designed for the ripple tank (IV/Al). All that is added is a base.

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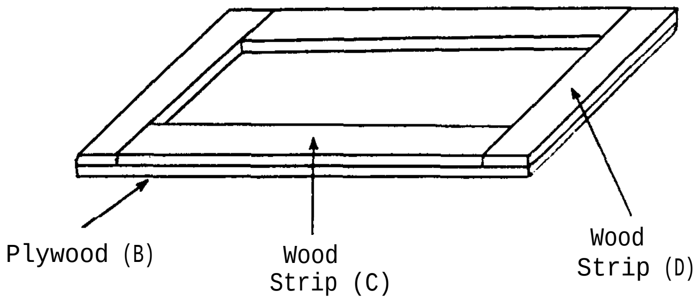
(2) Base

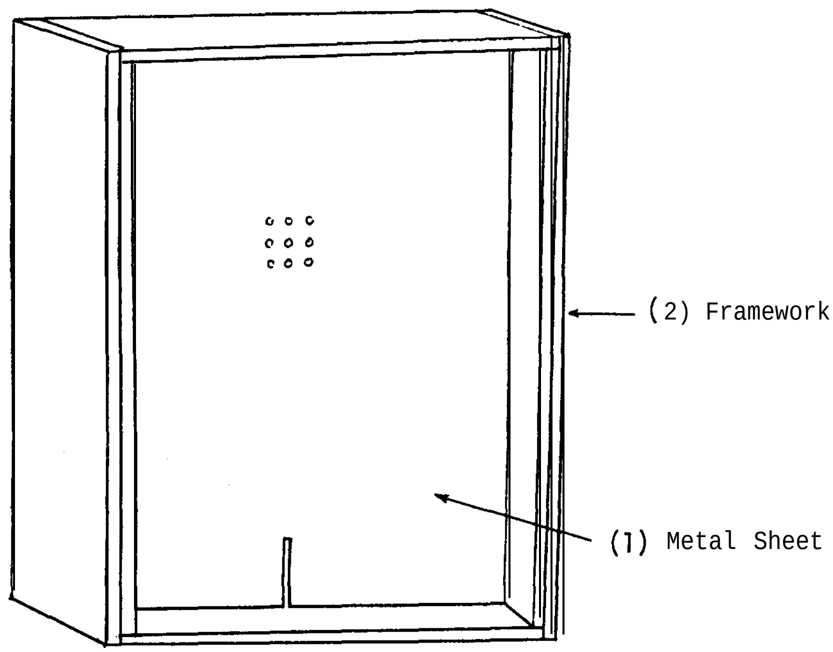


Make the base from the piece of plywood (B). Nail the two short pieces of wood (D) to the ends of the plywood (B) and nail the remaining wood strips (C) to the plywood, too. Make sure that they will hold the lamp housing firmly in position. Then nail it into position.

C. Notes

(i) This light source may be used in conjunction with the Slit/Aperture Combination (VI/AZ) to investigate the behavior of rays of light transmitted from the source. The light source is designed for use with all the items included in this chapter, including the interference and diffraction apparatus. If the bulb used is bright (e.g., 100 watts), there will be no need to black out the laboratory.

A2. Slit/Aperture Combination

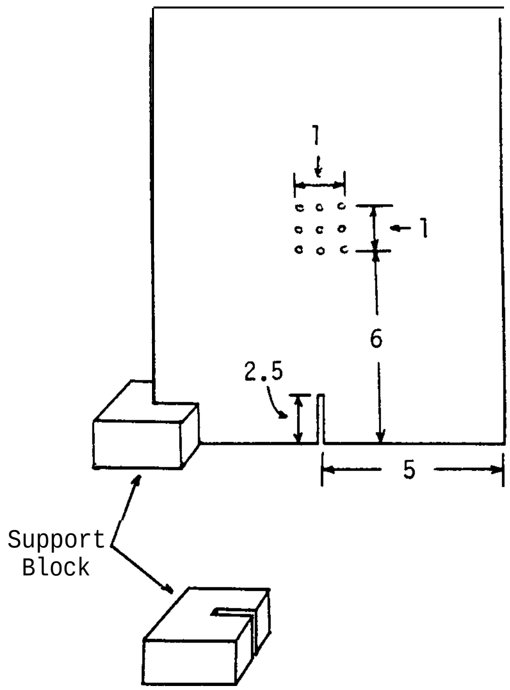


a. Materials Required

Components	Qu	Items Required	Dimensions
(1)Metal Sheet	1	Aluminum Sheet (A)	15 cm x 10 cm x 0.02 cm
(2) Framework	4	Wood Side Strips (6)	1 cm x 1 cm x 0.5 cm
	2	Wood Side Strips (C)	15 cm x 2 cm x 0.5 cm
	2	Wood Strips (D)	11 cm x 2 cm x 0.5 cm

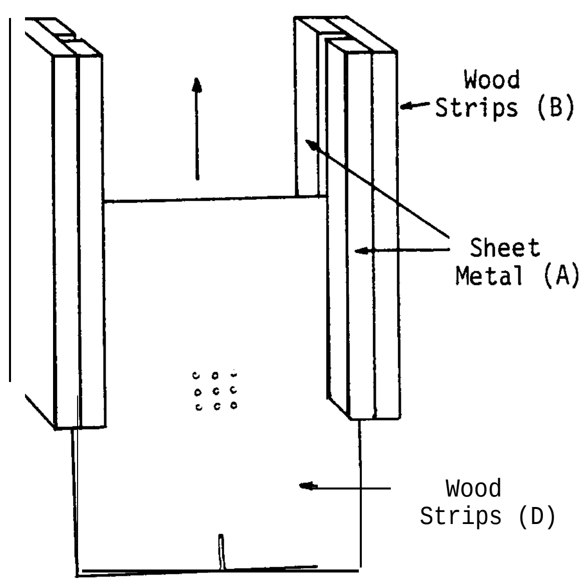
b. Construction

(1) Metal Sheet

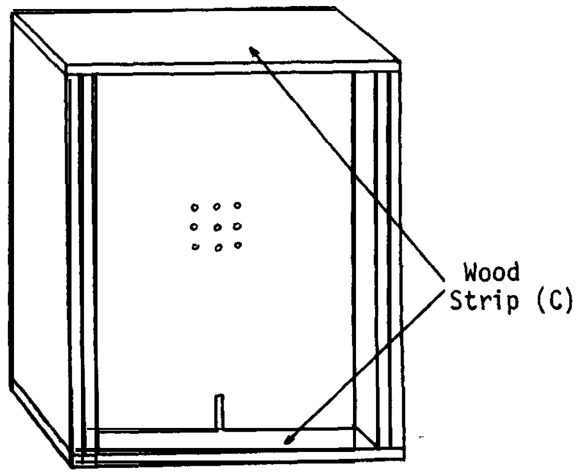


Cut the slit (0.1 cm width) and apertures (0.1 cm diameter) in any suitable thin sheeting (A) (metal, bakelite, cardboard) so long as the slit and apertures have clean cut edges. If the material used is relatively rigid, a small wooden block will provide adequate support. If the material tends to flex under its own weight, a framework, such as that indicated below, will be required for support.

(2) Framework



Nail or glue two wood strips (B) to a third strip (C), leaving about a 0.1 cm gap between them. Make an identical piece from the other two narrow strips (B) and the one remaining wide strip (C). Slide the metal sheet into position between the two pieces.



Nail the top and bottom pieces (D) to the two upright pieces to complete the framework. The thickness of the bottom strip (D) should not be much more than 0.5 cm, as there is a tendency for this strip to cut off a desirable portion of any light path.

c. Notes

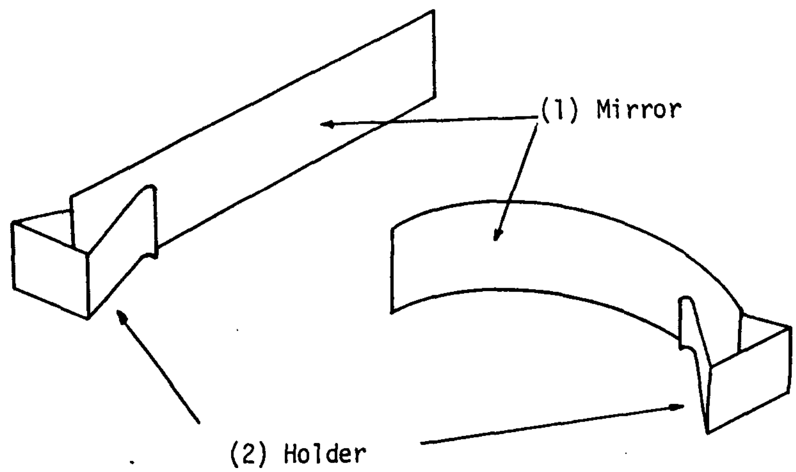
(i) The decision as to whether to use a frame will probably be one of economics. Thick metal sheets are much more expensive than thin ones, but the cost of labor involved in making a framework for a thin sheet may in some instances offset the difference between the two.

(ii) The slit is primarily intended for delineating light rays (from the Light Source, VI/A) which may be traced across a horizontal surface.

(iii) If the metal sheet is placed on its side the apertures will sit at an appropriate height in front of the Light Source (VI/Al), and may be used as objects for experiments with lenses.

B. REFLECTION APPARATUS

Bl. Mirrors and Electroplating ©

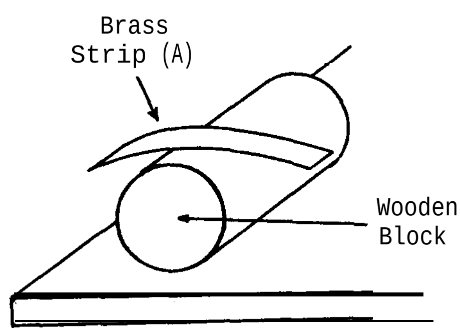


a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Mirror	2	Brass Sheet (A)	10 cm x 2.5 cm x 0.1 cm
(2) Holder	2	Metal Strapping (B)	Approximately 6 cm x 2 cm x 0.02 cm
	2	Plastic Tape (C)	2 c m x l c m

b. Construction

(1) Mirror



Cut the sheet of brass (A) on a metal guillotine (to be found in your nearest metalwork shop). If the metal sheet is cut with bench sheers some distortion is almost certain to result, thus lowering the quality of the mirror. If the mirror is to be curved, bend it over a smooth, curved, wooden block until the mirror becomes the arc of a circle of radius 8.5 cm.

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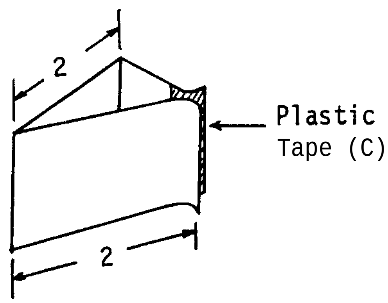
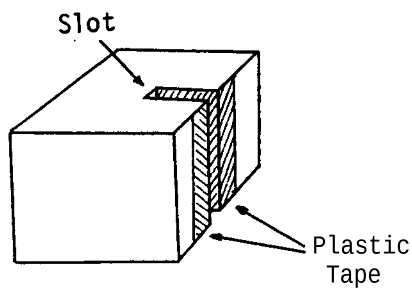
Polish the metal strips first with coarse carborundum paper, and then with successively finer and finer grades, taking care at each polishing to remove the deeper marks of the previous polishing.

Obtain a mirror finish by polishing the surface with a soft cloth and metal polish.

(2) Holder



Bend the piece of metal packing case band (B) into a triangular shape. Curve the endpieces and cover them with the plastic tape (C) to protect the mirror surface.



Alternatively, cut a slot (0.2 cm wide) in a wooden block (2 cm x 2 cm x 2 cm). Line the slot with plastic tape to prevent the wood from scratching the surface of the mirror to be held.

C. Notes

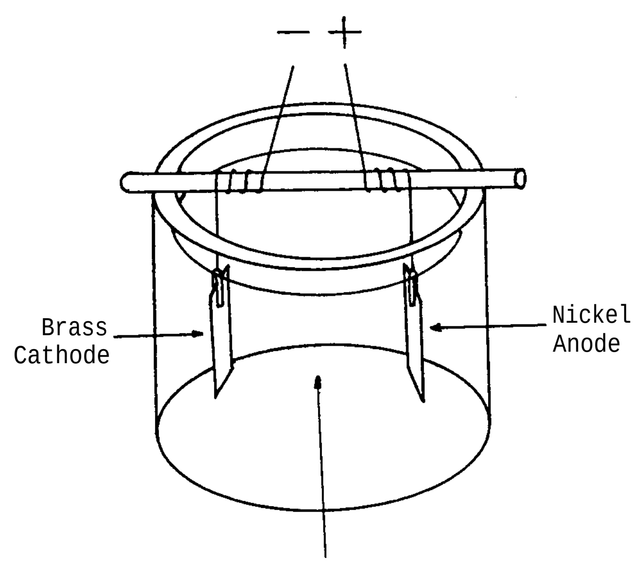
(i) Brass mirrors must be cleaned with metal polish before each usage. This process may be eliminated if the metal surface is electroplated. The procedure to be followed is described below:

Procure a plastic, or glass, container about 15 cm deep and 10 cm in diameter, and fill it with a nickel solution (e.g., Gleamax and Levelbrite).

Wash the polished brass mirror in caustic soda (soap) to remove grease and rinse with clean water. Grip the brass mirror in a crocodile clip, attached to an electrical lead, and suspend the brass mirror in the nickel solution. The mirror may be held in position by wrapping the electrical lead (by which it is suspended) around a wooden dowel bridging the container.

Suspend a nickel plate in a similar fashion from a second electrical lead. We now have an anode (nickel plate), a cathode (brass mirror) and an electrolyte (nickel solution).

Connect the anode to the positive terminal and the cathode to the negative terminal of a 6 volt battery, and pass a current through the nickel solution for 15 to 20 minutes. The quality of the final surface will depend primarily on the quality of the initial polished surface, prior to electroplating.

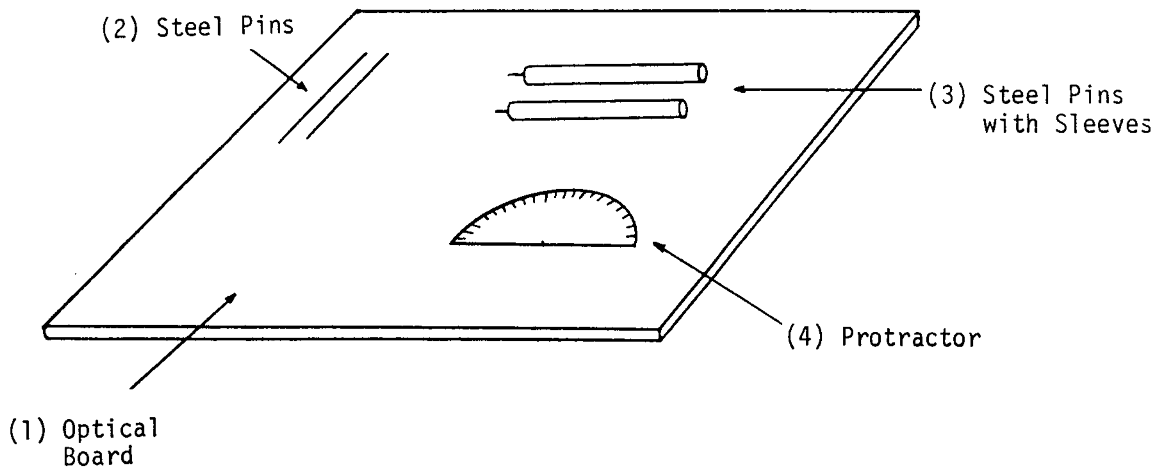


(ii) Mirrors may also be made by a very simple chemical process. Prepare three solutions as follows:

I. 40 ml H_2O	II. 10 g NaOH	III. 100 ml Concentrated fructose solution (Glucose or any aldehyde may be used, although the reaction may be slower).
60 ml Concentrated NH_4OH	100 ml H_2O	
10 g $AgNO_3$		

Just before using, mix equal volumes of solutions I and II. Then add the fructose solution to the new mixture in the ratio of 1:4. Silver will deposit on any glass surface in contact with the solution. If a microscope slide is placed in the solution, it will be coated on two sides. The external appearance will be dullish. Remove one such coating with a cloth. The glass-silver interface will be seen as an excellent mirror.

B2. Optical Board and Accessories



a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Optical Board	1	Hardboard (A)	40 cm x 40 cm x 0.5 cm
(2) Steel Pins	2	Steel Rods (B)	7 cm long, 0.1 cm diameter
(3) Steel Pins with Sleeves	2	Steel Rods (C)	7 cm long, 0.1 cm diameter
	2	Pencils (D)	6.5 cm long
(4) Protractor	1	Aluminum Sheet (E)	10 cm x 5 cm x 0.05 cm

b. Construction

(1) Optical Board

This is simply a piece of hardboard (A) into which pins can be readily stuck. Normally a plain sheet of paper will be placed on top of the hardboard to facilitate the recording of experimental observations. The Refraction Model Apparatus (VI/C3) is such a piece of hardboard.

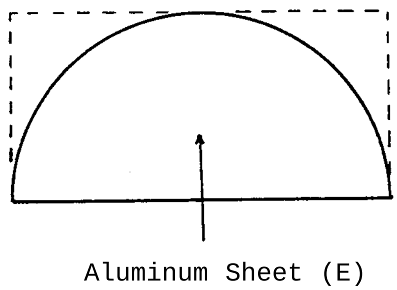
(2) Steel Pins

The steel rods (B and C) may be cut from cycle spokes or similar steel rods. Sharpen one end of each rod with the help of a file.

(3) Steel Pins with Sleeves

Remove the pencil lead from the pencils (D) with the help of a steel pin. Coat the steel pin (C) with epoxy resin, and slide it into the space originally occupied by the lead, so that, instead of the pencil lead, a steel pin protrudes from the end. Cover the sleeve with a white coat of paint.

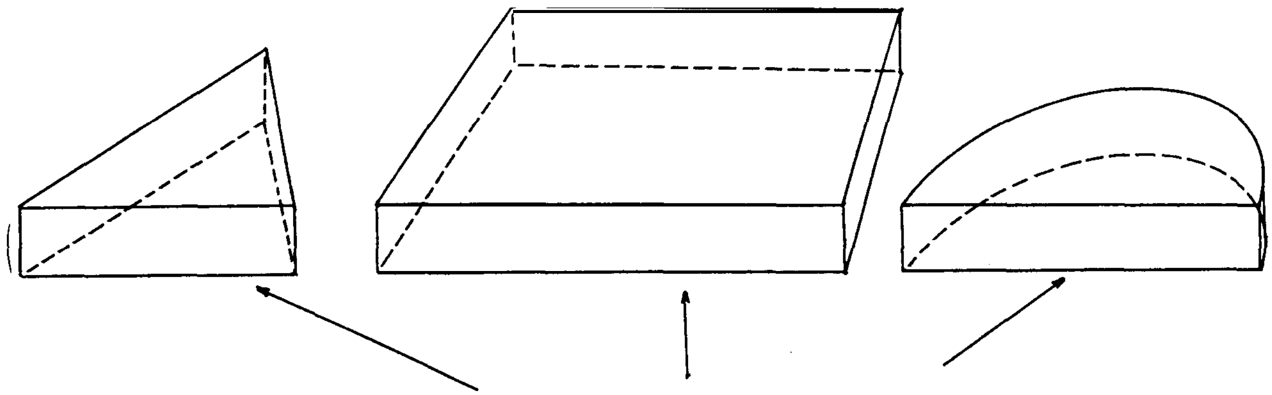
(4) Protractor



Make a protractor by cutting a semicircular piece of metal from the aluminum sheet (E). Mark as many angles around the periphery of the protractor as desired.

C. REFRACTION APPARATUS

Cl. Optical Prisms and Lenses ©



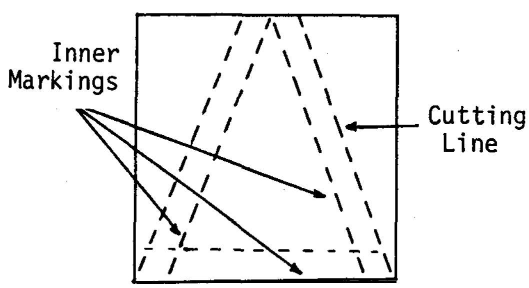
(1) Prisms

a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Prisms	1	Sheet of Acrylic (A)	16 cm x 10 cm x 2 cm

b. Construction

(1) Prisms



Triangular Prism

Take the sheet of acrylic'(A) and mark out the shape of the desired prism with a sharp point. Draw a parallel set of lines about 0.5 cm outside the initial marking. The inner markings should outline a triangle (3 cm x 3 cm x 3 cm), a rectangle (8 cm x 5 cm) and a semicircle (9 cm diameter).

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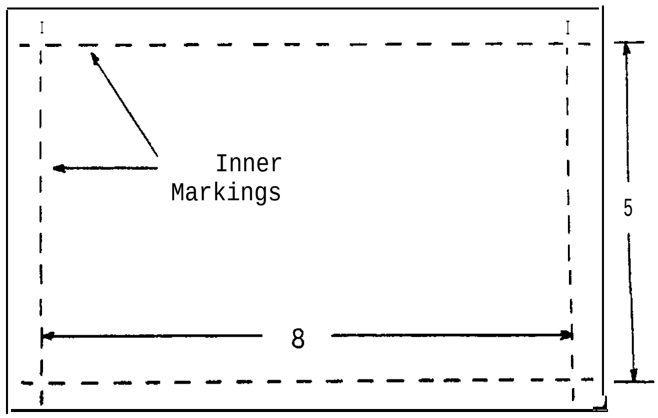
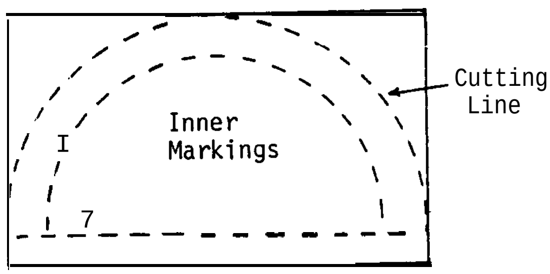
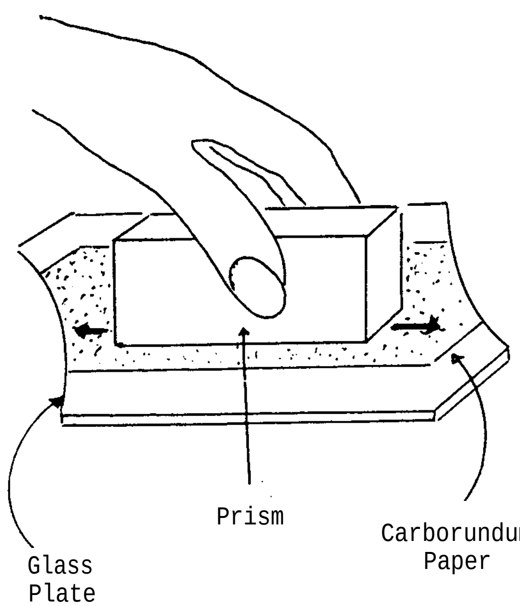


Rectangular Prism

Using a fine-toothed saw, carefully cut the plastic down to the outer markings. The cut produced will have very jagged edges, the plastic showing a tendency to chip. This is normal, and should cause no concern.



Semicircular Prism



The next step is to remove the rough edges from the prism, reducing its size to that of the inner markings. For this purpose place a coarse sheet of Carborundum paper on top of a smooth surface (e.g., a strong glass sheet). Then smooth down the surfaces of the prism by rubbing them on the Carborundum surface.

Repeat the process with successively finer and finer grades of Carborundum paper, taking care at each rubbing to remove the deeper marks of the previous rubbing.

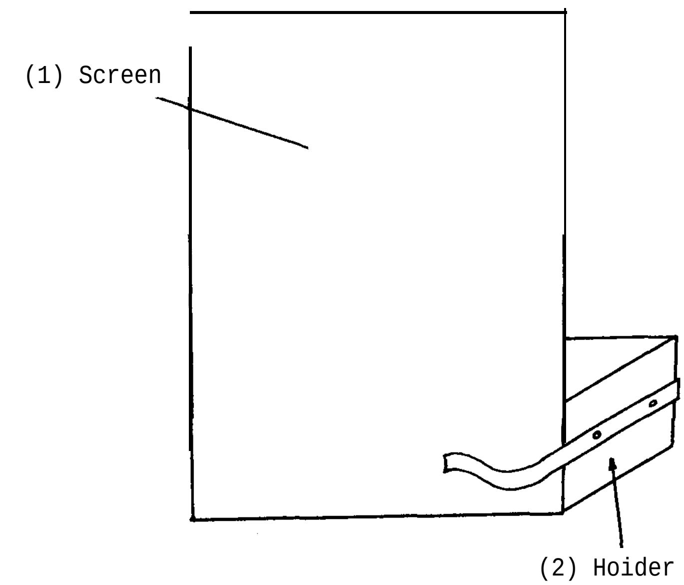
Finally, replace the Carborundum paper by a sheet of plain paper. Drop a little metal polish on the paper, and repeat the rubbing process. The surface produced will be highly polished.

The rubbing and polishing process is repeated with all the surfaces except that surface which will normally be in contact with the table top during experimentation. This surface is smoothed with Carborundum paper, but not metal polish, thus leaving the surface sufficiently rough to scatter light.

c. Notes

(i) Plastic is not as hard as glass, and is therefore more easily scratched and damaged. From time to time it is therefore necessary to repolish the surfaces with metal polish, as described above.

C2. Screen with Holder



a. Materials Required

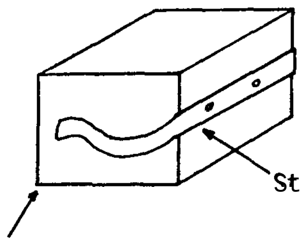
Components	Qu	Items Required	Dimensions
(1) Screen	1	Cardboard (A)	25 cm x 15 cm
	1	White Paper (B)	25 cm x 15 cm
	1	Black Paper (C)	25 cm x 15 cm
(2) Holder	1	Wood Block (D)	4 cm x 4 cm x 4 cm
	1	Steel Band (E)	Approximately 8 cm x 1 cm x 0.02 cm

b. Construction

(1) Screen

Make the screen from the stiff piece of cardboard (A). It is very convenient to have a front white surface and a rear black surface. This may be achieved by sticking appropriate sheets of paper (B,C) on the two surfaces.

(2) Holder

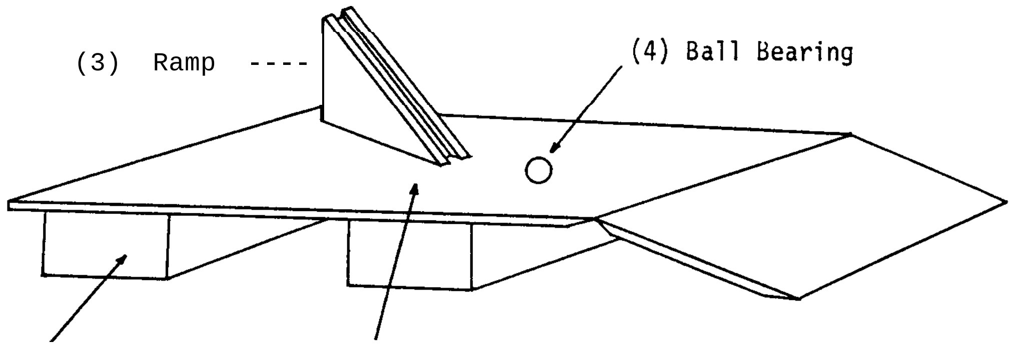


Bend a length of packing case steel (E) as shown and nail it to the side of the wooden block (D).

C. Notes

(i) The white surface of the screen is used for normal image formation, while the black surface is useful whenever the screen is used as a barrier to exclude light.

C3. Refraction Model Apparatus

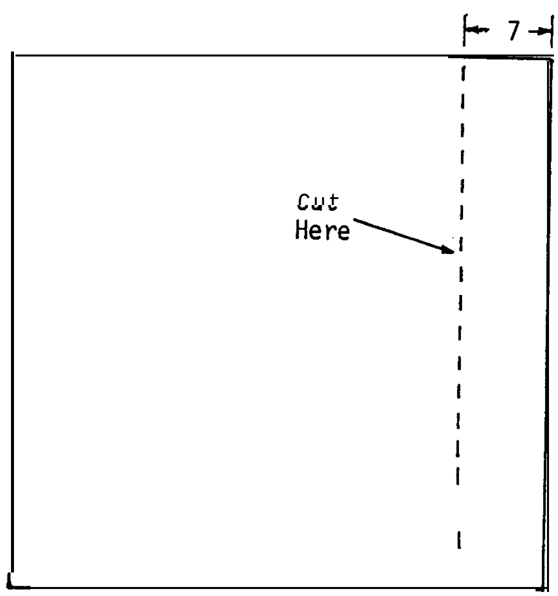


a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Platform	1	Hardboard (A)	40 cm x 40 cm x 0.5 cm
	2	Hinges (B)	Approximately 2 cm long, sidepieces no more than 0.5 cm wide
(2) Supports	2	Wood (C)	30 cm x 4 cm x 2 cm
(3) Ramps	1	Wood (D)	12 cm x 5 cm x 2 cm
	1	Wood (E)	12 cm x 3 cm x 2 cm
(4) Ball Bearing	1	Ball Bearing (F)	2.5 cm diameter

b. Construction

(1) Platform

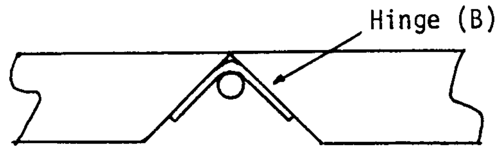


Hardboard (A)

Cut a 7 cm strip from one side of the plywood (A), and shape the newly cut edges back at an angle of 45° as illustrated. Reattach the 7 cm strip to the platform with very small hinges (B) avoiding the creation of a gap between the strip and main platform. Shape the free edge of the 7 cm strip to an angle of 45°. This shaping insures good contact between the strip and the table.

(Also see illustration on next page.)

Side View

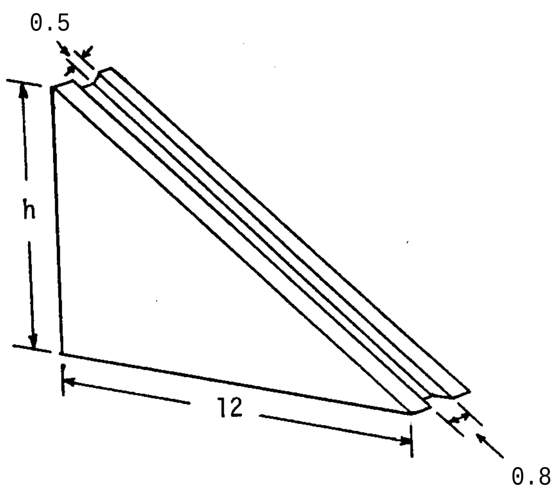


Detail

(2) Supports

Books, or blocks of wood (C), may be used to elevate the platform to different heights above the table top (e.g., 2 and 4 cm).

(3) Ramp



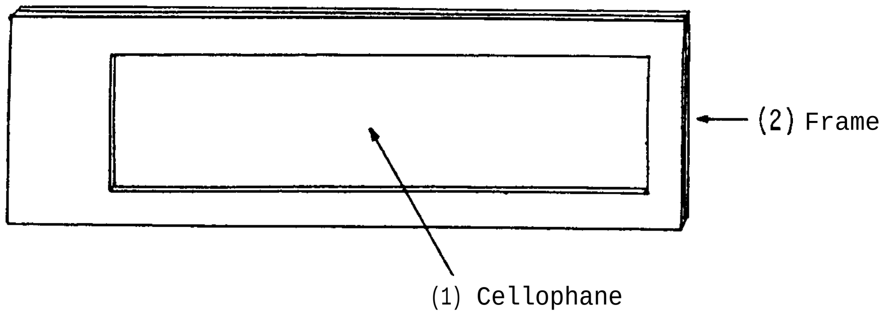
Cut two triangular shapes out of the pieces of wood (D,E). The height (h) of one triangular shape will be 5 cm and the other will be 3 cm, while both will have a base 12 cm long.

The groove is best cut with the help of a saw.

C. Notes

(i) This apparatus is used to demonstrate the refraction of light according to Newton's Corpuscular Theory. The ball bearing may be rolled down the small ramp, across the top platform and down the ramp, or alternatively down the large ramp, across the table top and up the ramp. In either case refraction occurs in crossing the ramp from one level (or medium) to another, and appropriate comparisons may be made with the transmission of light across a boundary (ramp) from one medium (level) to another.

C4. Filter

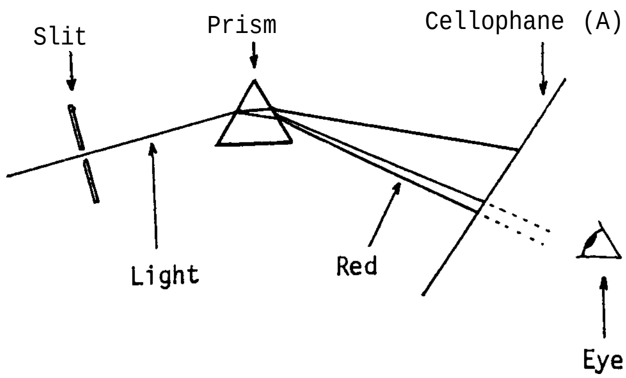


a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Cellophane	1	Red Cellophane (A)	10 cm x 3 cm
(2) Frame	2	Cardboard (B)	10 cm x 3 cm

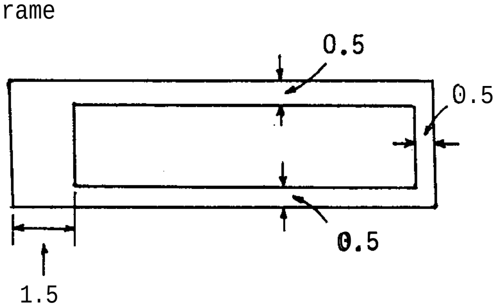
b. Construction

(1) Cellophane



Test different strips of red cellophane (A) for suitability by noting what parts of a spectrum can be seen through the cellophane. The cellophane cutting out almost all colors other than red will be most suitable.

(2) Frame



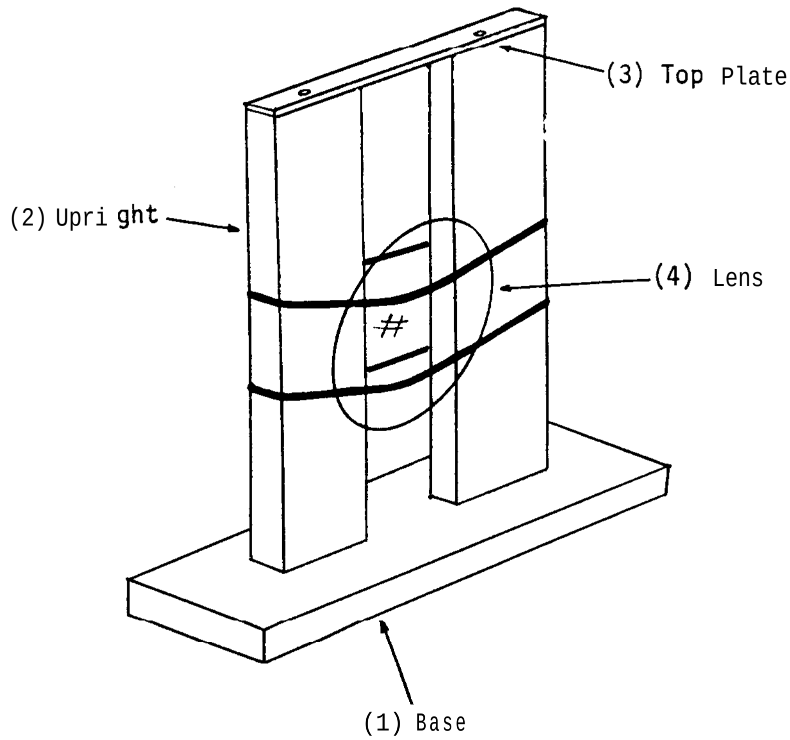
Cut the two pieces of cardboard (B) to the shape indicated, and stick (or clip) a suitable piece of red cellophane (A) between the two pieces.

C. Notes

(i) Filters are very useful not only in studying the way in which different colors of light superimpose one on the other, but also for the creation of monochromatic light. This is particularly important in studying interference and diffraction phenomena.

D. LENS APPARATUS

Dl. Lens with Holder ©



a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Base	1	Wood (A)	10 cm x 5 cm x 1 cm
(2) Uprights	2	Wood Strips (B)	12 cm x 2 cm x 1 cm
	2	Screws (C)	1.5 cm long
(3) Top Plate	1	Metal Sheet (D)	7 cm x 1 cm x 0.1 cm
	2	Screws (E)	Approximately 0.7 cm long
(4) Lens	1	Magnifying Glass (F)	--

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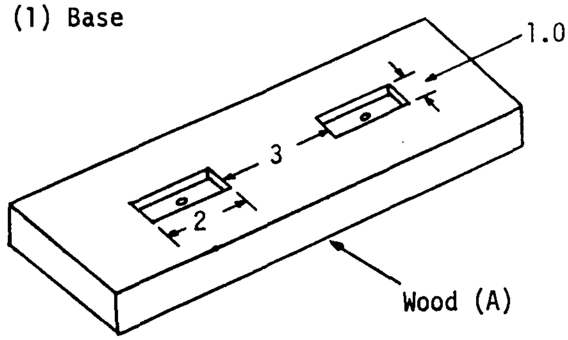
b. Construction

(1) Base



Make two insets (0.5 cm deep) in the wood (A) to take the two uprights (B). Drill a small hole (0.2 cm diameter) in the middle of each inset.

(2) Uprights

Set the uprights (B) in the base insets with wood cement, insuring a firm joint by screwing the very small screws (C) through the base into the upright.

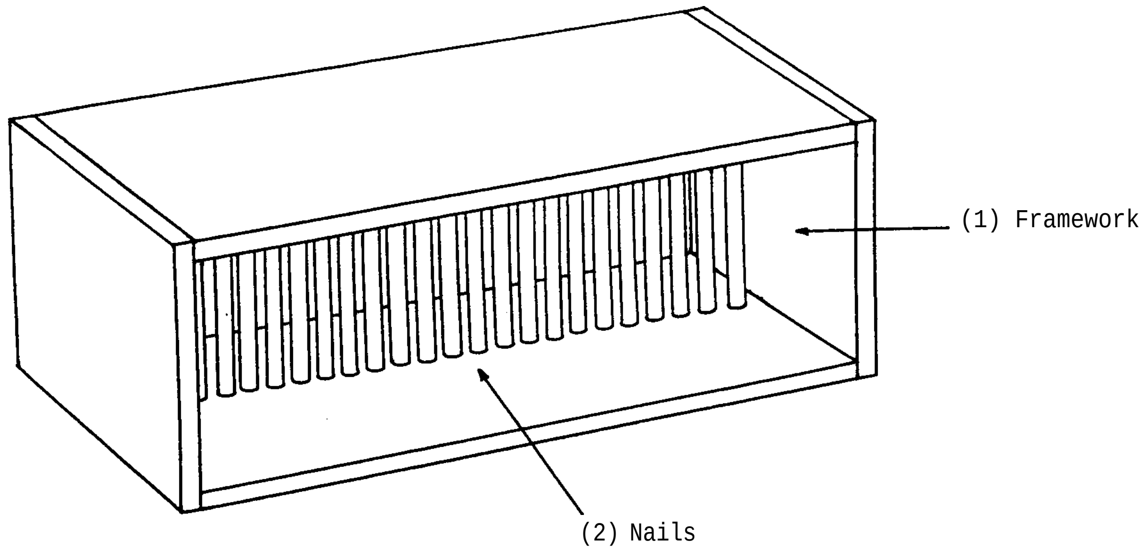
(3) Top Plate

Cut the top plate out of aluminum or brass (D). Drill a small hole (0.2 cm diameter) at a distance of 1 cm from each end. Attach the top plate to the uprights with very small screws (E).

(4) Lens

Purchase a suitable magnifying glass (F) locally. It may be held in any position on the upright by means of rubber bands.

D2. Multiple Slits

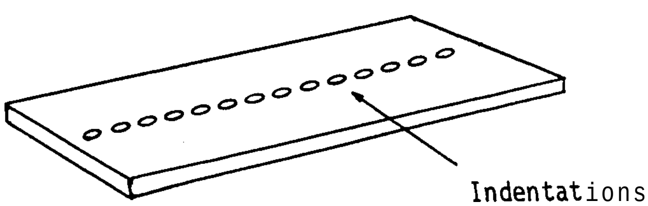


a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Framework	2	Wood Strips (A)	10 cm x 2 cm x 0.5 cm
	2	Wood Strips (B)	4 cm x 2 cm x o.5 cm
(2) Nails	1	Box of Nails (C)	0.2 cm diameter, more than 4 cm long

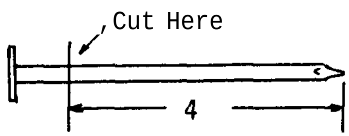
b. Construction

(1) Framework



Make regular indentations down the middle of the top and bottom strips (A) of the framework, the indentations being 0.4 cm apart. These indentations can easily be made with a hammer and nail. The remaining two pieces of wood (B) will serve as sidepieces for the framework. Do not complete construction of the framework until the nails (C) are in place.

(2) Nails



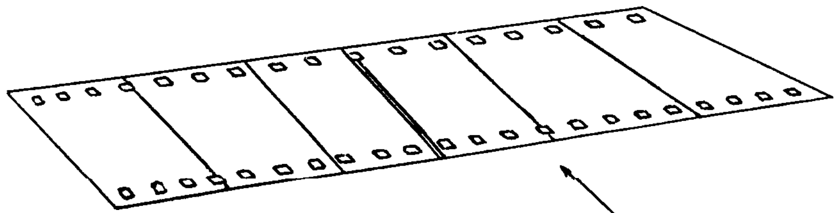
Take a handful of nails (C) and cut off the top ends to produce a uniform set of nails, each 4 cm long. Tap the nails into the bottom strip (A), positioning them in the indentations. Then press the upper strip (A) onto the upright nails, using the indentations on the upper strip for guidance in positioning the nails parallel to one another. Finally, attach the sidepieces (B) of the framework using very small nails or wood cement.

c. Notes

(i) The multiple slits are used primarily to break up beams of light into multiple pencils of light. Many alternative devices could be used for the same purpose, e.g., a hair comb supported by a wooden block.

E. DIFFRACTION AND INTERFERENCE APPARATUS

El. Fixed Single and Double Slits



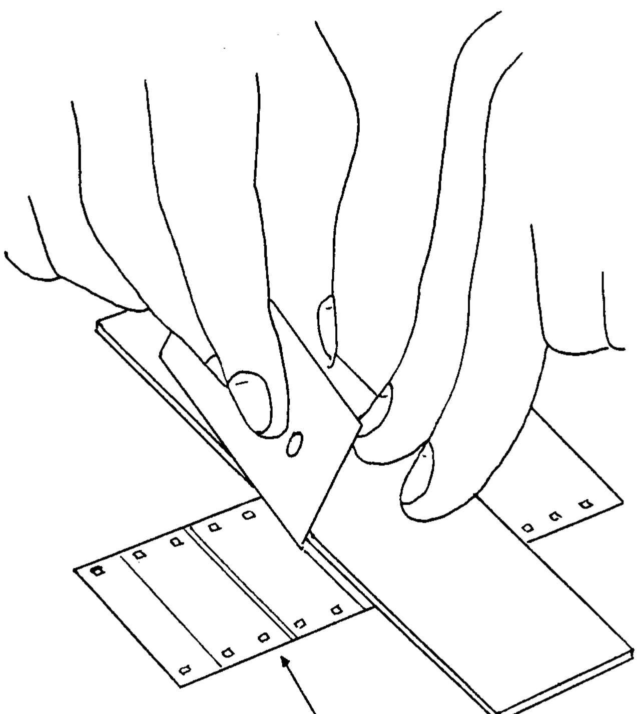
(1) Fixed Slits

a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Fixed Slits	1	Exposed Film (A)	Approximately 5 cm x 3.5 cm

b. Construction

(1) Fixed Slits



Exposed Film (A)

Take an exposed strip of film (A) (or a slide coated with colloidal graphite) and draw a straight line across it using a razor and a straight edge as a marker. The width of the slit may be increased, if desired, by drawing the razor over the same approximate line two or three times. Do not cut through the film.

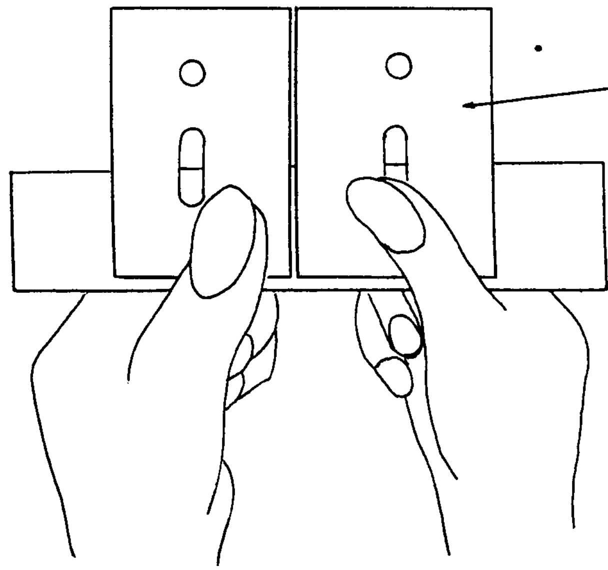
A double slit may be made in an almost identical way, Simply hold two razors face to face, and draw the line across the film with the two razor blades pressed closely together. The space between the slits may be increased, if desired, by holding the blades at an angle to the vertical as the double line is drawn against the straight edge.

C. Notes

(i) In making single or double slits it is well worthwhile repeating the procedure several times on different parts of the film, and then selecting the best slits after testing.

(ii) If the slits are held in a vertical position close to the eye, and if the vertical filament of the Light Source (VI/Al) at a distance of about three meters is viewed through the slits, interference and diffraction patterns will be observed even in daylight. The patterns are clarified by the use of the Filter (VI/C4) placed in front of the slits.

E2. Adjustable Single Slit



a. Materials Required

Components	Qu	Items Required	Dimensions
(1) **Adjustable Slit**	2	Razor Blades (A)	--
	1	Metal Strip (B)	Approximately 7 cm x 2 cm

b. Construction

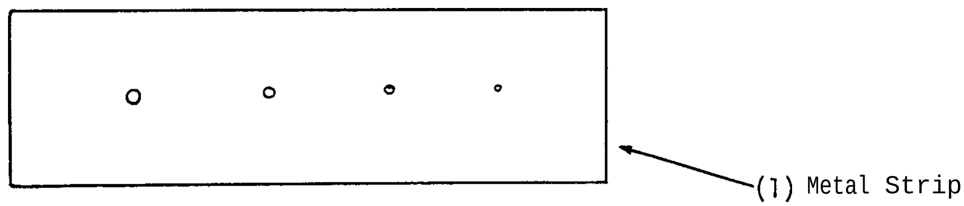
(1) Adjustable Slit

Hold the two razor blades (A) against the metal strip (B) so that the edges of the blades are almost touching and are parallel to one another.

c. Notes

(i) If the slit is held in a vertical position close to the eye, and the vertical filament of the Light Source (VI/Al) viewed at a distance of about three meters, a diffraction pattern may be observed in daylight conditions. The pattern is clarified by the use of the Filter (VI/C4) placed in front of the slit. The effect on the pattern of changing the slit width may readily be observed.

E3. Diffraction Holes



a. Materials Required

Components	Qu	Items Required	Dimensions
(1) Metal Strip	1	Metal Strip (A)	10 cm x 2.5 cm x 0.1 cm

b. Construction

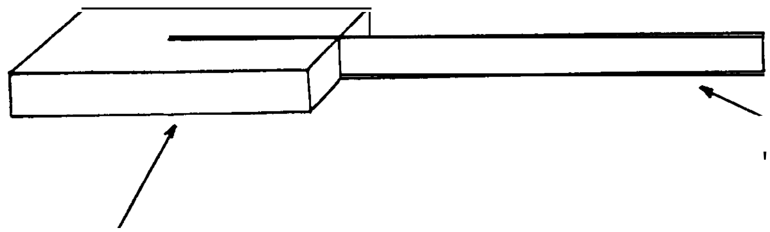
(1) Metal Strip

Drill four holes (diameters approximately 0.1, 0.08, 0.05, and 0.02 cm) in the metal strip (A) at regular intervals.

c. Notes

(i) Circular diffraction patterns may be studied with these holes and the Light Source (VI/Al) placed in such a position that the light filament is viewed through the small hole in the lid of the lamp housing, thus acting as a point source. If this point source is viewed at a distance of about three meters by looking through one of the diffraction holes,when the strip is held close to the eye, a diffraction pattern will be seen even in daylight conditions. The pattern will appear clearer if the Filter (VI/C4) is placed in front of the diffraction hole.

E4. Interference Strips



a. Materials Required

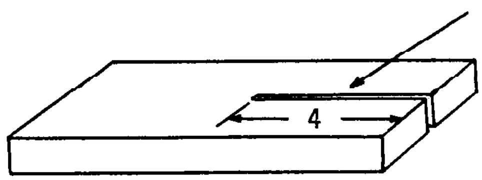
Components	Qu	Items Required	Dimensions
(1) Metal Strip	1	Metal Strip (Copper or Steel)	14 cm x 1 cm x 0.1 cm
(2) Handle	1	Wood	7 cm x 1 cm x 1 cm

b. Construction

(1) Metal Strip

The metal strip (A) may be of any desired metal. In this instance, two are specifically recommended, namely copper and steel (from packing case bands).

(2) Handle



The handle is made from the wood (B). Cut a slit down the middle of the handle with a saw. **Cement the metal strip into this inset with epoxy** resin.

c. Notes

(i) If the end of the metal strip is placed in 'a hot flame, interference bands will be produced on the strip.