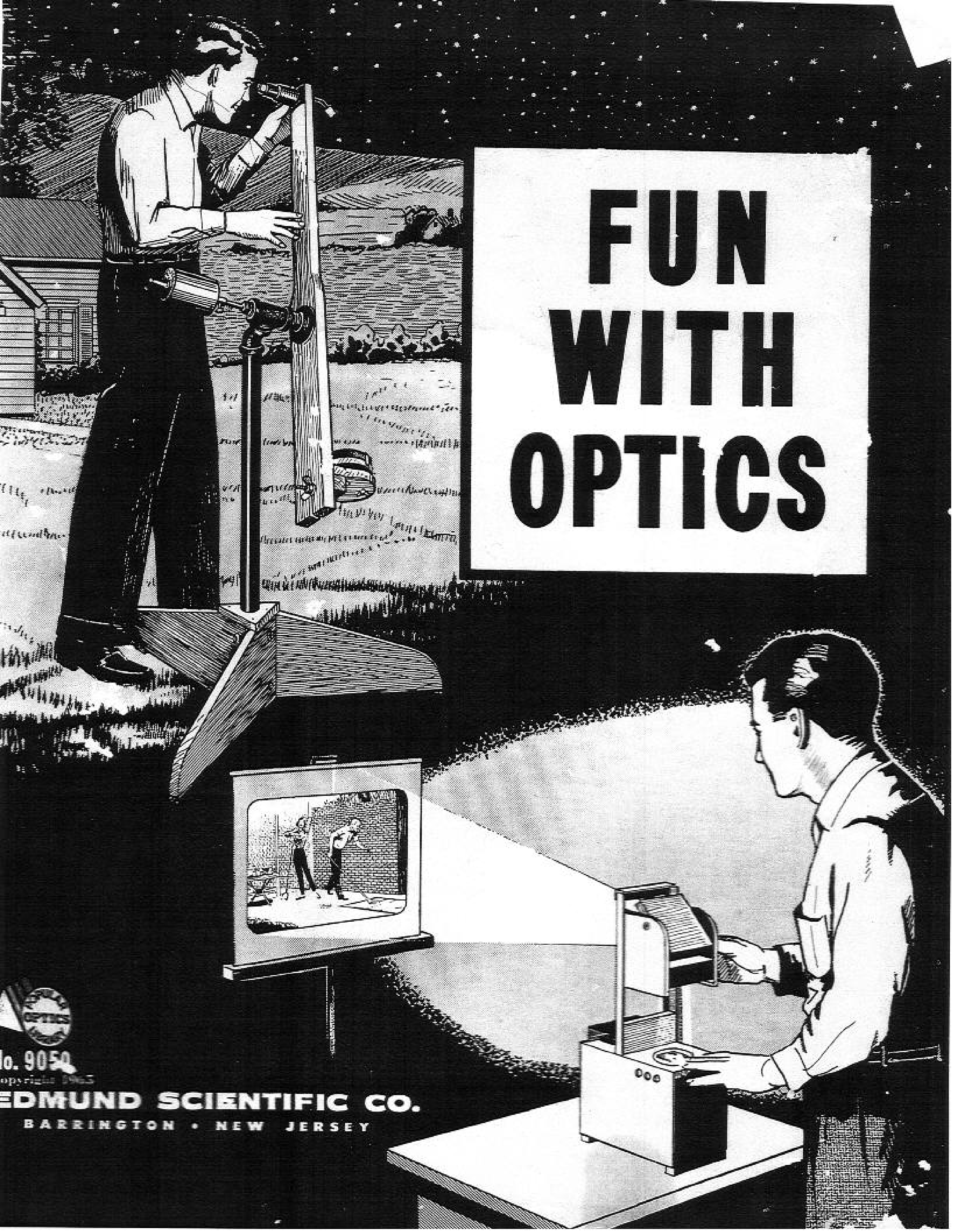
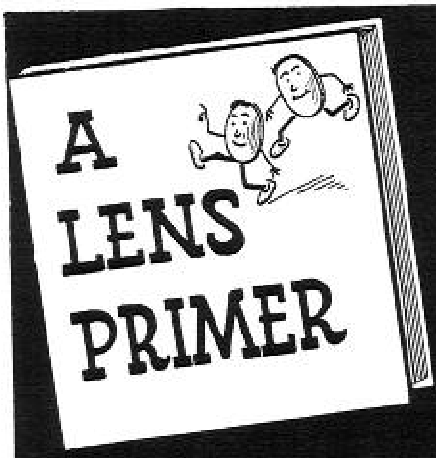
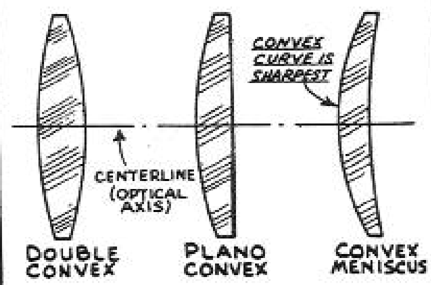


FUN WITH OPTICS

EDMUND SCIENTIFIC CO.
BARRINGTON • NEW JERSEY

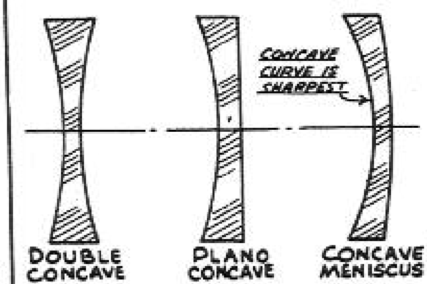
A LENS PRIMER





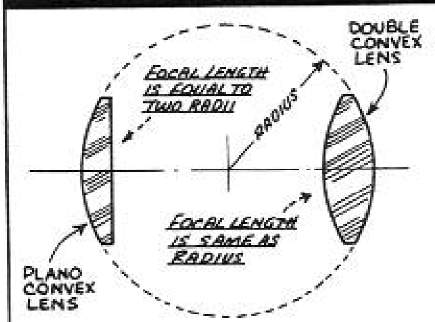
POSITIVE LENSES

A LENS IS POSITIVE IF IT CAN FOCUS PARALLEL LIGHT TO A POINT. IF THE LENS IS A SINGLE PIECE OF GLASS IT IS A SIMPLE LENS



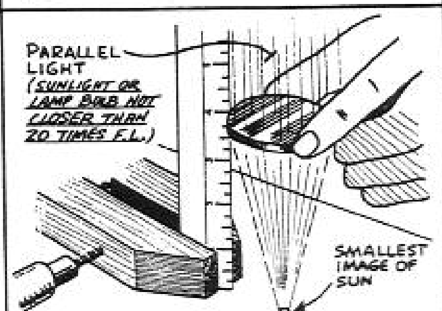
NEGATIVE LENSES

NEGATIVE LENSES SPREAD PARALLEL LIGHT RAYS AND CANNOT FOCUS THE RAYS TO A POINT. USED ALONE AT EYE, NEGATIVE LENS REDUCES



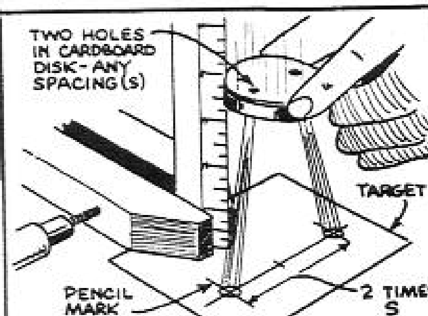
FOCAL LENGTH

ALL SIMPLE LENSES ARE BASED ON CIRCULAR CURVES. THE RADIUS OF THE CURVE CONTROLS THE FOCAL LENGTH AND ALSO LIMITS THE DIAMETER



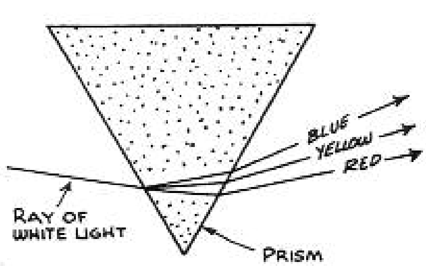
FINDING F.L. - POSITIVE LENS

HOLD THE LENS IN SUNLIGHT AND ALONGSIDE A RULER. MOVE UP AND DOWN TO FORM SMALLEST IMAGE OF THE SUN. READ FOCAL LENGTH ON RULER



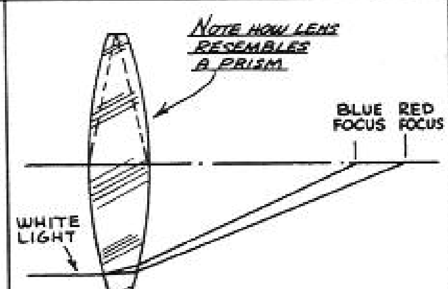
FINDING F.L. - NEGATIVE LENS

MAKE TWO SMALL HOLES IN A DISK OF CARDBOARD AT ANY CONVENIENT SPACING. PLACE DISK OVER LENS. FOCUS RAYS TO STRIKE TARGET AT 2S SPACING



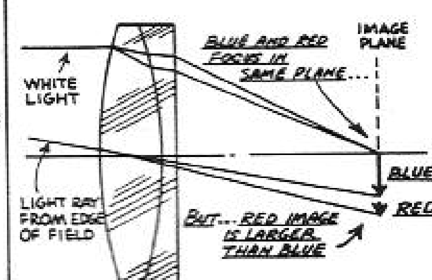
WHITE LIGHT

WHITE LIGHT IS COMPOSED OF ALL THE COLORS. A NARROW BEAM OF SUNLIGHT DIRECTED THROUGH A PRISM EMERGES AS A COLORED BAND—THE SPECTRUM



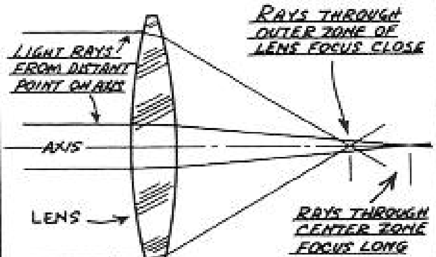
LONGITUDINAL COLOR

SIMPLE POSITIVE LENS BREAKS UP WHITE LIGHT JUST LIKE A PRISM. BLUE RAYS FOCUS CLOSER THAN RED. THIS FAULT IS CONSTANT OVER THE WHOLE FIELD OF VIEW



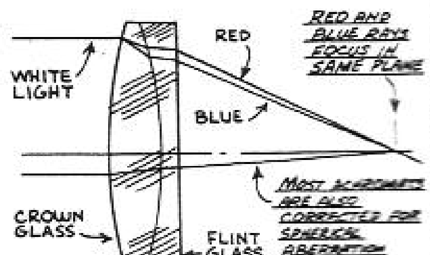
LATERAL COLOR

LATERAL COLOR IS A PRODUCT OF MAGNIFICATION AND IS A COMMON FAULT IN TELESCOPES. IT INCREASES WITH SIZE OF FIELD...IS NOT PRESENT FOR AXIAL OBJECT



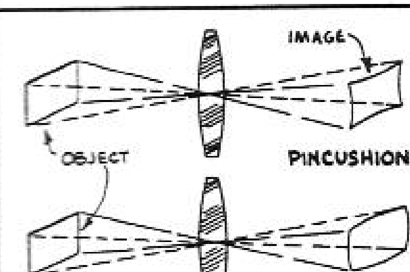
SPHERICAL ABERRATION

LIGHT RAYS THROUGH OUTER ZONE COMES TO A FOCUS CLOSER THAN RAYS THROUGH CENTER. VARIES WITH LENS DIAMETER AND IS LESS FOR A SMALL LENS



ACHROMATIC LENS

AN ACHROMAT IS CORRECTED TO FOCUS RED AND BLUE RAYS IN SAME PLANE. AS A MATTER OF COURSE, SUCH A DOUBLET IS ALSO CORRECTED FOR SPHERICAL ABERRATION

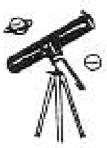


DISTORTION

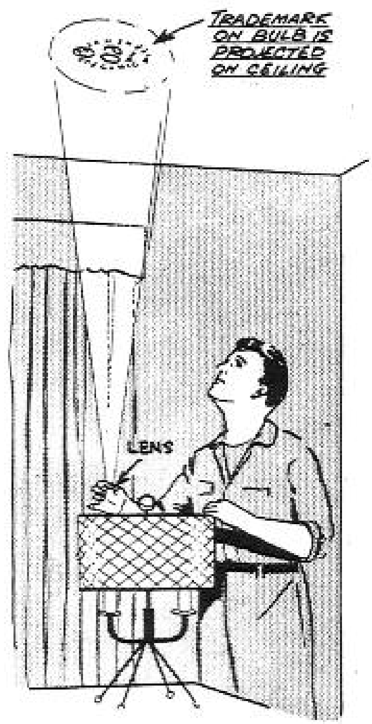
THIS FAMILIAR ABERRATION INCREASES WITH THE FIELD OF VIEW. IT IS RARELY APPARENT OVER A NARROW FIELD. IT OCCURS REGARDLESS OF LENS DIAMETER

FUN WITH OPTICS

edited by SAM BROWN

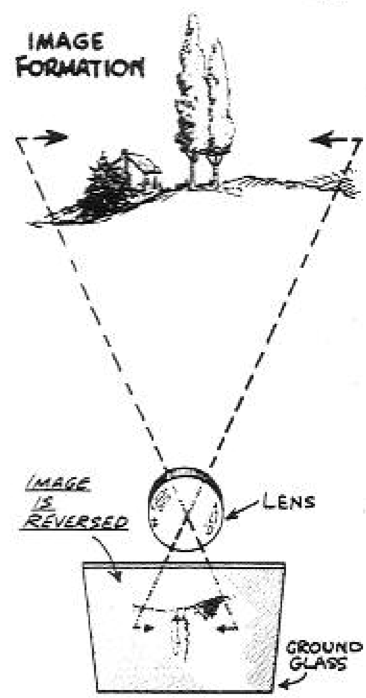


OPTICAL INSTRUMENTS have always fascinated the average person. However, it is only within recent years that the lenses, prisms and mirrors necessary to make these instruments have been made generally available to do-it-yourself hobbyists. Vast war surplus stocks of lenses and prisms started the ball rolling, and today there is such a widespread interest in optics as a hobby as to justify commercial production of components to satisy the needs of the homeshop builder. It's really fun to make your own telescope, assemble your own binocular, build your own projector, make optical gadgets for your camera or fit your pet rifle with a homemade scope.



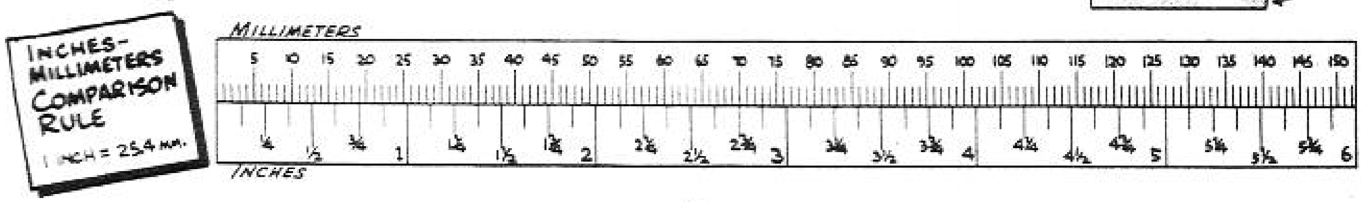
Basic to all optical instruments is the formation of an image. If you take any positive lens of medium focal length (5 or 6 inches) and hold it over an electric lamp, as shown, you will quickly find that when the lens is held a certain distance from the lamp, it will form an image of the trademark on the ceiling. The projected image is enlarged and reversed. This type of image formation is used in microscope and projectors.

In another type of image formation, the lens picks up light rays from a distant object and reforms the picture on a ground glass or piece of tracing paper held behind the lens, as shown. You will recognize this immediately as being the principle of the camera. The same type of image formation is also used in telescopes and binoculars. In these instruments the image forms "on air" inside the telescope where it becomes accessible for viewing with any type of magnifier or eyepiece. A concave mirror will also focus light rays to form an image, and many telescope builders prefer this construction. Because the light rays are simply reflected instead of being bent or refracted, the mirror is fully achromatic.

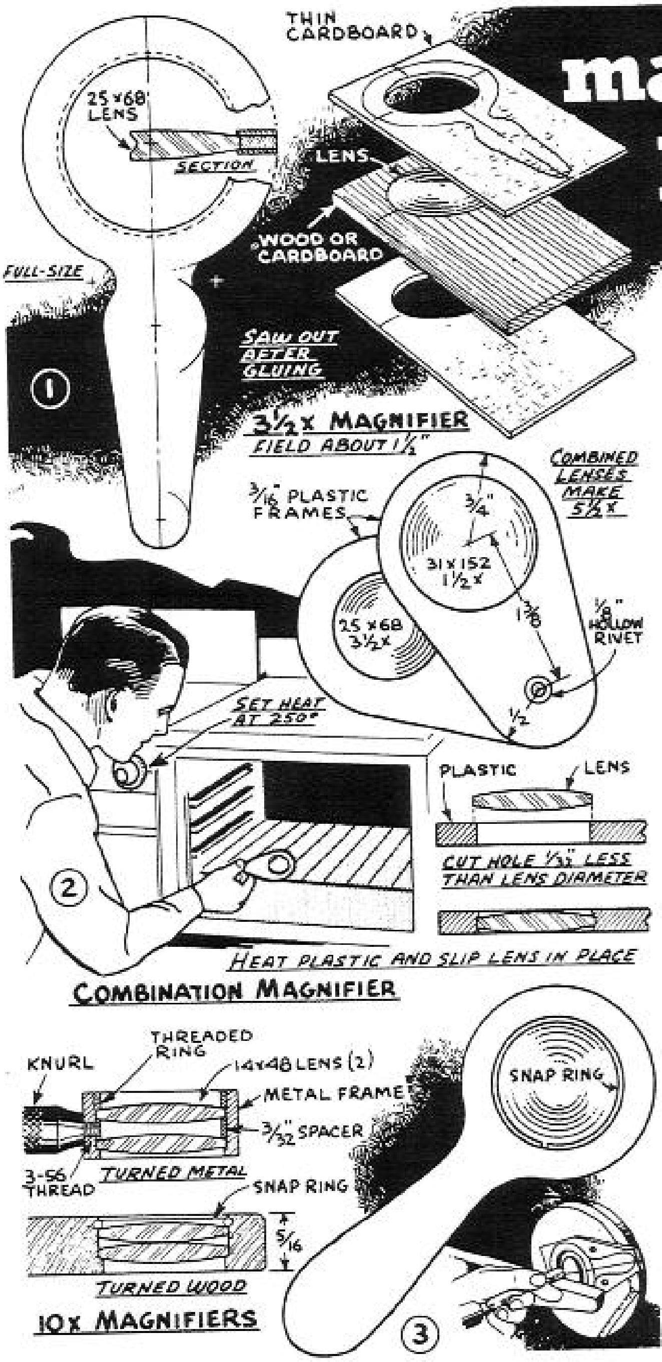


Most of the measuring done in optical construction is expressed in common inches and fractions. An exception is that the diameter and focal length of small lenses are commonly given in millimeters. You will have no trouble understanding this system once you get the general idea of 25 millimeters being equal to 1", approximately. The diameter and focal length of a lens are often expressed together, such as a "25 x 75mm" lens. The first figure is the diameter of the lens; second figure is the focal length. Converted to inches, this example would be 1" diameter by 3" focal length approximately.

Construction of optical instruments can be in wood, cardboard or metal as suits your skill and equipment. Perhaps the most useful of all power tools for this kind of work is the metal lathe, but if you don't have this piece of equipment, you can do creditable work with hand tools. As a matter of fact the many kit items available permit the construction of most instruments with little more than a screwdriver.



make your own MAGNIFIERS

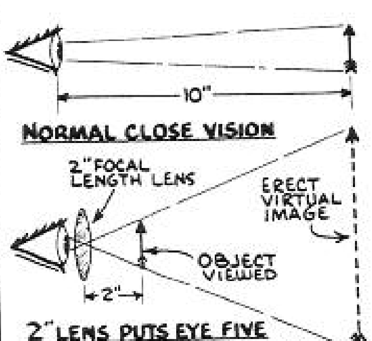


MAKING A magnifier means that you put a lens in a suitable frame. One simple way of doing this is to make a sandwich of three pieces of cardboard, with the lens snugly fitted in a hole in the center piece, as shown in Figure 1. Better yet, use just one thickness of plastic (the thermoplastic type, such as Lucite) and cut just one hole, making it a little smaller than the lens. Now if you put the plastic frame in the kitchen oven, it will become soft and flexible. You can then easily snap the frame over the lens, and when it cools you will have a nice professional-looking job. The detail in Figure 2 shows how two plastic frames can be riveted together to make a combination magnifier with three different powers--1-1/2X, 3-1/2X and 5-1/2X.

If you want a high power magnifier, use two 14x48mm lenses in contact. This will give 10X magnification. Figure 3 shows suitable mounts for this magnifier in both wood and metal. 10X is about as high as it is practical to go in a simple magnifier because of the decreasing size of field and the short working distance. However, if you want 20X, it's yours with any 1/2" focal length lens or two 1" focal length lenses in contact.

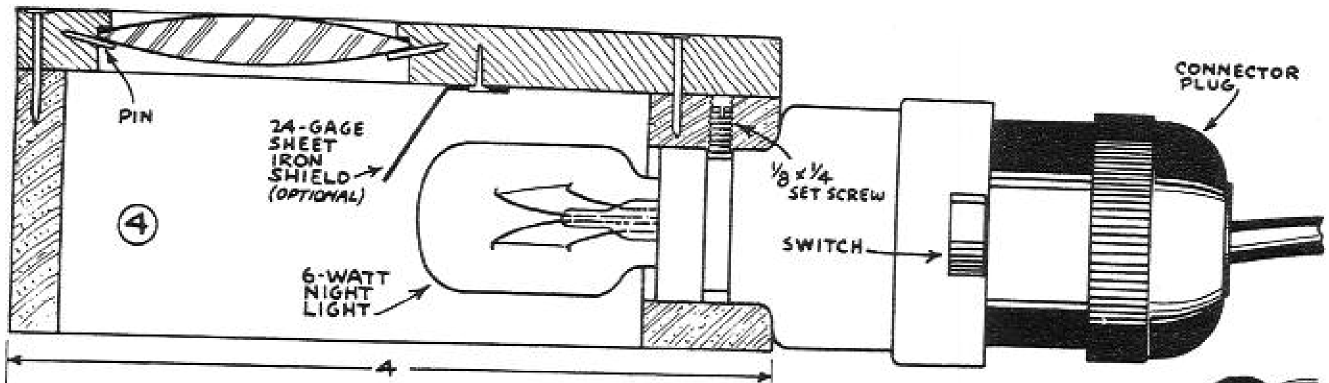
Any magnifier is a failure if the object viewed is not properly illuminated. To make the magnifier independent of exterior light, the light is often built right into the frame,

Power of MAGNIFIERS

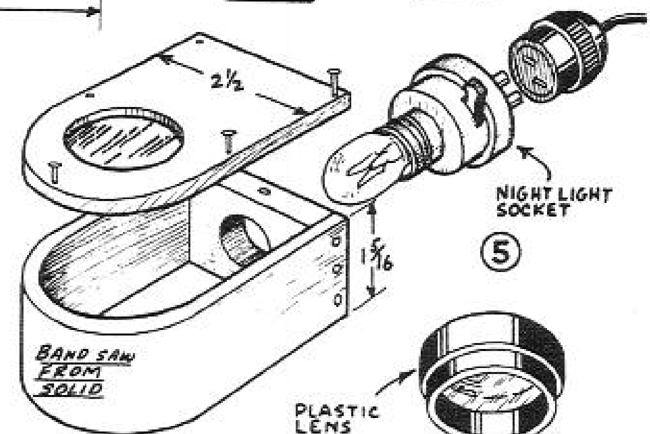


The simple rule to find the rated power of any magnifier is to divide its focal length into 10". This rating is exact for eyepieces and other applications where the eye is immediately behind the lens. With hand magnifiers, greater magnification is obtained by locating the eye several inches behind the lens. Used in this way, a 10" lens will magnify about 2X and even 20 to 30" focal length lenses will show 1-1/4X or more magnification.

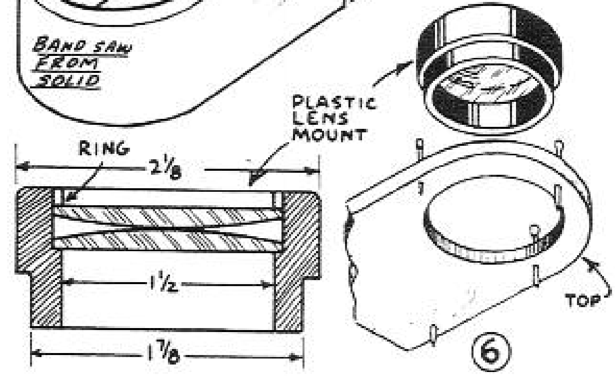
FOCAL LENGTH OF LENS		RATED POWER
INCH	MM.	
1"	25	10x
2"	51	5x
3"	76	3.3x
4"	102	2.5x
5"	127	2x
6"	152	1.7x
7"	178	1.4x
8"	203	1.3x
9"	229	1.1x
10"	254	1x



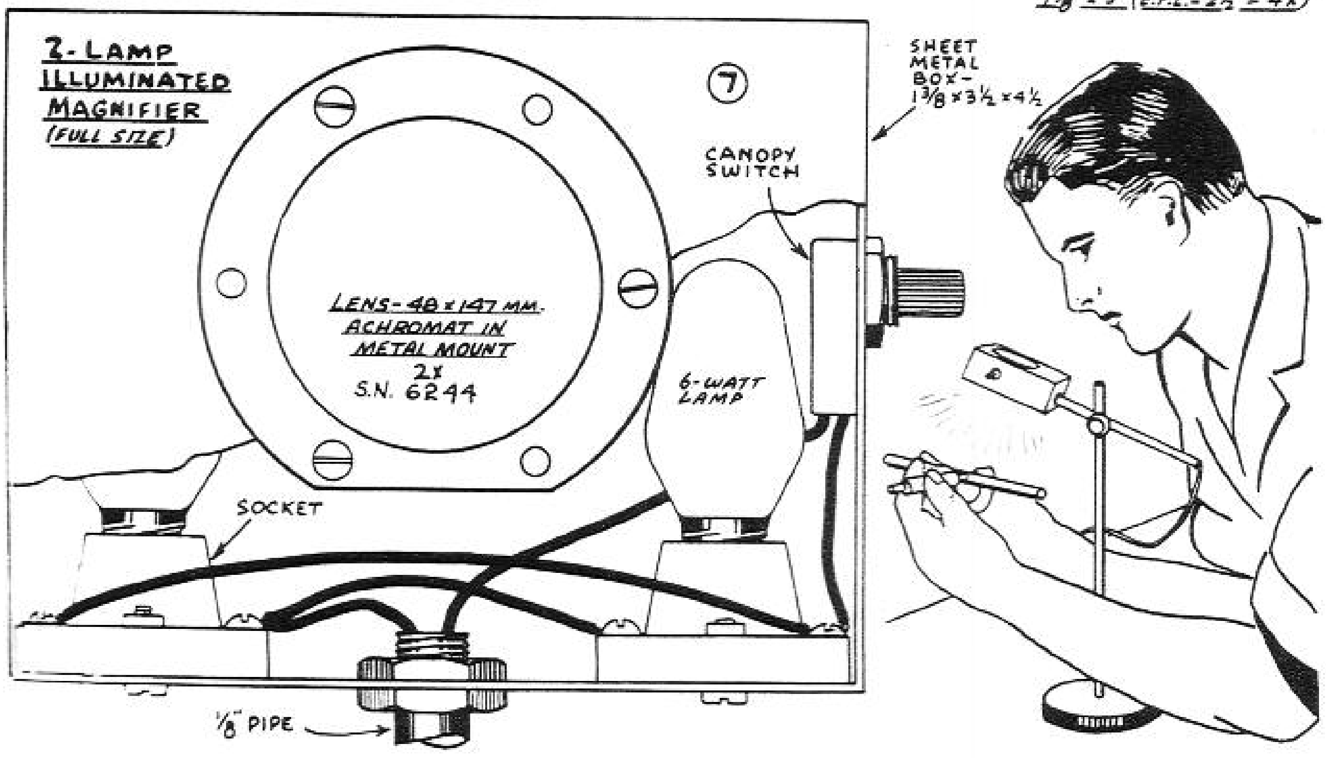
ONE-LAMP ILLUMINATED MAGNIFIER *(FULL SIZE)*
SUGGESTED LENS— 1⅝" DIA. BY 3¼" F.L. (3X)



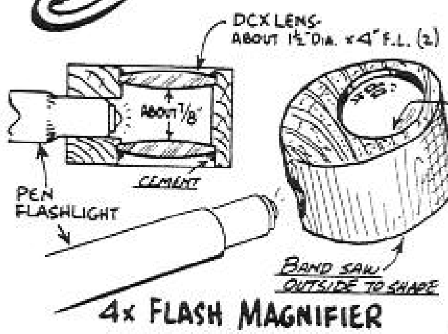
as shown by the typical construction in Figures 4 and 5. The lamp is a 6 or 7-watt night light contained in its own socket. These units can be purchased at most electrical stores. In order to have good working distance, magnifiers of this kind should be in the low-power range of 2, 3 or 4X. Either a single lens, Figure 4, or two in contact, Figure 6, can be used. Figure 7 shows a neat style in a two-lamp illuminated magnifier. This uses a 6" achromat in a metal mount and gives about 2X. The construction shown is in sheet metal, with 6 or 7-watt lamps in standard porcelain cleat receptacles made for this size lamp (candelabra screw base). If you are handy at the lathe, it is not much of a job to make the adjustable mounting. Similar mounts can be purchased, or, you can make a neat mounting with a 10 or 12" flexible gooseneck, which you can buy at most electrical stores.

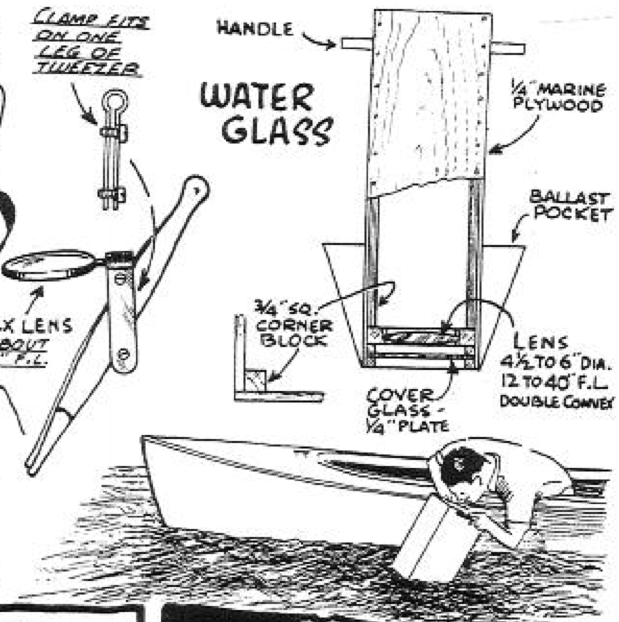


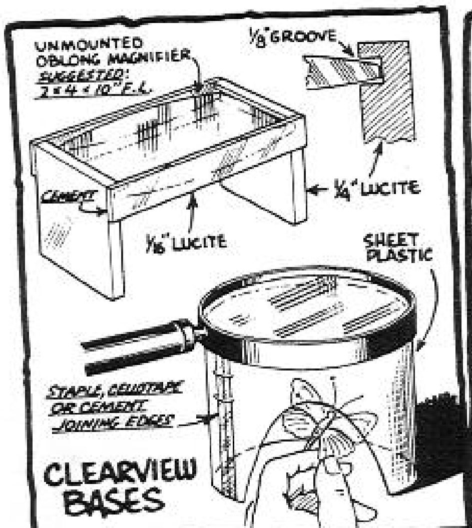
ALTERNATE LENS SYSTEM – *SUGGESTED: TWO P.C. 1⅝" x 5" (E.F.L.=2½"=4X)*

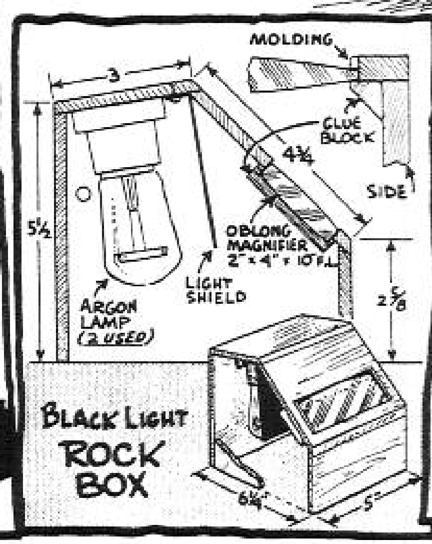


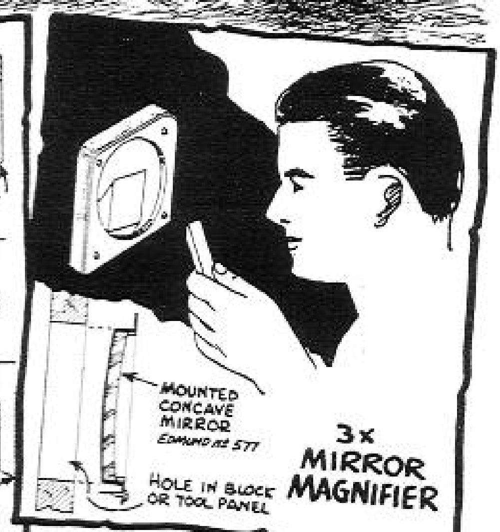
magnifier Ideas

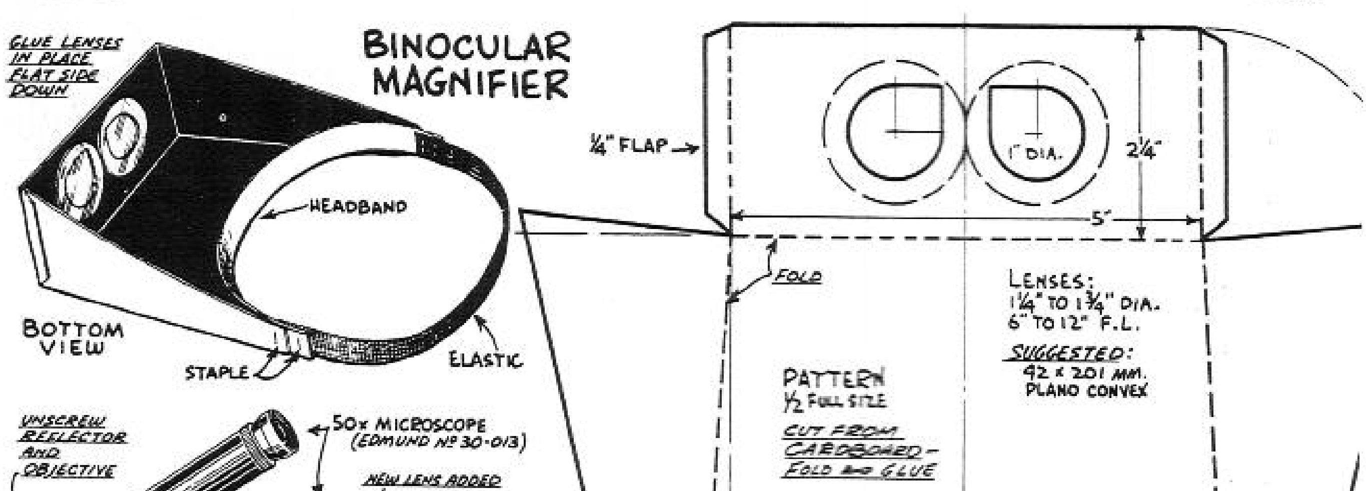


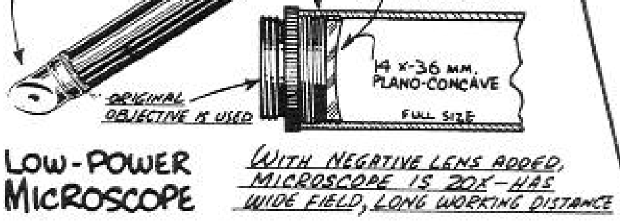






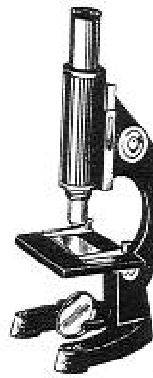






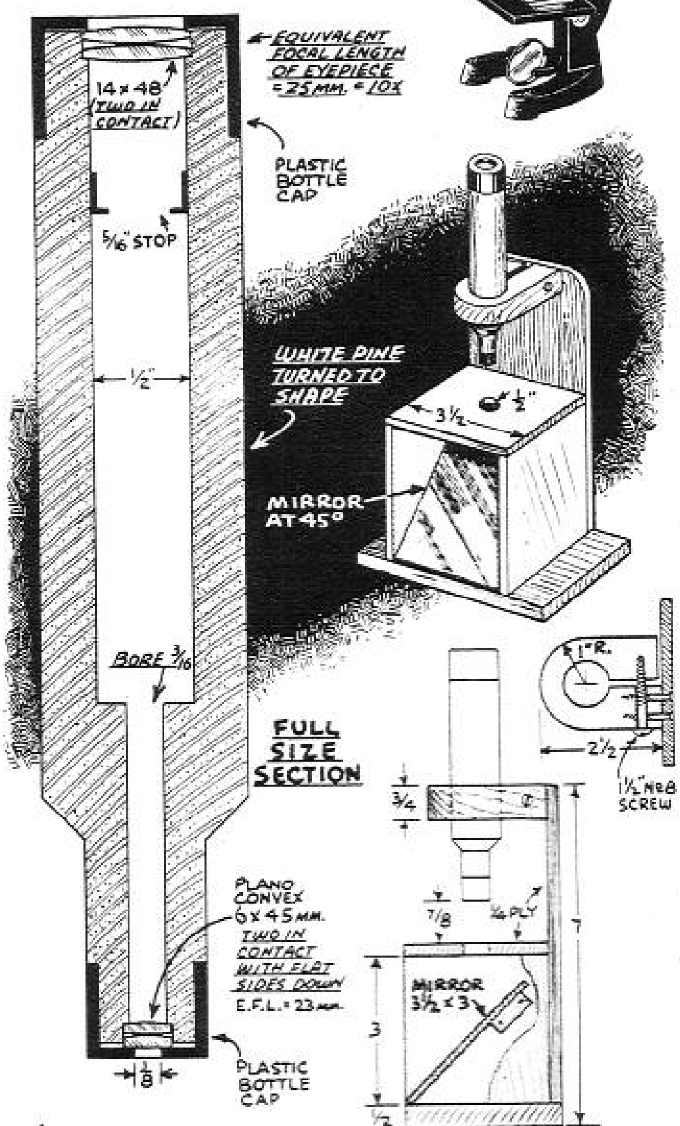
DOUBLE-HEADER MAGNIFICATION

The MICROSCOPE



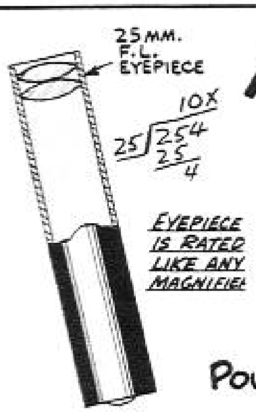
HIGH POWER beyond the range of the simple magnifier is obtained by double-header or compound magnification. In this optical system--the microscope--one lens is used to produce a magnified image of the object, while a second lens further magnifies the magnified image. The total magnification is the magnification of the first lens (the objective), multiplied by the magnification of the second lens, the eyepiece. Most professional microscopes have a top power of about 1500X although up to 3600X can be obtained. Good-quality student microscopes go 900X; junior or toy microscopes are good to about 450X. 300X is plenty of power if you want a microscope "just for fun."

Simple homemade microscopes are inexpensive and easy to build. A typical 40X model is shown in the drawing. It can be used as a pen microscope or may be mounted on a stand with 45-degree mirror to reflect light through slides placed on the stage. In the low-power range (under 50X), simple lenses as shown will perform practically as good as more expensive achromats. The construction calls for turning a piece of wood on the lathe, but you can do the job just as well with cardboard tubing. Telescoping tubes are often used and in this way you can vary the power by changing the optical tube length--the longer the tube length, the higher the power. If stronger lenses are used, it is preferable to use a shorter focal length objective rather than a stronger eyepiece.

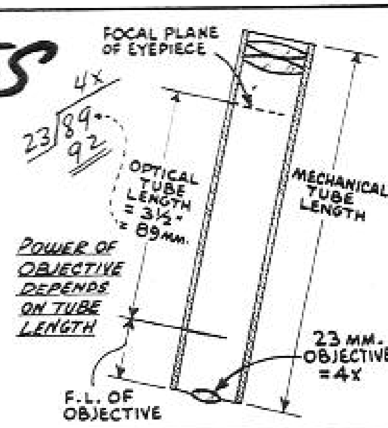


40x MICROSCOPE

Power of MICROSCOPES

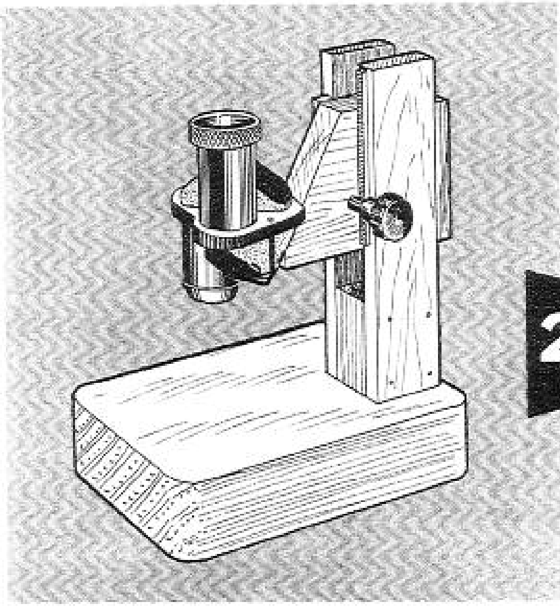


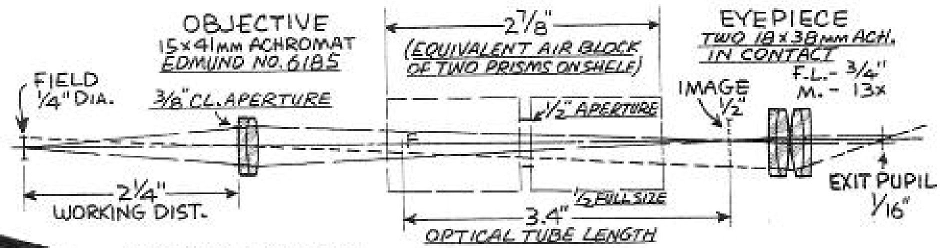
The eyepiece is rated like any simple magnifier, that is, F. L. in millimeters divided into 250. Objective power depends on the optical tube length. In most microscopes this is 160mm, but there are many variations. Example shown, right, is the homemade microscope above. When a manufactured objective is given a power rating, it is usually based on 160mm tube length. Thus, 10X indicates 16mm F. L. Total power is obtained by the formula below.



POWER = POWER OF EYEPIECE X POWER OF OBJECTIVE

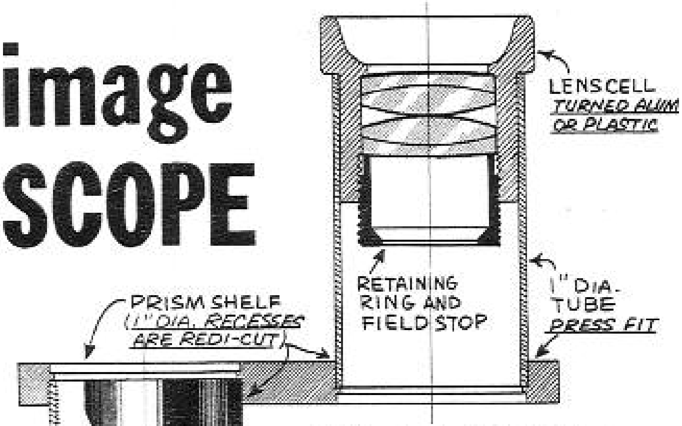
EXAMPLE SHOWN: 10x TIMES 4x = 40x





OPTICAL SYSTEM

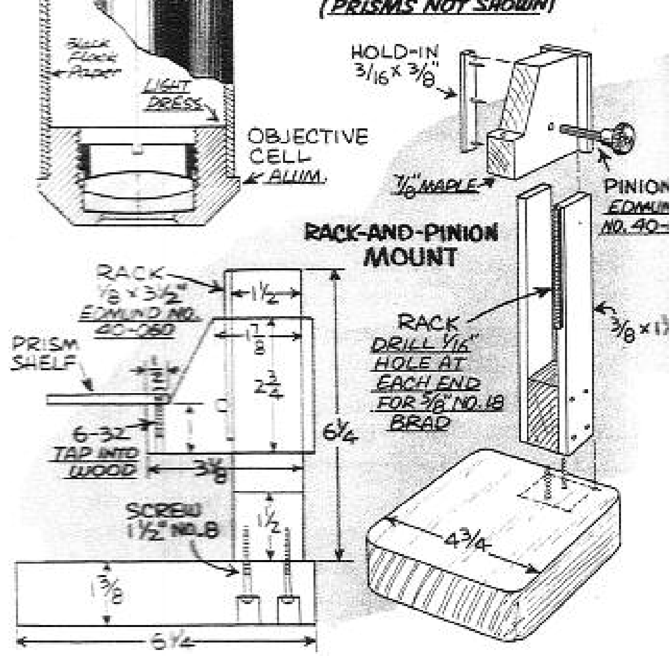
25x Erect-image MICROSCOPE



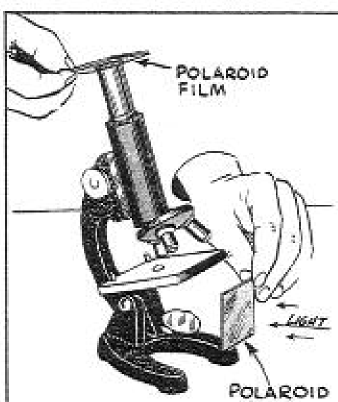
FULL-SIZE SECTION
(PRISMS NOT SHOWN)

YOU CAN buy a 7x50 binocular prism cluster complete with shelf, prisms, clips and shields, and on this base build an excellent erect-image microscope. Either the right or left-hand prism shelf can be used, with perhaps a slight preference for the left side. The design shown here works at 25x although the power can be made more or less by simply making the optical tube length longer or shorter. More than 25x is seldon desirable for the simple reason that more power always means a smaller field of view--when you get down to a pinhead field, there is little need for an erect image.

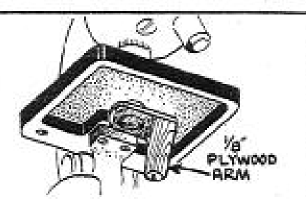
Standard 1-inch outside diameter aluminum or brass tubing is used for both the objective tube and eyepiece tube. The tubes are a press fit in recessed holes already cut in the prism shelf. A 1/2-inch diameter cardboard glare stop should be fitted between the two prisms. The prisms are covered with metal shields (supplied) and need no other protection although the sides may be painted if desired. You can purchase a metal stand or make one of wood, as shown; the pedestal is mounted off to one side to put objective near center of stage.



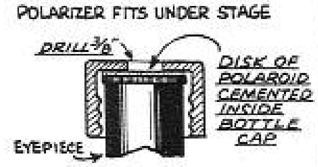
See Your Slides in POLACOLOR!



Many crystals and fibers appear in gorgeous colors when viewed with polarized light. You will need two pieces of inexpensive polarizing film. One piece--the polarizer--is held between the light and the slide; the second piece--the analyzer--is fitted over the eyepiece. For occasional use, you can hold the polarizing film in your hands. A permanent setup, as at right, is easy to make. Rotate the analyzer to get the best color effect.



POLARIZER FITS UNDER STAGE



ANALYZER CELL CAN BE MADE FROM BOTTLE CAP

EXTENSION TUBE METHOD

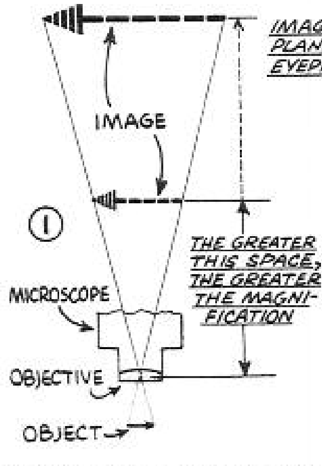
More POWER *from your* MICROSCOPE

THE LONGER you make the tube of a microscope, the more power you will get. The technical term for the actual distance involved is the "optical tube length," Fig. 2. This is commonly 160mm or about 6-1/4" in standard microscopes, and about 5" in junior instruments like the Edmund 300x microscope.

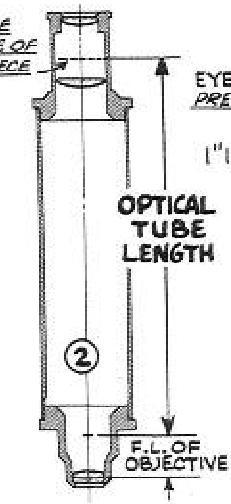
Fig. 3 shows the Edmund 300x microscope fitted with a telescoping extension made of cardboard tubing. This provides 3 to 5 inches extension, giving magnifications of 480 to 600x with the strongest objective. If you want more power, all you need is a longer extension. Of course, if you "push" the magnification too much you will get poor image quality.

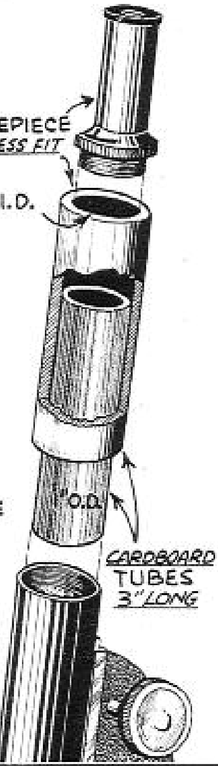
If desired, the extension can include an elbow. This can be done with either a prism or a first surface mirror, the construction with mirror being as shown in Fig. 4. As dimensioned, this will give about one-third more power, increasing the original magnifications of 50, 150 and 300x to 65, 200 and 400x. You make the elbow by first squaring-up a block of white pine or mahogany to the dimensions given. Then, proceed with the common machine operations shown.

At times you may want to reduce power in order to obtain a larger field. This can be done by using an eyepiece of longer f.l. than the original 3/4" eyepiece. Edmund No. 5223 eyepiece of 28mm f.l. is excellent. Also, it fits nicely over the main tube of microscope. This will give reduced powers of about 36x, 108x and 225x for the three standard objectives. But the main feature is the increase in field, which will be three times larger.



PRIMARY MAGNIFICATION





TELESCOPING EXTENSION TUBE FOR EDMUND 300x MICROSCOPE

POWER Calculation

FORMULA: MAGNIFICATION INCREASE OVER ORIGINAL M.

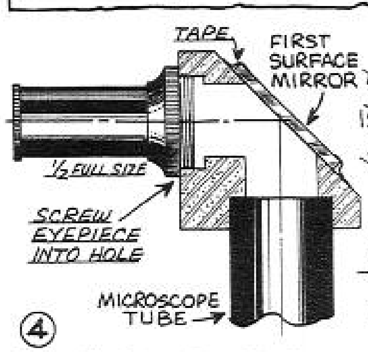
$$\text{M.I.} = \frac{\text{EXTENSION LENGTH}}{\text{OPTICAL TUBE LENGTH}}$$

Example: EDMUND 300X MICROSCOPE WITH OPTICAL TUBE LENGTH OF 5" AND 3" EXTENSION

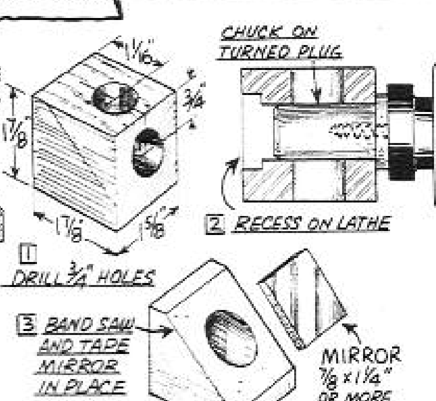
$$\text{MAG. INCREASE} = \frac{3}{5}$$

$$\text{M.I.} = \frac{3}{5} \times 300 = 180\times$$

$$\text{WHOLE MAG.} = 300 + 180 = 480\times$$

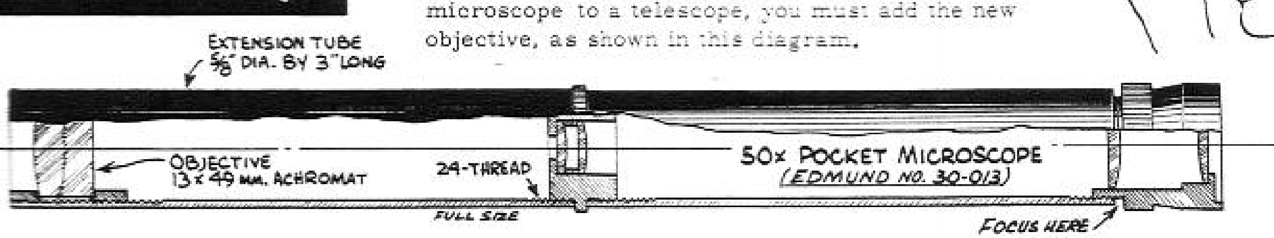


EXTENSION WITH ELBOW

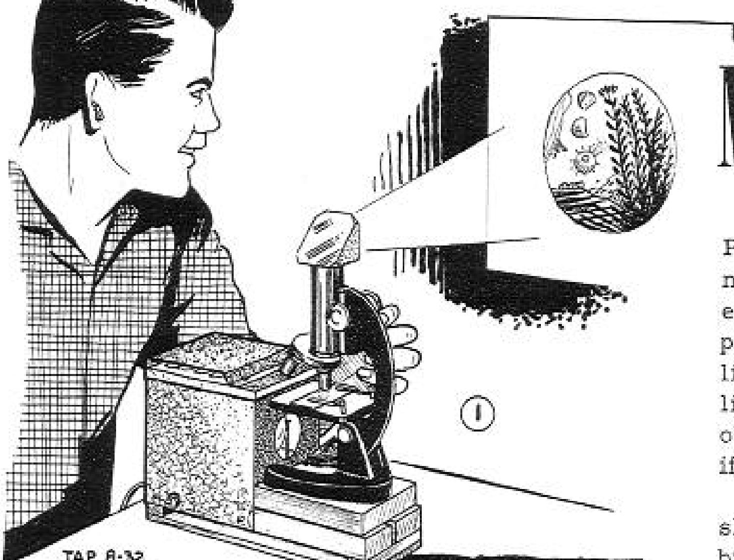


8x TELESCOPE from Microscope

The optical system of the microscope is the same as the rear end of an erecting telescope. You can convert an erecting telescope, such as a riflescope, to microscope by removing the objective. On the other hand, if you want to change a microscope to a telescope, you must add the new objective, as shown in this diagram.



Micro PROJECTION



PROJECTION offers an interesting and useful means of showing your microscope slides. It is especially fascinating to place a drop or two of pond water in a chamber slide and then watch the living micro jungle perform on the wall of your living room. Magnifications up to 500x are easily obtained; in fact, any magnification is possible if you have a strong enough light.

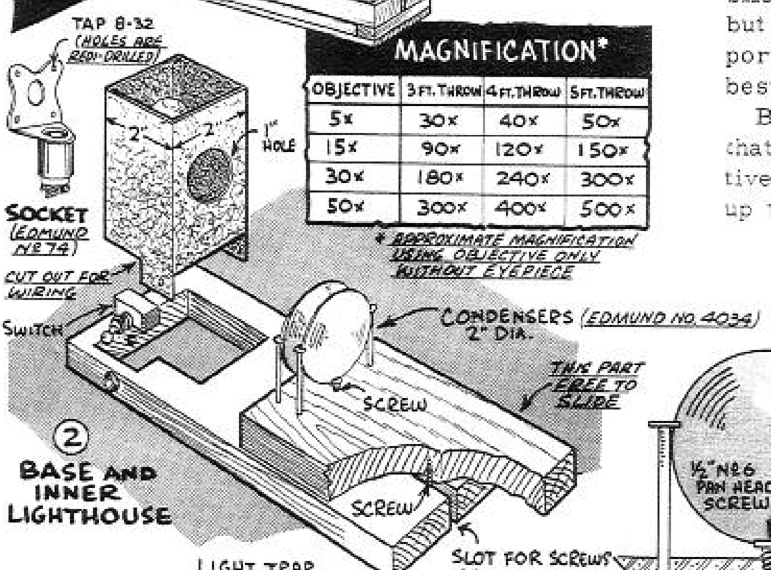
The light unit shown is very much like a 35mm slide projector. The microscope is not fastened but simply rests on a base block, which also supports the condensers, the whole being movable for best illumination.

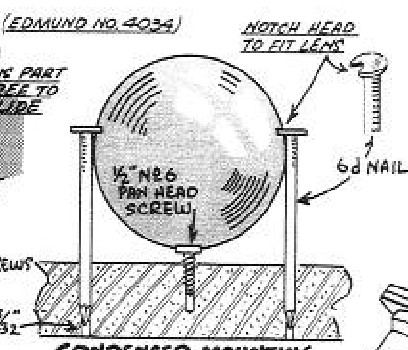
Best results are obtained with the objective alone, that is, you remove the eyepiece. The 30x objective--about 1/5 inch focal length--performs nicely up to about 5 ft. throw, which give a magnification

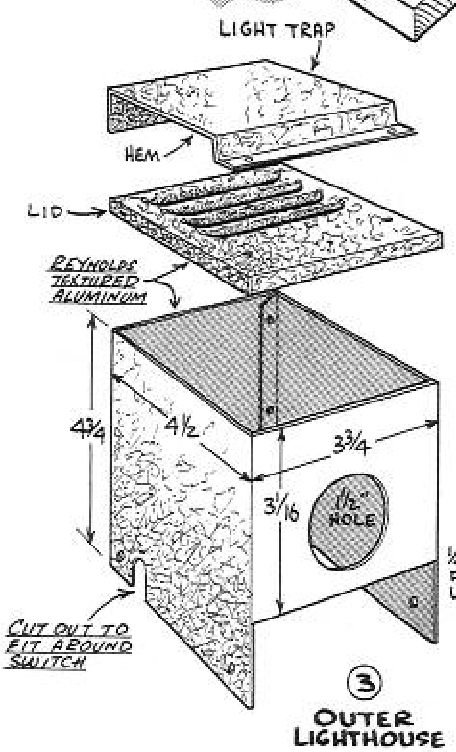
MAGNIFICATION*

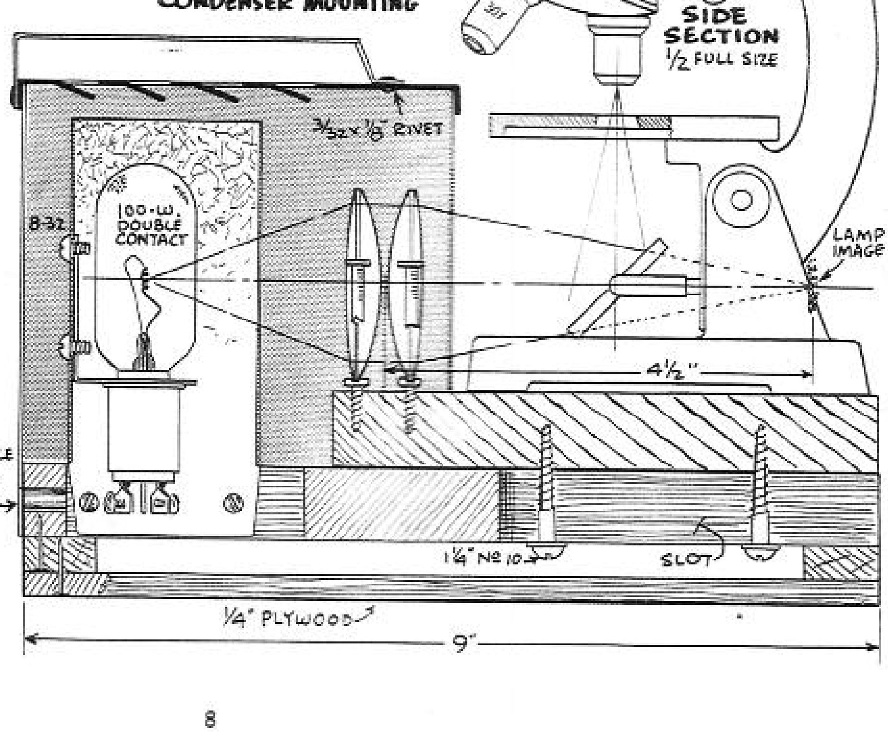
OBJECTIVE	3 FT. THROW	4 FT. THROW	5 FT. THROW
5x	30x	40x	50x
15x	90x	120x	150x
30x	180x	240x	300x
50x	300x	400x	500x

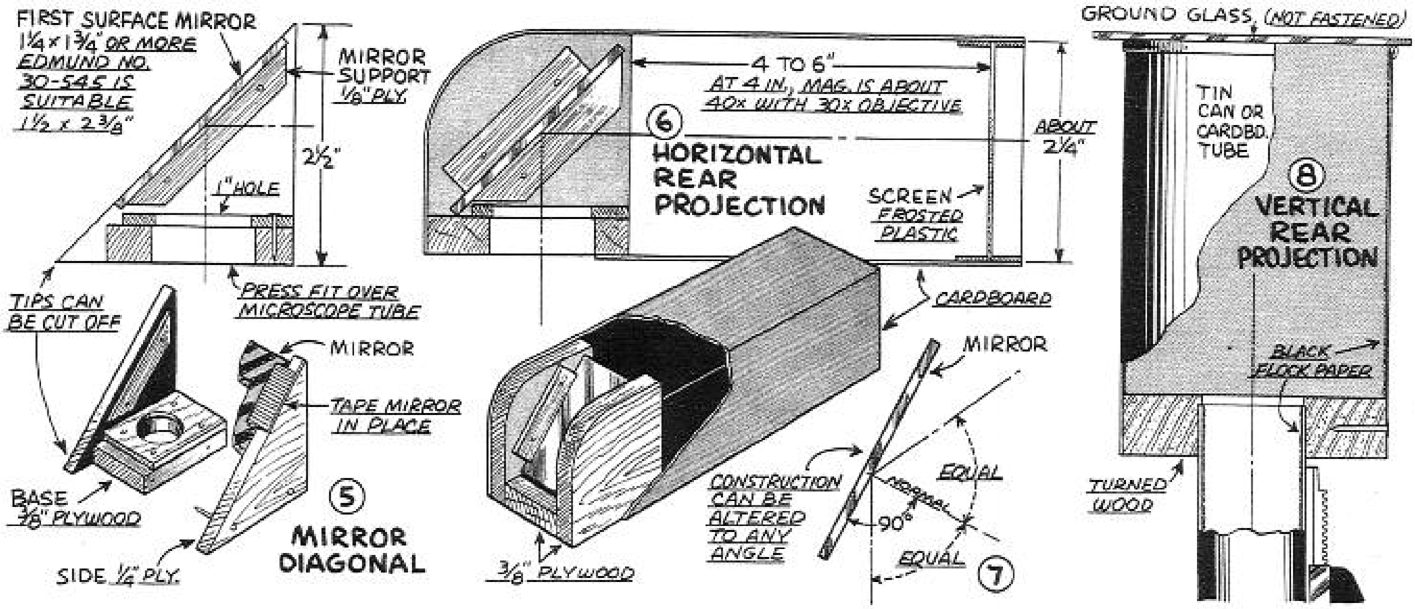
* APPROXIMATE MAGNIFICATION USING OBJECTIVE ONLY WITHOUT EYEPIECE











of about 300x. If the eyepiece is used, you can obtain 300x with 10 or 12-inch throw, but both illumination and extent of field are a little less than the same magnification with objective alone. Try both ways and suit yourself.

Projection can be done on any white ceiling. Horizontal projection requires the use of a prism, Fig. 1, to change the path of light. The same thing can be done with a homemade mirror diagonal, Fig. 5. Rear projection--either horizontally or vertically--can be done with the homemade units shown in Figs. 6 and 8. Experiment a little before you build to get the magnification you want--the longer the tube the greater the magnification.

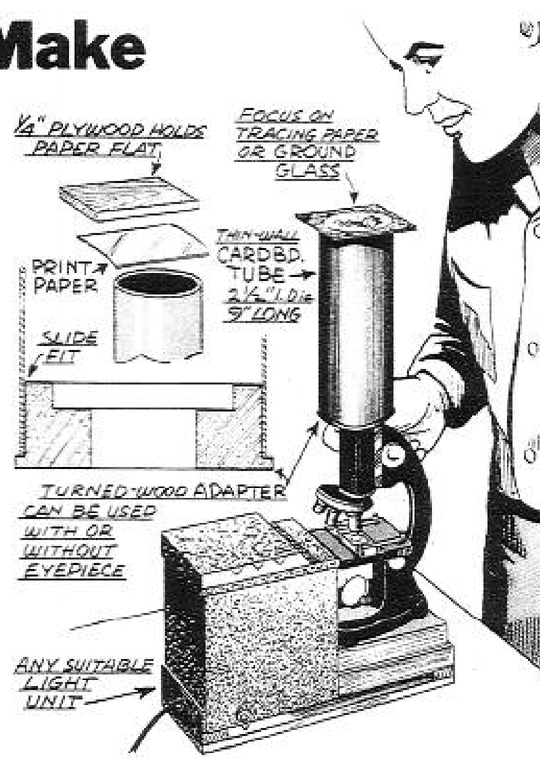
When a mirror diagonal is used, it is practical to alter the angle of view to any suitable angle, Fig. 7, but this complicates the construction and is best avoided on a first instrument. In all rear projection systems, frosted plastic makes an ideal lightweight screen. In a pinch, you can use tracing paper or even wax paper. Glare is not usually a problem in micro projection, but if you note any "hot" spots in the image, they may be eliminated by lining the microscope tube with black flock paper, which can be obtained in plain or adhesive back from Edmund Scientific Co. This clothlike material is twice as effective as plain black paint for reducing internal reflections inside tubes.

Paper Negatives are Easy to Make

FROM visual projection to photo prints is just a matter of substituting a sheet of No. 2 print paper in place of the viewing screen. The resulting print will be a paper negative, that is, white areas will be black and black areas will be white. In most cases, this is satisfactory for micro prints.

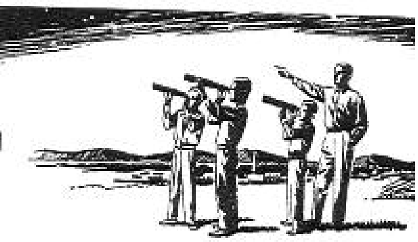
Vertical projection is ideal for making photo prints. A 9-inch tube length will give you up to 50x with objective alone or up to 200x with the eyepiece in place. With lighting shown on opposite page, exposure will be about 2 seconds. You can use a weaker light if desired, but it must be strong enough to permit focusing. In any case, the tube projection setup will eliminate stray light--the only light that can strike the print paper is that coming through the tube.

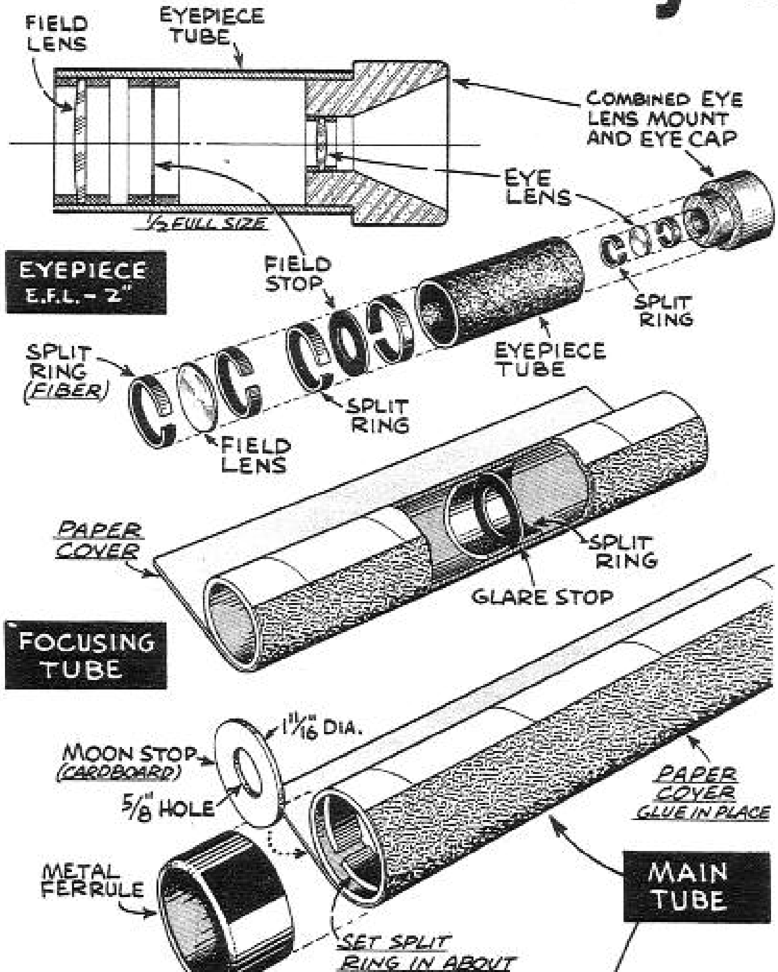
If you have never developed photo prints, don't worry about this part of the procedure--it's just a matter of dunking the prints in developer, stopbath and fixing solution, in succession. Edmund sells a complete photo kit for this including trays, chemicals, etc., or you can buy what you need at any drug or camera store. Of course, the setup as shown may also be used with a 35mm single lens reflex camera to make regular negatives on film--all you do is rest the camera (without lens) on top of the cardboard tube.



KIDS LIKE THIS SIMPLE LENS REFRACTOR

8x "Sky Starter"

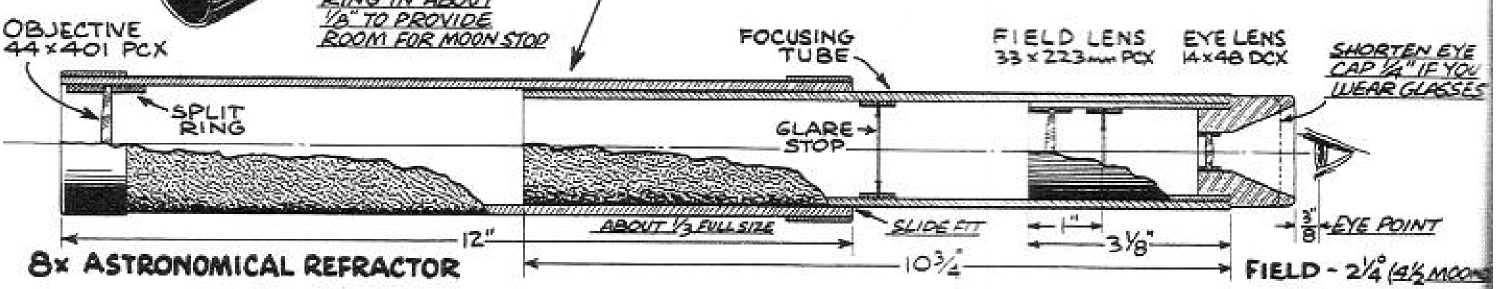




EDMUND No. 70,238 construction kit includes all the glass and parts to make an 8X astronomical refractor telescope. Of course the simple lens objective will show some false color and the image sharpness is not the best. However, the scope is good enough to show craters on the moon in sharp detail, and it will reveal hundreds of stars not visible to the naked eye.

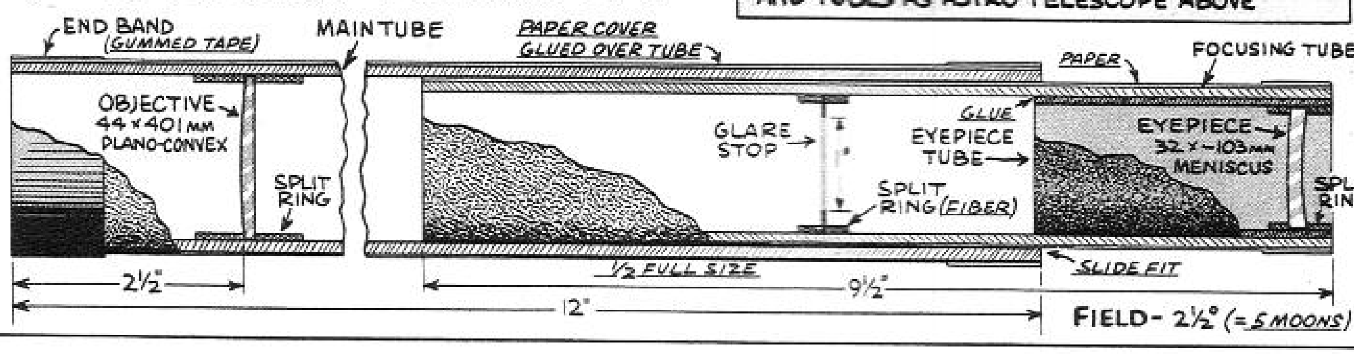
All of the parts can be put together in a dry assembly in less than ten minutes. The scope so assembled will stay put for testing, after which you can make the permanent assembly by touching the various split rings with a dab of glue and applying the cover paper and metal end bands.

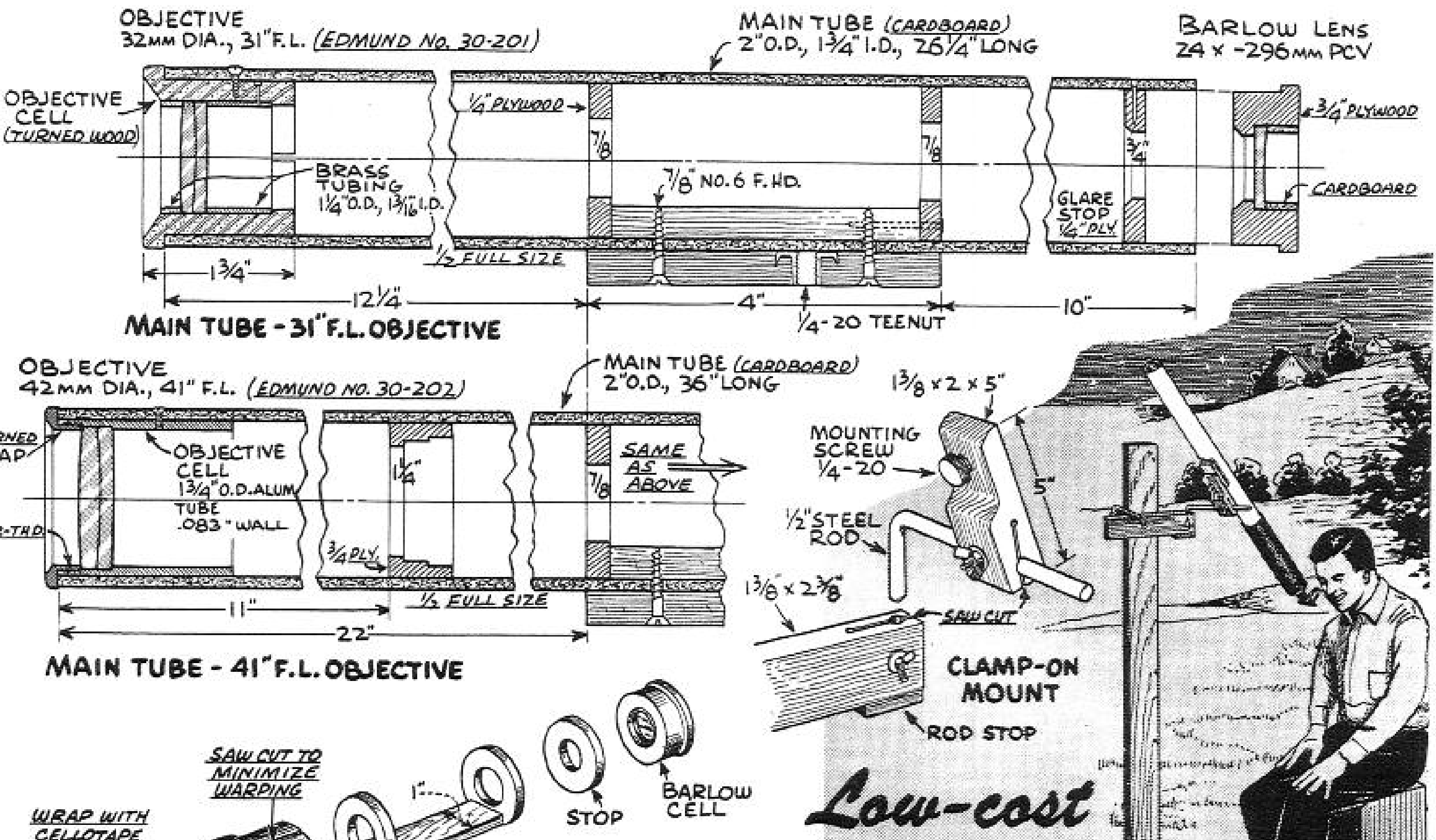
On a bright object like the moon, a smaller aperture at the objective lens will still admit plenty of light. It is suggested that you take advantage of this situation by using the cardboard "moon stop" shown. With this in place you will see moon craters in sharp detail, while the color fringe will vanish. Full aperture should be used for stars since you need all the light you can get.

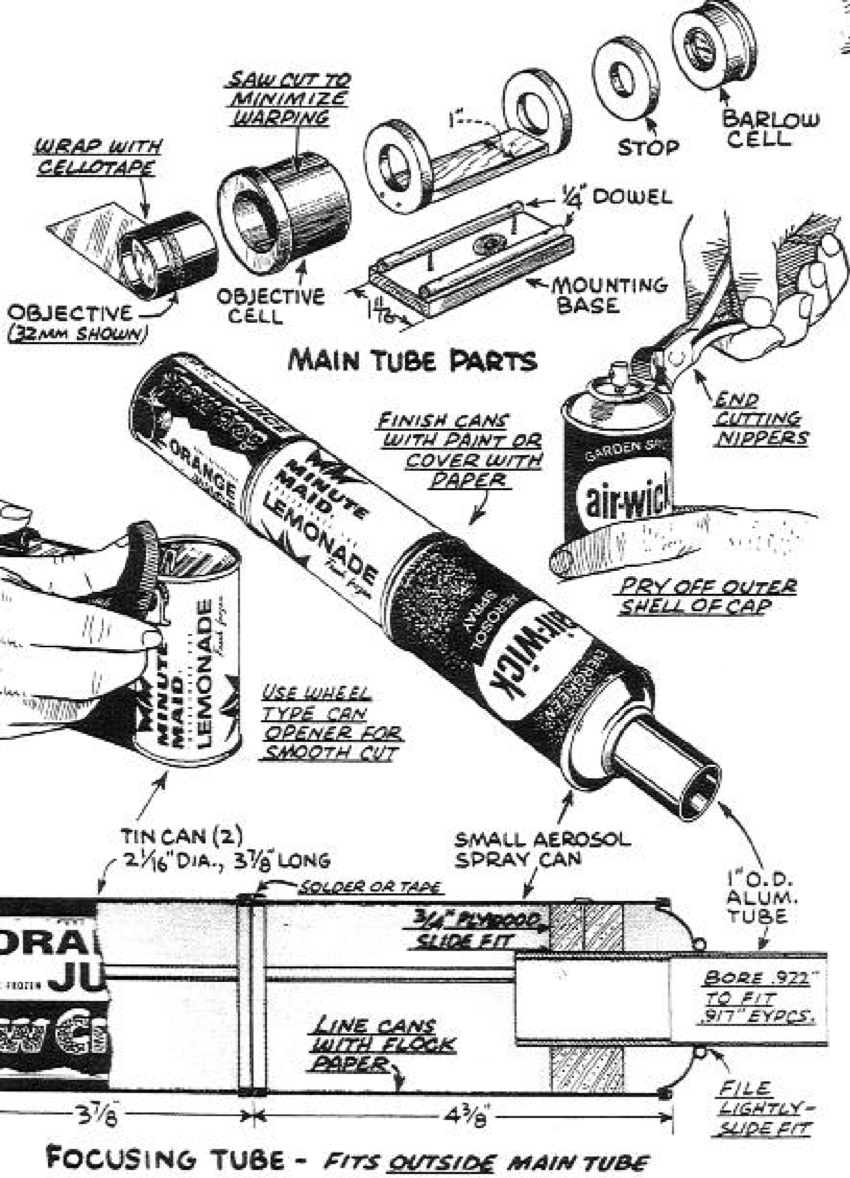


4x GALILEAN TELESCOPE

THE GALILEAN TELESCOPE SHOWS AN ERECT IMAGE AND IS A GOOD LOW-POWER SCOPE FOR DAY OR NIGHT USE. DESIGN SHOWN USES SAME OBJECTIVE AND TUBES AS ASTRO TELESCOPE ABOVE





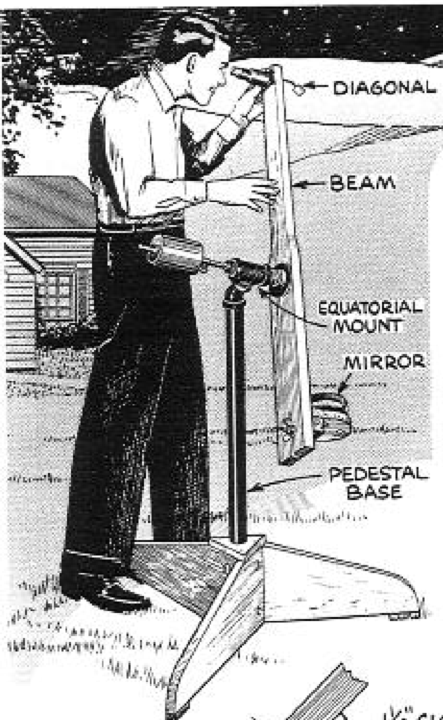


Low-cost REFRACTORS

YOU WILL enjoy making and using either of the two low-cost refractors shown on this page. Both use the same construction and differ only in objective mounting and main tube length.

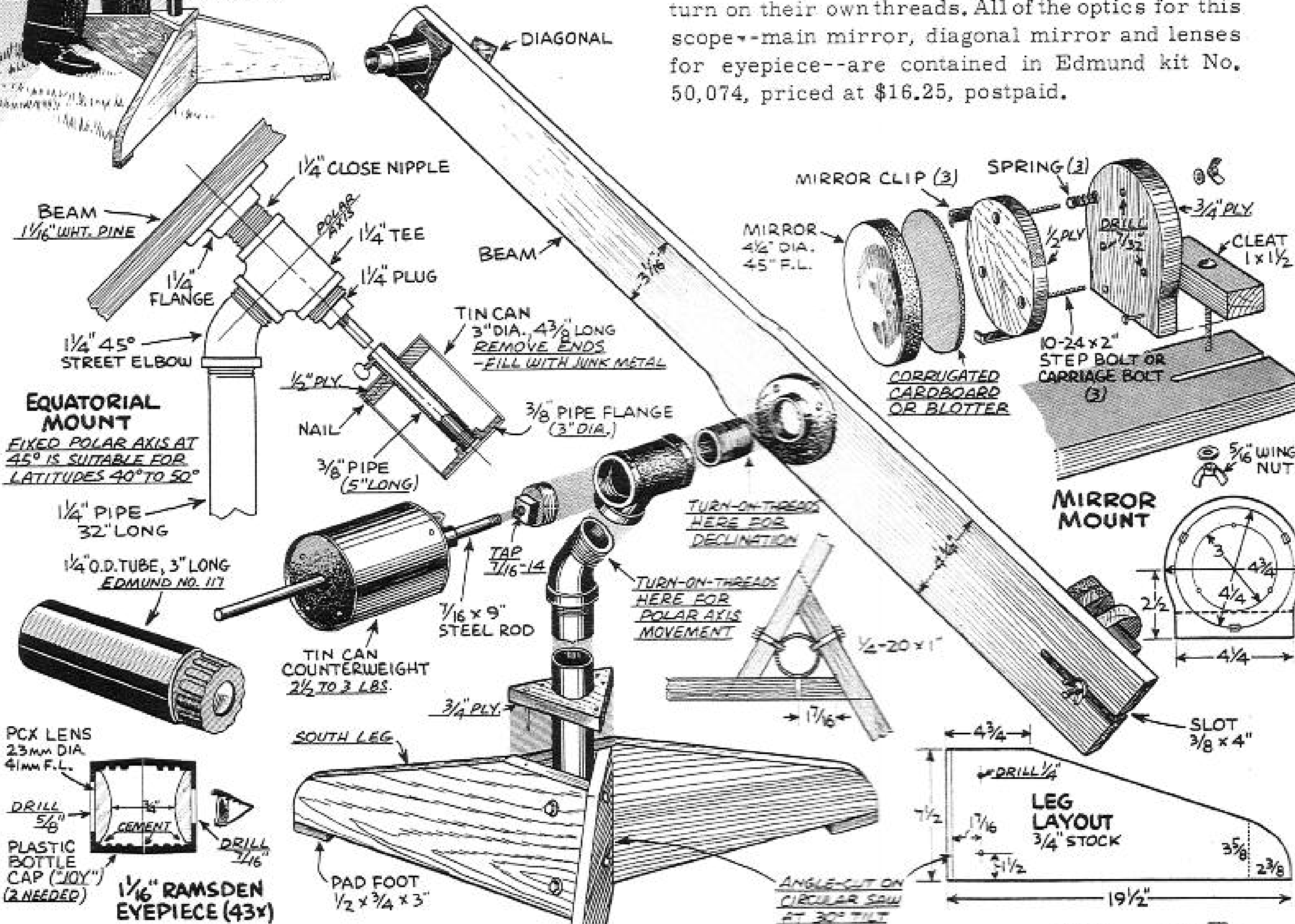
The mechanical design departs from the conventional by using a focusing tube which fits outside the main tube. This is made from three tin cans as shown and is lined with black flock paper for a smooth slide fit over the 2-inch diameter main tube. The outside focusing tube provides a rough adjustment to suit various accessories, eyepieces, etc., while a fine focus is provided in the usual manner with a slide-fit eyepiece tube. Much of the long focusing travel is needed for the simple lens Barlow; this is spaced for 2X amplification and needs about 6 inches out-focus travel.

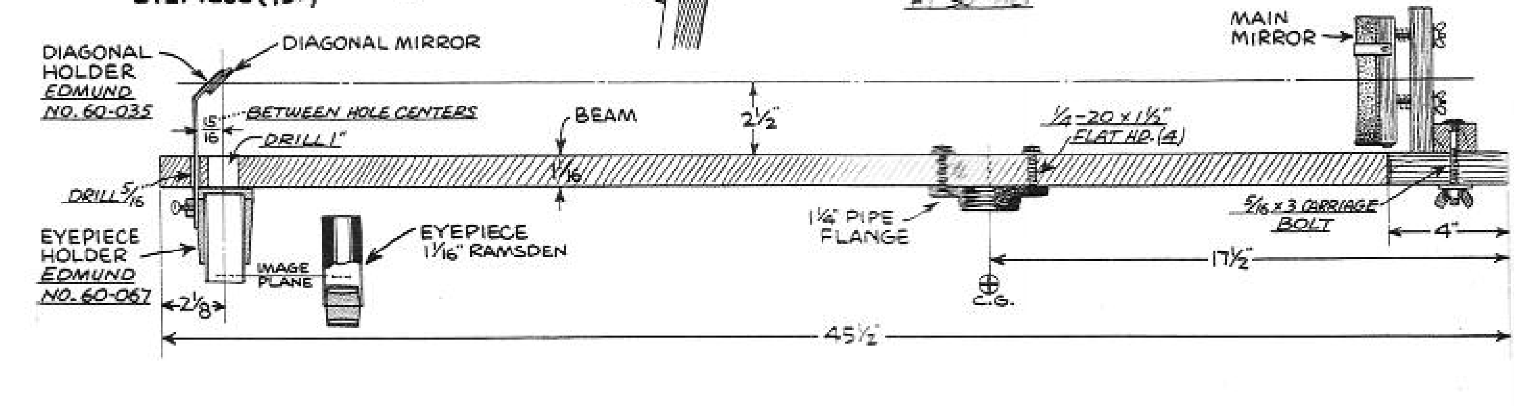
A 1-inch eyepiece is recommended as basic equipment. This will give 31X and 41X for the two designs. The Barlow system will double the power. A simple clamp-on mount is shown which can be attached to any post, fence or garage door.

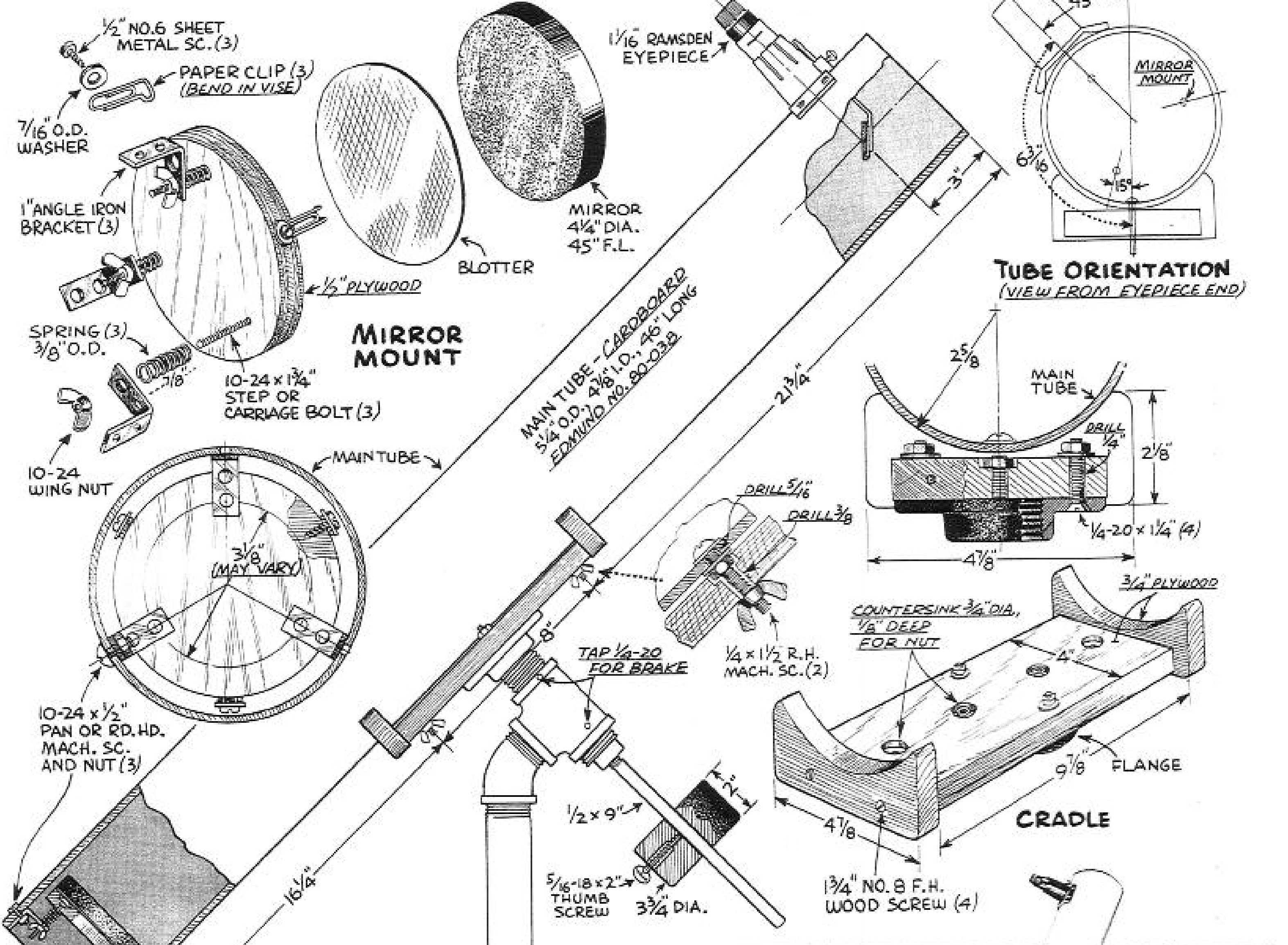


4¼-inch "SKY BEAM"

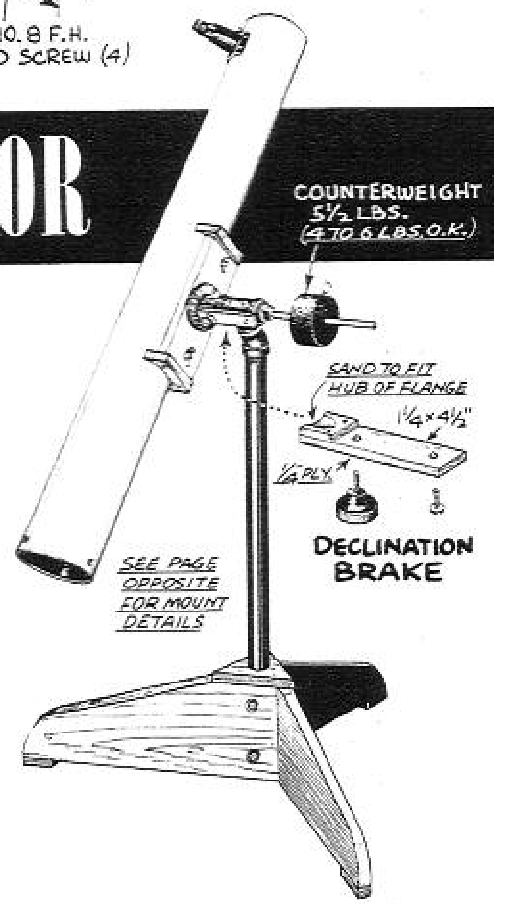
USED in the dark and shielded from outside light, the astro telescope does not actually require a tube. Many scope builders seeking a way to make a cheap reflector have taken advantage of this fact, mounting the mirror and eyepiece holder at opposite ends of a single beam of wood. The design shown is typical homemade construction with equatorial mount made of pipe fittings. The fixed polar axis of 45 degrees is satisfactory for latitudes between 40 and 50 degrees, and as a matter of fact can be used with some success at any latitude. Movement on both axes is obtained by letting the pipe fittings turn on their own threads. All of the optics for this scope--main mirror, diagonal mirror and lenses for eyepiece--are contained in Edmund kit No. 50,074, priced at $16.25, postpaid.







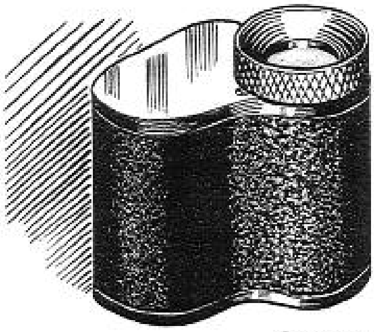
Easi-bilt 4¼" REFLECTOR

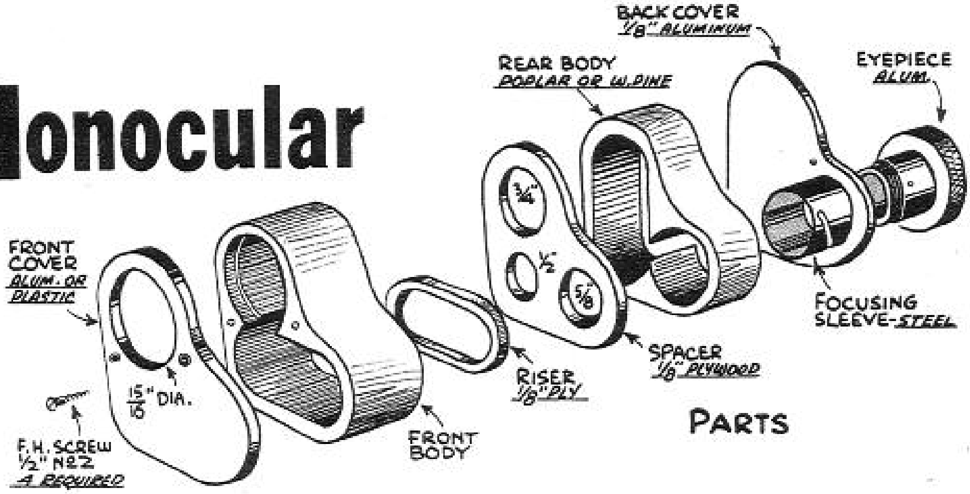


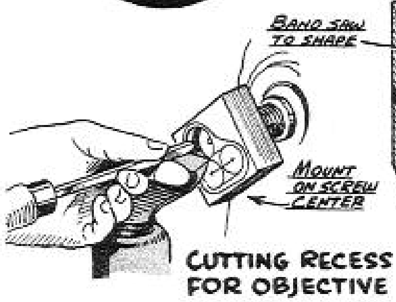
IF YOU want a good telescope on a lean budget and minimum work, this is it. You use the same Edmund parts as the tubeless job on opposite page, plus a cardboard tube which adds a few dollars to the cost, but worth every penny for better appearance and protected optics. The homemade mirror mount will cost less than a dollar; angle irons shown are a standard size available at Wards, Sears or any hardware store, about 5¢ each. The pipe mount is the design on opposite page with a handy declination brake added.

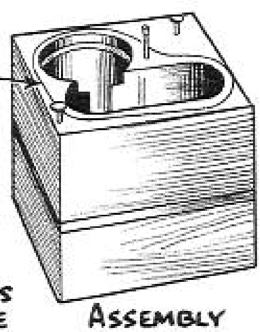
The first operation in building the scope is cutting the eyepiece hole in main tube. This is easy with either a portable jig saw or a hole saw. Lacking these, the job can be done with a keyhole saw or even a knife. Drill the two mounting holes next; orientation as shown will put the eyepiece in a comfortable position for most sky objects. The total cost of this telescope--mount and all--is less than $30. Total weight: 22 lbs. Power: 43x with eyepiece specified and you can push this up or down by making or buying other eyepieces.

5x "Mini" Monocular

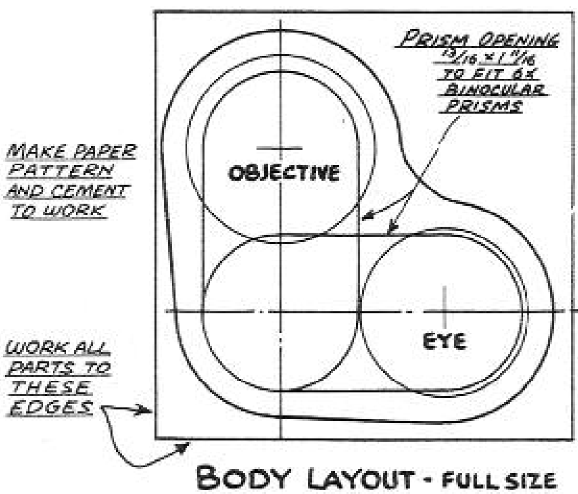


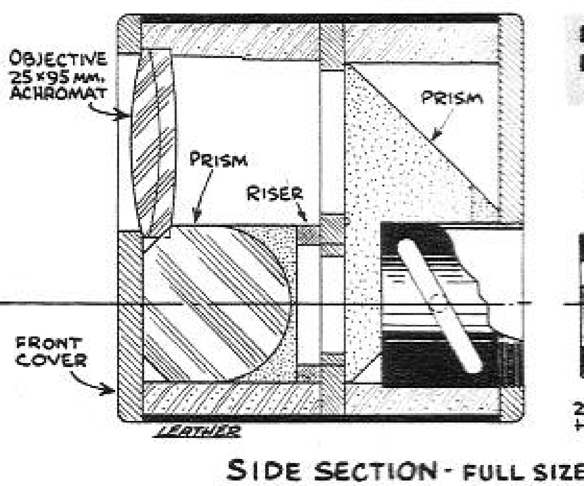




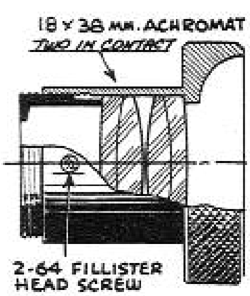


MINI MONOCULAR uses regular 6x30 binocular prisms housed in a wood body. The main point in construction is an accurate layout--work all parts from the full-size pattern. Prism holes are easily worked if you have a 13/16 in. wood bit for the drill press; the remaining wood can be jig sawed or band sawed. If you prefer a full 5x power, use a 26x104mm objective, making the front body 1/8 in. thicker and using a 1/4 in. thick prism riser between the prisms.

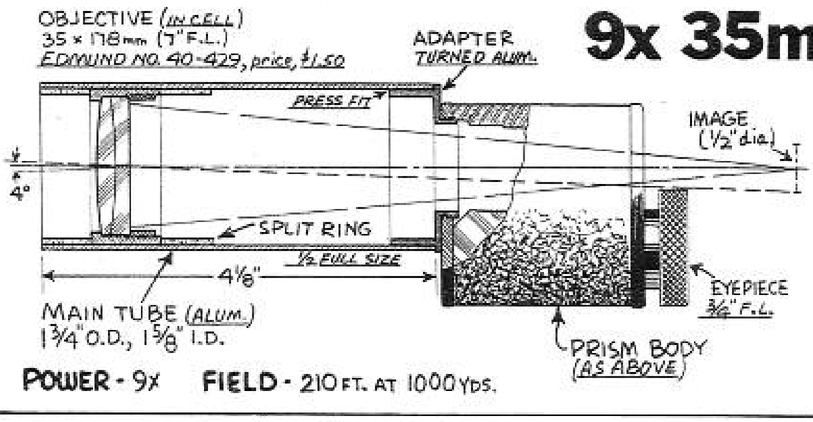




POWER: 4.8x
FIELD: 375 FT. AT 1000 YDS.

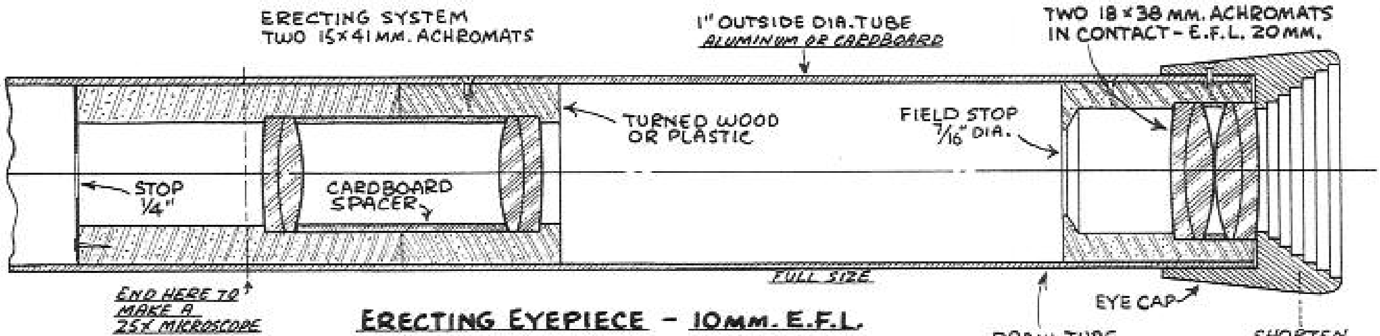


9x 35mm MONOCULAR

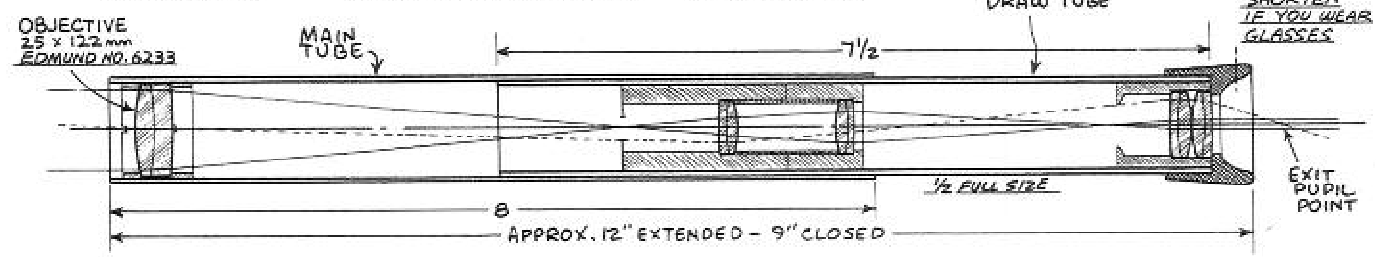


POWER - 9x FIELD - 210 FT. AT 1000 YDS.

Using the wood body shown above with adapter and new objective, you can make a nice 9x monocular at low cost. This power is about all you can hold steady in your hand. Most of the work is making the adapter, which is not too much of a job if turned from aluminum bar stock. The objective cell (supplied) is a neat fit inside 1-3/4 in. tubing.

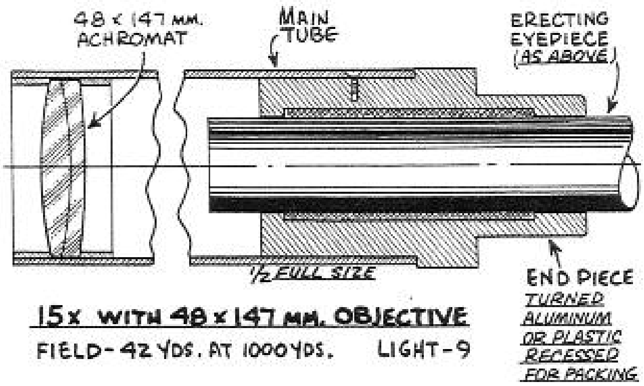


ERECTING EYEPIECE - 10MM. E.F.L.



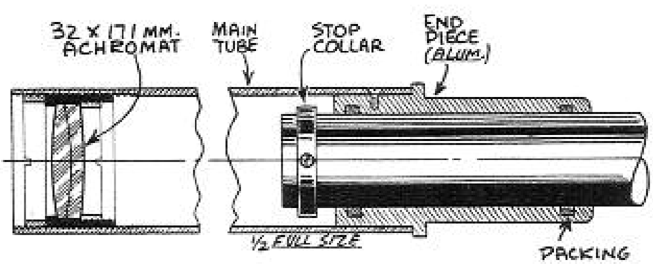
12X WITH 25 × 122 MM. OBJECTIVE

FIELD - 52 YDS. AT 1000 YDS. LIGHT - 4



15X WITH 48 × 147 MM. OBJECTIVE

FIELD - 42 YDS. AT 1000 YDS. LIGHT - 9



17X WITH 32 × 171 MM. OBJECTIVE

FIELD - 36 YDS. AT 1000 YDS. LIGHT - 3.2

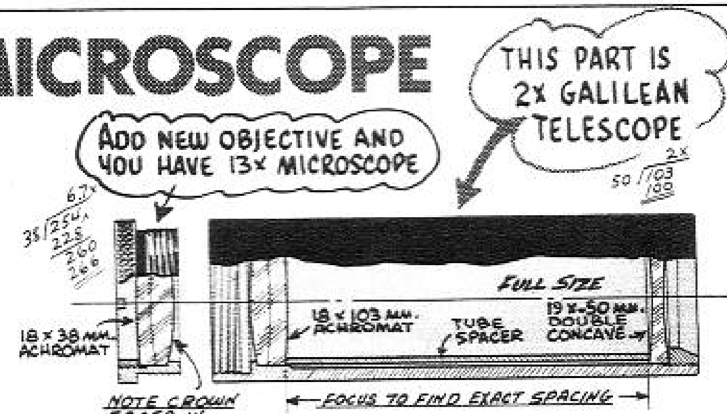
Achromatic ERECTING EYEPIECE

A GOOD WAY to make a terrestrial telescope is by building an erecting eyepiece as a separate unit. Such an eyepiece can be used with almost any achromatic objective. The erecting eyepiece shown has a focal length of 10mm, which means that the power of any telescope using it is the f.l. of objective in millimeters divided by 10. In other words, the power is the f.l. of objective in millimeters with the decimal point moved one place to the left--a 122mm objective is 12.2x.

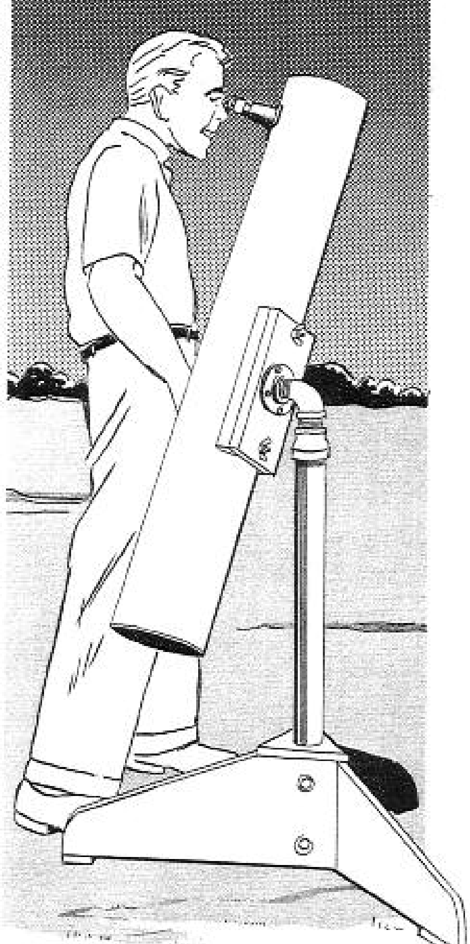
Construction can be wood-and-cardboard or all-metal as desired; lens cells of wood are quite practical if the wood is bone dry. Of the three designs shown, the 48x147mm objective is the brightest, but the other two are a bit sharper. The erecting eyepiece alone makes a good 25x microscope with front end stopped at dotted line in top diagram.

TELESCOPE to MICROSCOPE

Any small telescope focused at infinity can be changed to a microscope by simply adding an extra lens at the front. The microscope image will be erect or inverted, the same as the telescope; example shown is Galilean telescope and image is erect. The total power is the power of new objective (rated as a simple magnifier) times the power of the telescope. The working distance is the f.l. of the new objective.



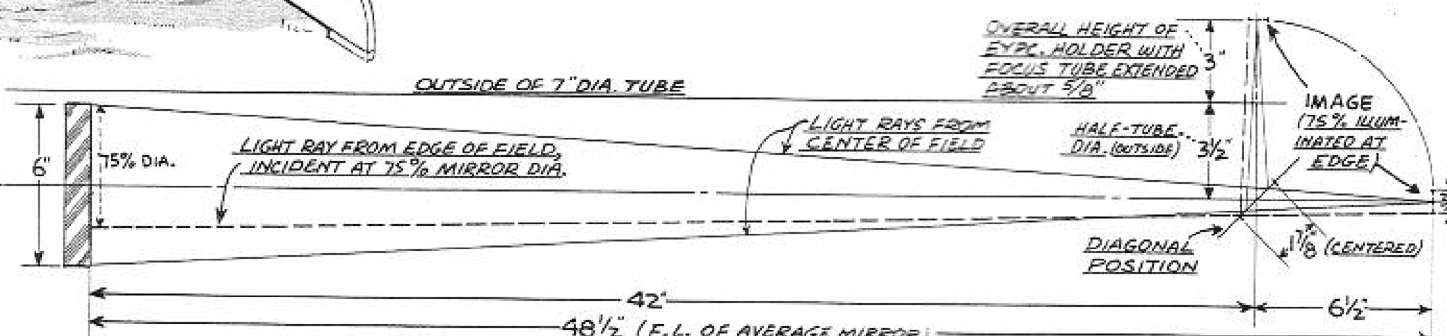
UTILITY SIX REFLECTOR



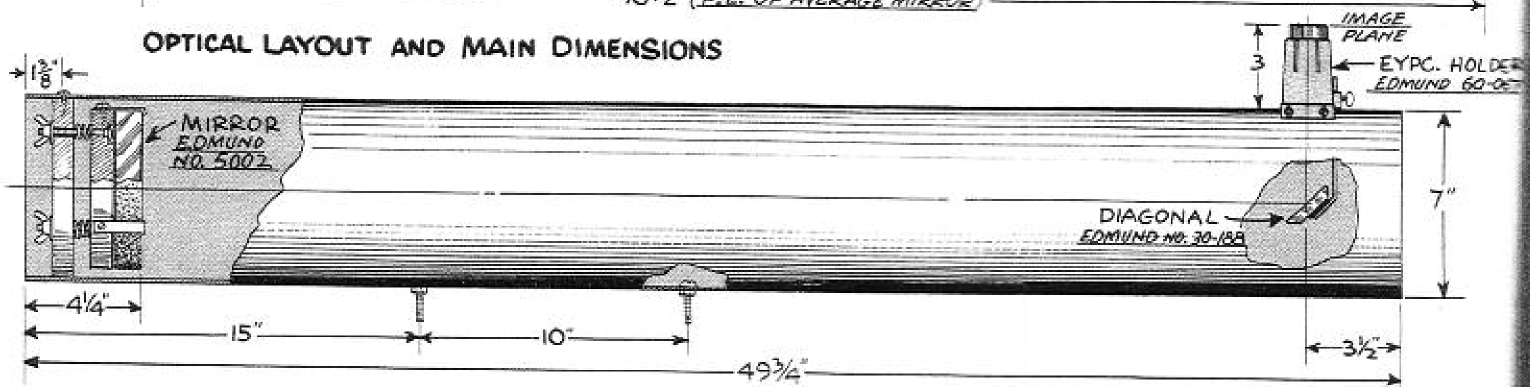
THE HEART of any reflecting telescope is the main mirror. If you are on a tight budget, the best plan is to use a top-quality mirror and then save as you can with homemade parts. The result will be something like the design shown with simple turn-on-threads altazimuth mount and slide focusing.

The mount uses a 2-inch pipe pedestal about 30" long more or less depending on your height. The exact height for an altazimuth mount is such as to put the eyepiece level with your eyes when the main tube is pointing straight up. However, eyes other than your own will probably peer into the eyepiece, so you have to keep in mind Mr. and Mrs. Average. The wood legs can be pre-drilled and are fitted to the pedestal one at a time--you put together, take apart as often as needed to mark hole positions and drill the tap holes in the pedestal. With normal care, the final leg will lock in place and secure the whole assembly without the need of additional fastenings. The pipe fittings on which the telescope turns round-and-round (azimuth) and up-and-down (altitude) should be lapped with oil and fine abrasive for a smooth fit.

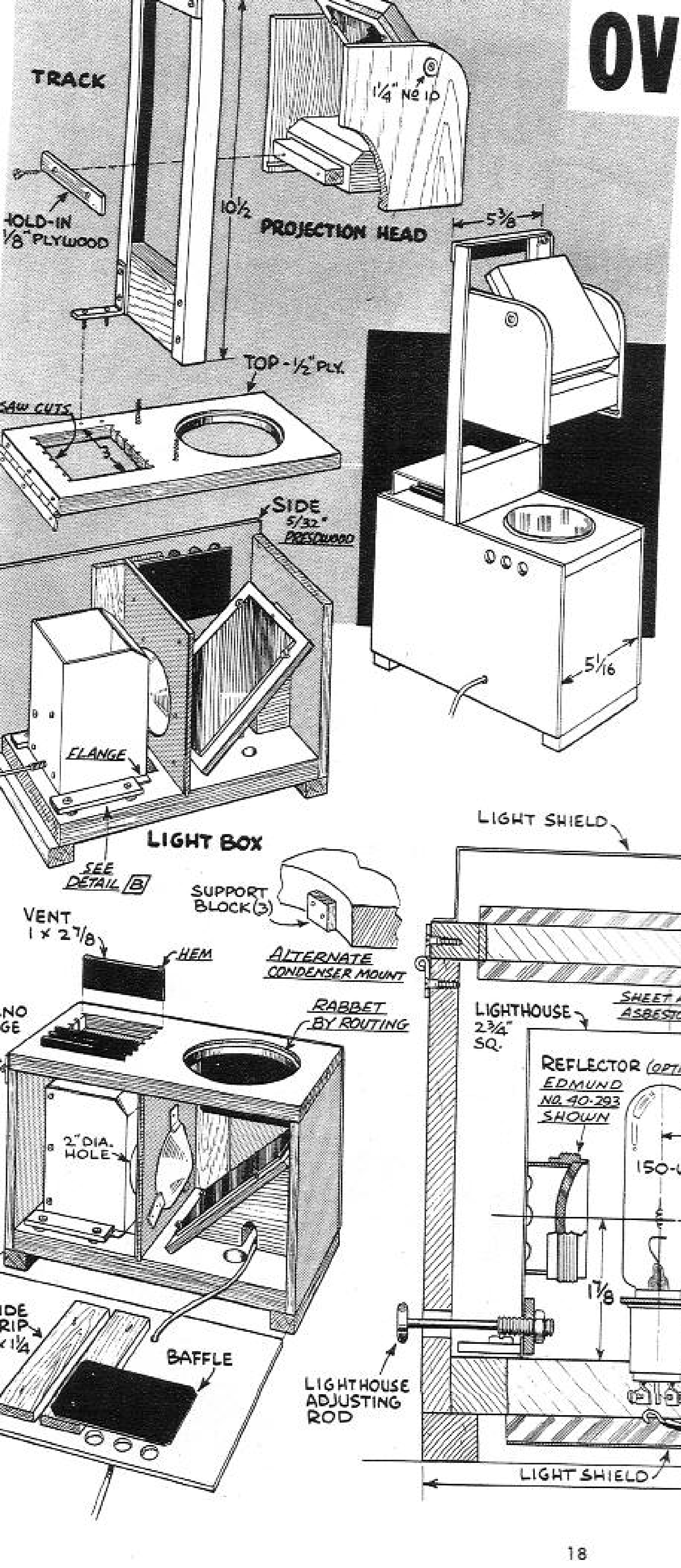
The construction of the telescope itself is fairly standard. If you have power tools, the homemade mirror mount is a simple job of band sawing the wood to shape and drilling a few holes. The mirror clips are made by partly flattening 1-inch angle irons. If these are the four-hole type, they will hammer out flat with a little hump at the center, as shown. The plastic slide focus at the eye end is not as convenient as rack-and-pinion, but it saves a few dollars and you can always switch to R&P later. The eyepiece hole in main tube is the main chore. There is nothing much to this if you have a hole saw of the proper diameter, but lacking this equipment you can always do the job with the old-reliable system of drilling many small holes to cut the opening and then smooth it by filing. A square hole with rounded corners is entirely satisfactory. Collimating instructions are given in the Edmund book, "How to Use Your Telescope." square hole with rounded corners is entirely satisfactory. It is worthwhile buying a really good eyepiece, and if it is to be the "one and only," you should make it something about 1 inch or a little more focal length--Edmund No. 5223 is recommended.

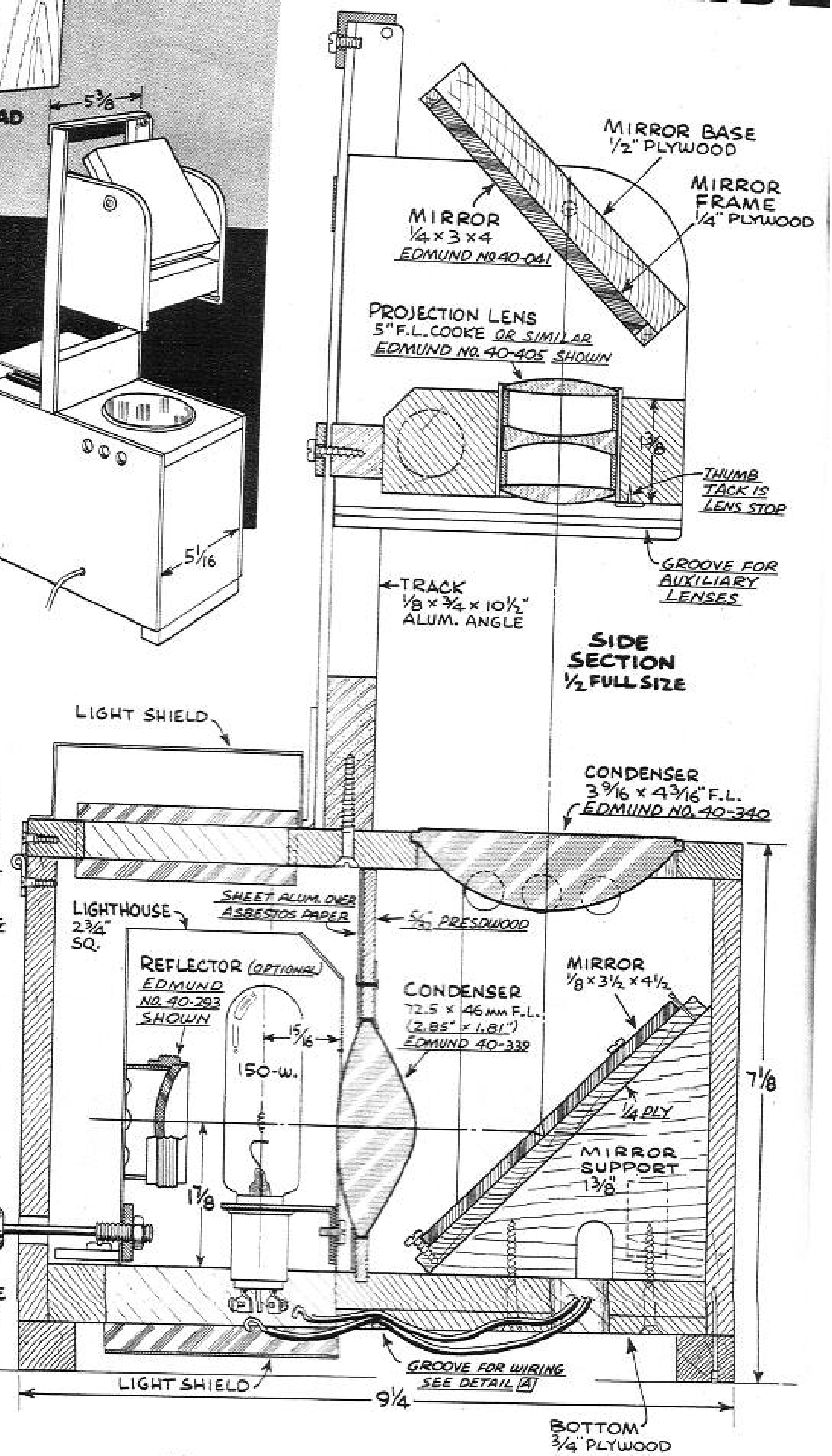


OPTICAL LAYOUT AND MAIN DIMENSIONS



OVERHEAD SLID



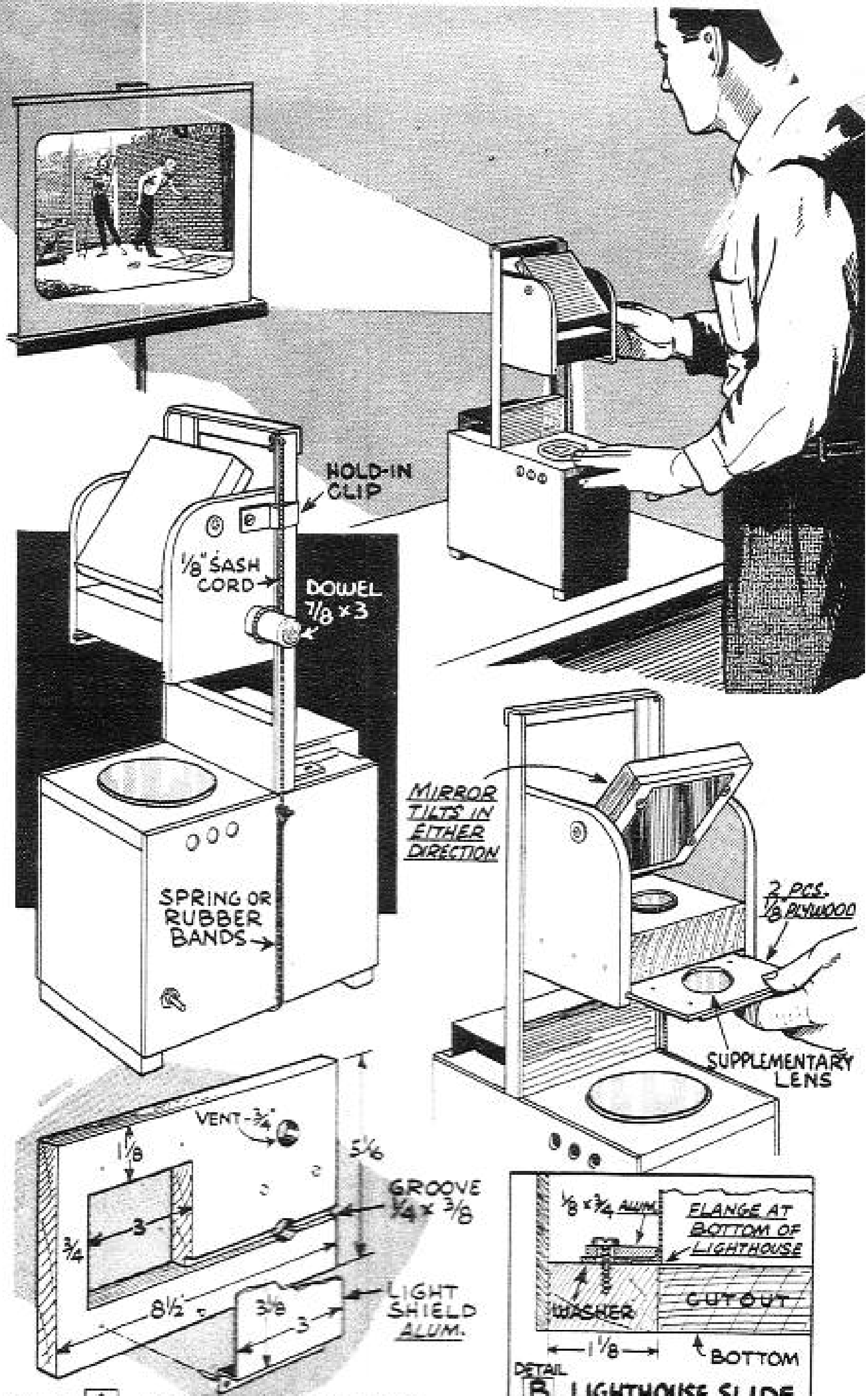


ROJECTOR

ALTHOUGH SMALL as overhead projectors go, this compact model will do most of the work of large instruments. It is a nice size for home or hobby use. The light box has a hinged lid which carries the track on which the projecting head is moved up and down by means of simple yet practical string-and-dowel focusing. The string should be under fair tension, which can be obtained with a spring or several ordinary rubber bands. This spring tension also keeps the lid in place. By releasing the rubber bands, the lid can be lifted. Further disassembly for cleaning can be made by withdrawing the panel holding the first condenser.

The sheet metal lighthouse is flanged at the bottom to permit a slide adjustment of about 1 inch, this movement being needed if you plan to use auxiliary lenses. Edmund No. 74 socket (25¢) can be used to hold the lamp, but you will have to hammer the bracket flat and rebend in opposite direction, as per the side section diagram.

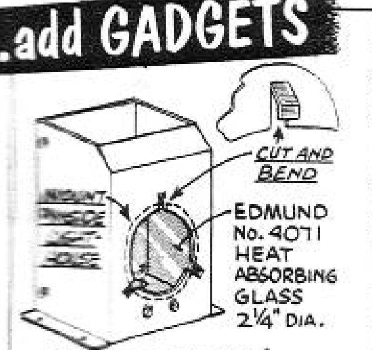
This projector is designed for a maximum focal length of 5 inches. Suggested is Edmund No. 40,405 construction set ($2.95) which is a 5-inch Cooke triplet complete with spacing rings and easy to assemble. For big pics at short throw, a 42 x 201mm plano convex lens or similar will reduce the focal length to about 3 in. and this will show 35mm slides 20 inches wide at 4-ft. In auxiliary lenses, you can use almost anything under 5 in. focal length.



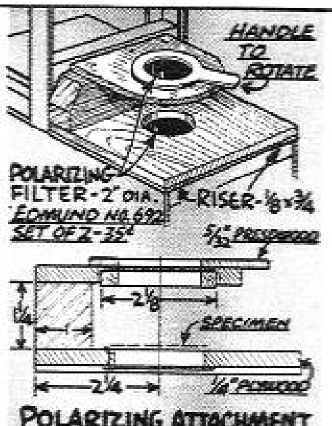
DETAIL A UNDERSIDE OF BOTTOM

DETAIL B LIGHTHOUSE SLIDE

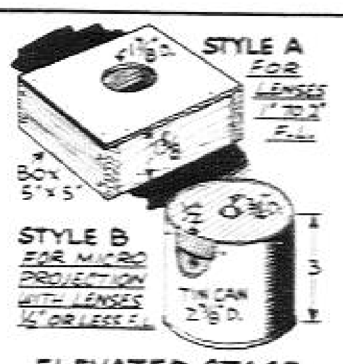
...add GADGETS



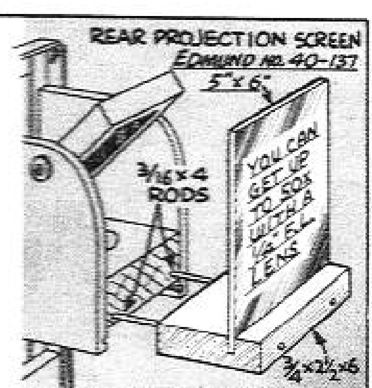
22° COOLER! ... NEVER OVER 108° AT STAGE... RECOMMENDED!



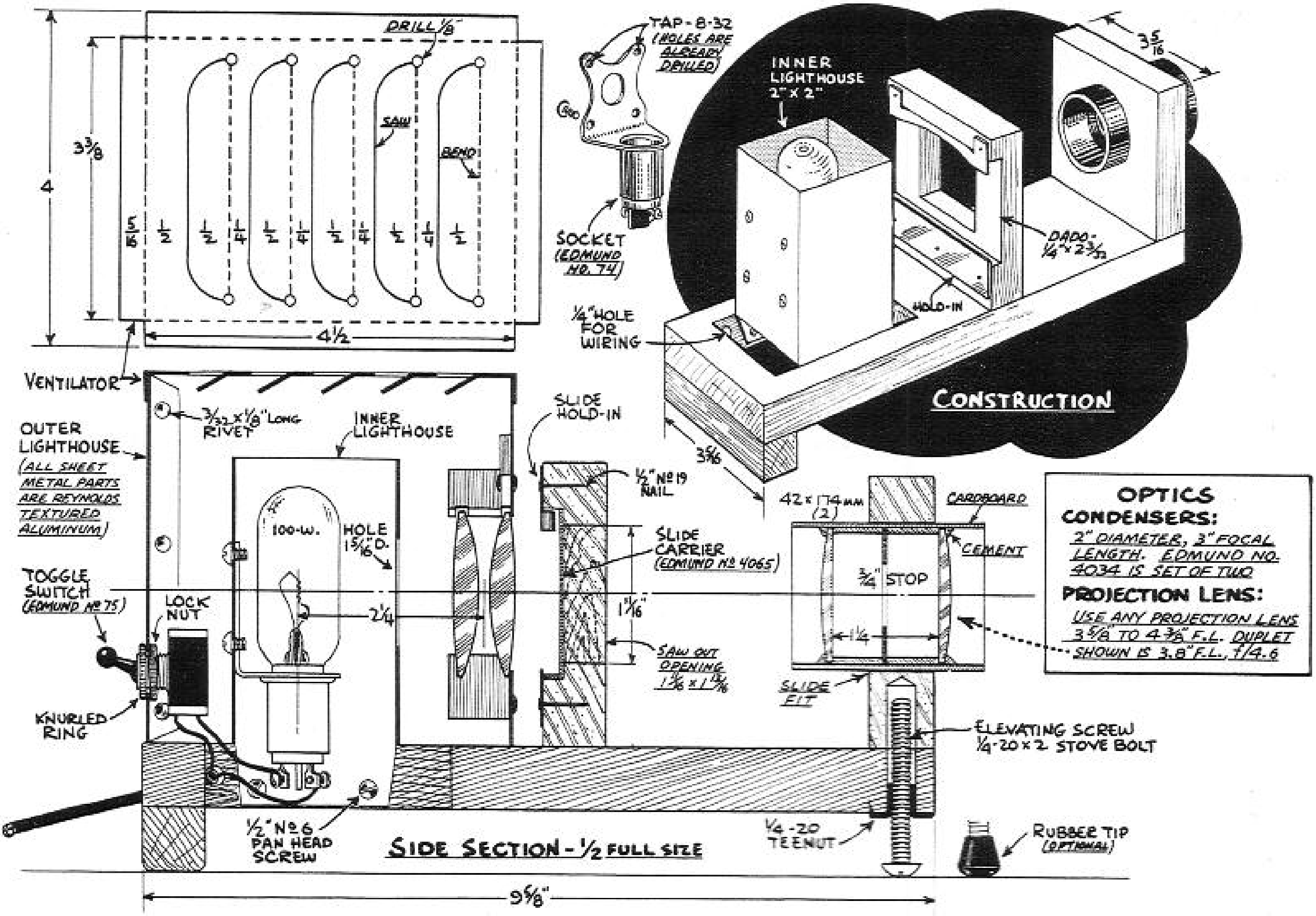
POLARIZING ATTACHMENT



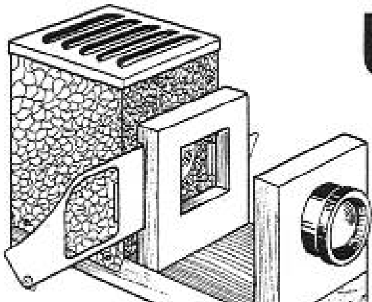
ELEVATED STAGE ...GIVES BRIGHTER LIGHT ON SMALL COPY



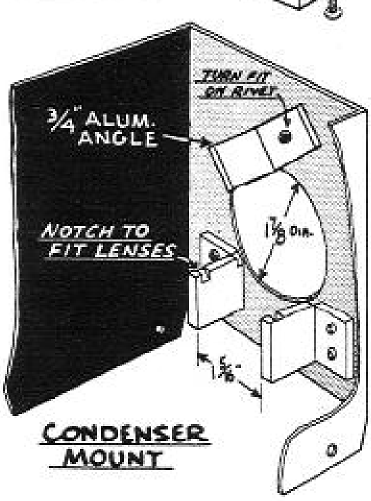
REAR PROJECTION



Utility Slide Projector



ASSEMBLY



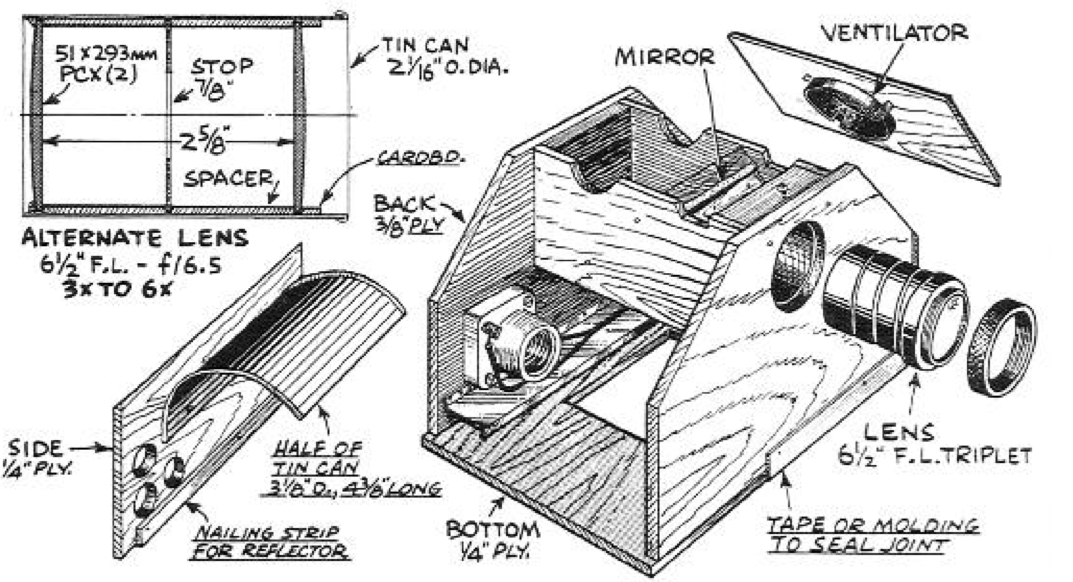
CONDENSER MOUNT

HERE'S a simple 35mm slide projector stripped down to bare essentials yet capable of showing bright, sharp pictures with an inexpensive simple lens duplet. If desired you can vary the design, providing only that you stick to the spacing of the optical elements as given. Extra shielding can be added over the lighthouse if you find the slight light leakage annoying.

Start by making the two sheet metal lighthouses. Notice how two sides of each are extended to permit mounting to the wood base. The Reynolds textured aluminum specified is a bit lightweight for the big outer lighthouse; it can be stiffened considerably by mounting the condensers on a separate piece and then riveting this piece inside the lighthouse itself. The notched pieces of aluminum angle used to mount the condensers should hold the lenses accurately in place but should not press rigidly against the glass. The top angle pivots on a single rivet and can be turned out of the way to fit or remove the lenses.

After the sheet metal parts are made, you should have no trouble with the wood parts and final assembly. A better projection lens may be used if desired, although the duplet shown works well and is bright at 6 to 10-ft. throw.

Opaque PICTURE PROJECTOR

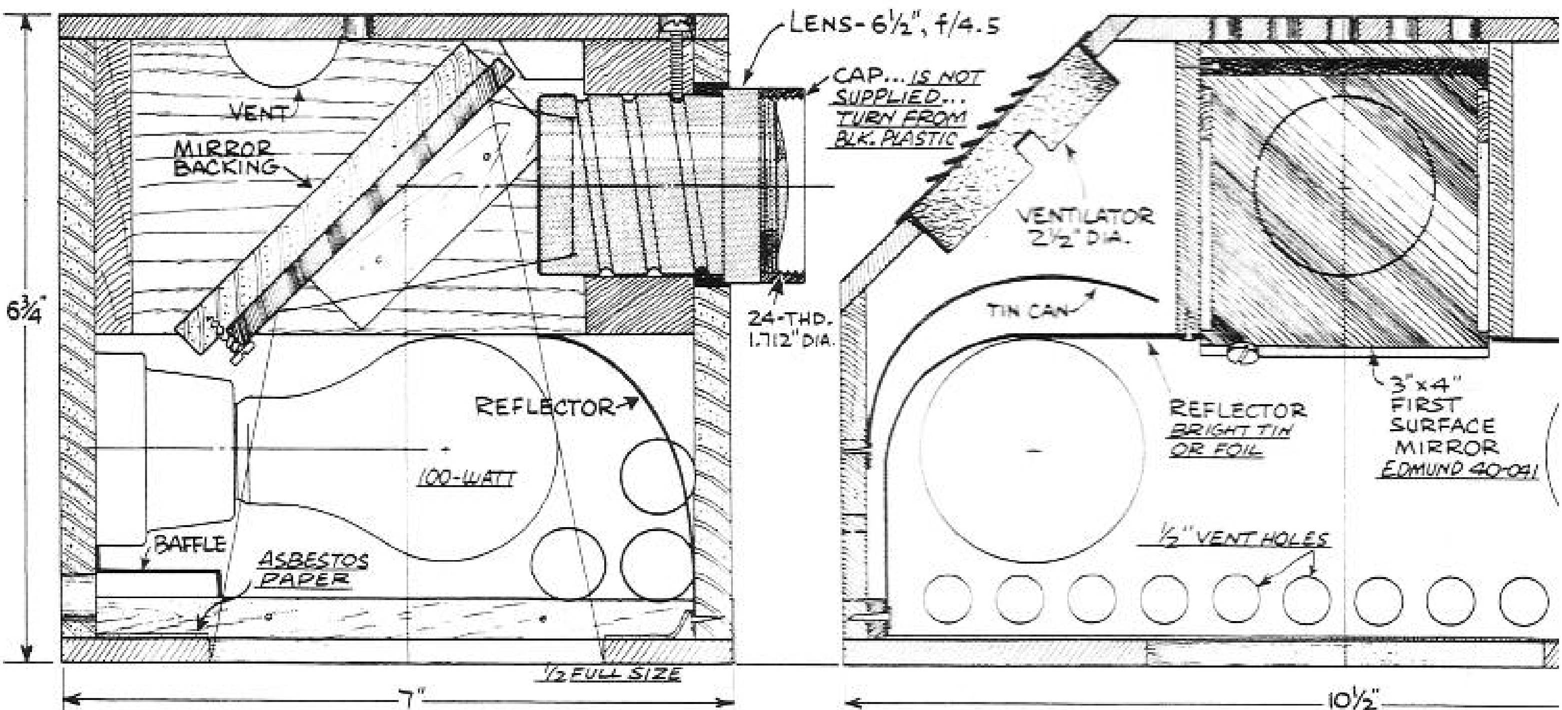


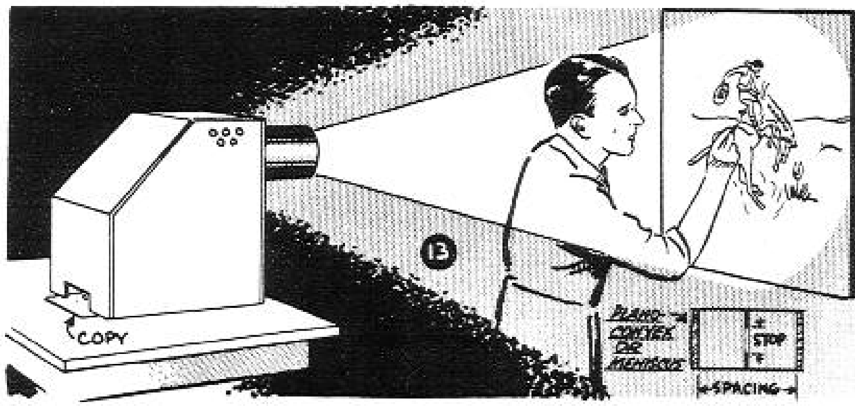
COMPACT TABLE MODEL COVERS 4x4" COPY AT 3x TO 7x BLOW-UP

SCREEN MAGNIFICATION up to 7X is obtained with this easy-to-build opaque projector. It will project any kind of opaque copy, such as photos, halftones, comics, etc. The screen image is erect and is black-and-white or full color--just like the copy.

Two 100-watt lamps provide a fair degree of screen brightness, although it must be remembered all opaque projectors need at least semi-darkness for good visibility. A good projection lens like the one specified will cost several dollars, but you can make a less expensive job by using the alternate simple lens duplet costing less than a dollar. The barrel for this lens is a small tin can, the kind used for frozen fruit juice.

The construction may be simplified by using the split tin can as reflectors, as in drawing above. However, the actual plan uses these only as a kind of heat shield, the actual reflectors being bright tin or foil on asbestos paper, fitted as shown.





(14) SYMMETRICAL LENS SYSTEMS

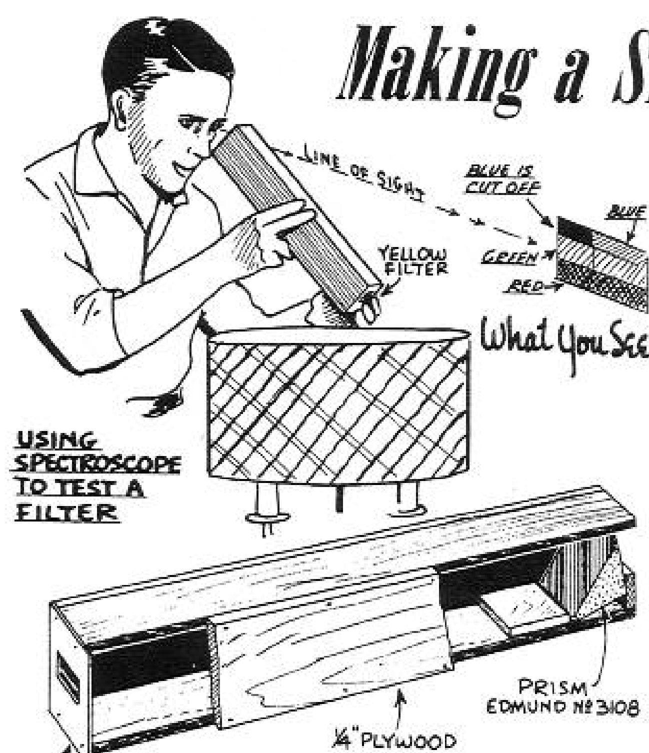
INDIVIDUAL LENS F.L.	SUGGESTED SPACING	SUGGESTED STOP DIA.	EQUIVALENT FOCAL LENGTH
10"	2½"	¾"	6"
12	3	⅞	7"
14	3½	1	8"
16	4	1⅛	9"
18	4½	1¼	10"
20	5	1⅜	11"
22	5½	1½	12½"
24	6	1⅝	13¾"

the lens barrel, which causes the ball to skip over the threads. Final focusing is done by turning the lens barrel so that the ball works in the thread. The construction of the box itself is the same as Figure 2, except it is shorter and the copy board is in a fixed position.

Figure 9 shows another box arrangement using an 8" of 10" lens. This is easily made from a discarded apple box. Instead of cutting slots for copy board, you can nail in strips of wood. Two 60-watt lamps will provide plenty of illumination to project line drawings.

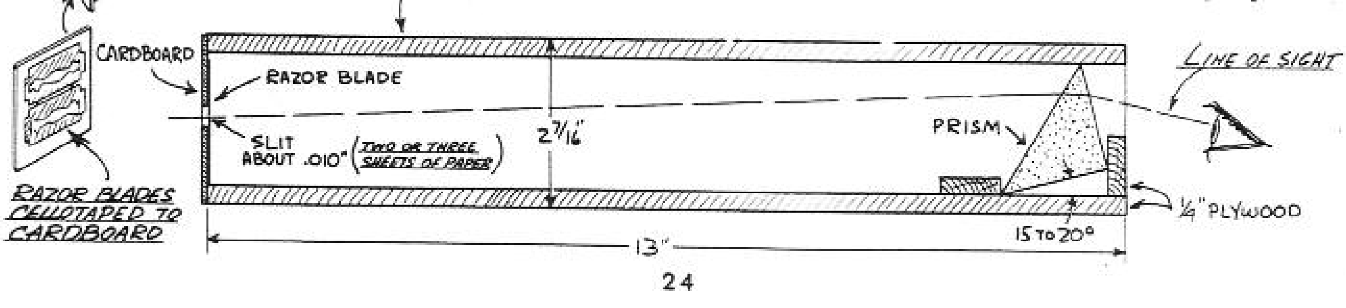
Any "straight shot" projector will invert the image. This is usually of no oonsequence because you can make the image right side up by simply turning the copy upside down. You can't, however, change left to right, and when this reversion is desired it is necessary to use a prism or mirror in the lens system. One simple way of working is to use the prism or mirror in front of the lens, as shown in Figure 4. In a second method, a mirror is built into the box, as shown in Figures 11 and 12. The specific projector dimensioned here uses a 13" focal length lens, and projection is done horizontally, Figure 13, with the box placed over the copy. All of the focusing travel is provided by sliding the long lens barrel in the split ring housing. The lens barrel is reversed for enlargements over 3X.

Making a Simple SPECTROSCOPE



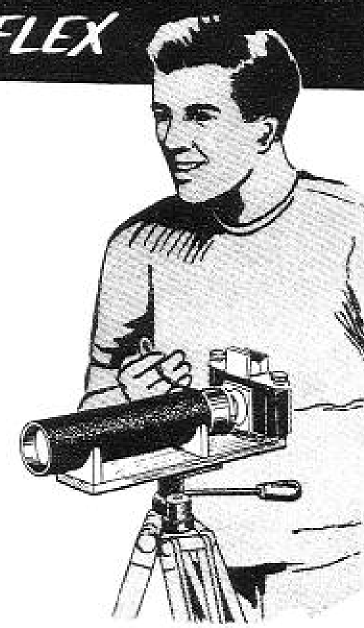
THE SIMPLE spectroscope made with a single prism is a useful and instructive instrument. As shown, the construction is simply a wood or cardboard tube with a prism at one end and a slit at the other end. The simplest way to make the slit is to use two razor blades, making the distance between them equal to two or three sheets of paper.

When you use the spectroscope, you point the tube at the object or toward a light, but you look somewhat higher. If you look at a lamp bulb, you will see the full spectrum from blue to red, appearing as a hand about 1/2" wide. To test a filter, hold it in front of the slit and note what colors it blocks off. What you see when testing a yellow filter is shown in the drawing--the blue rays are cut off and that area of the spectrum shows black. Colored cellophane can be used for demonstration purposes.



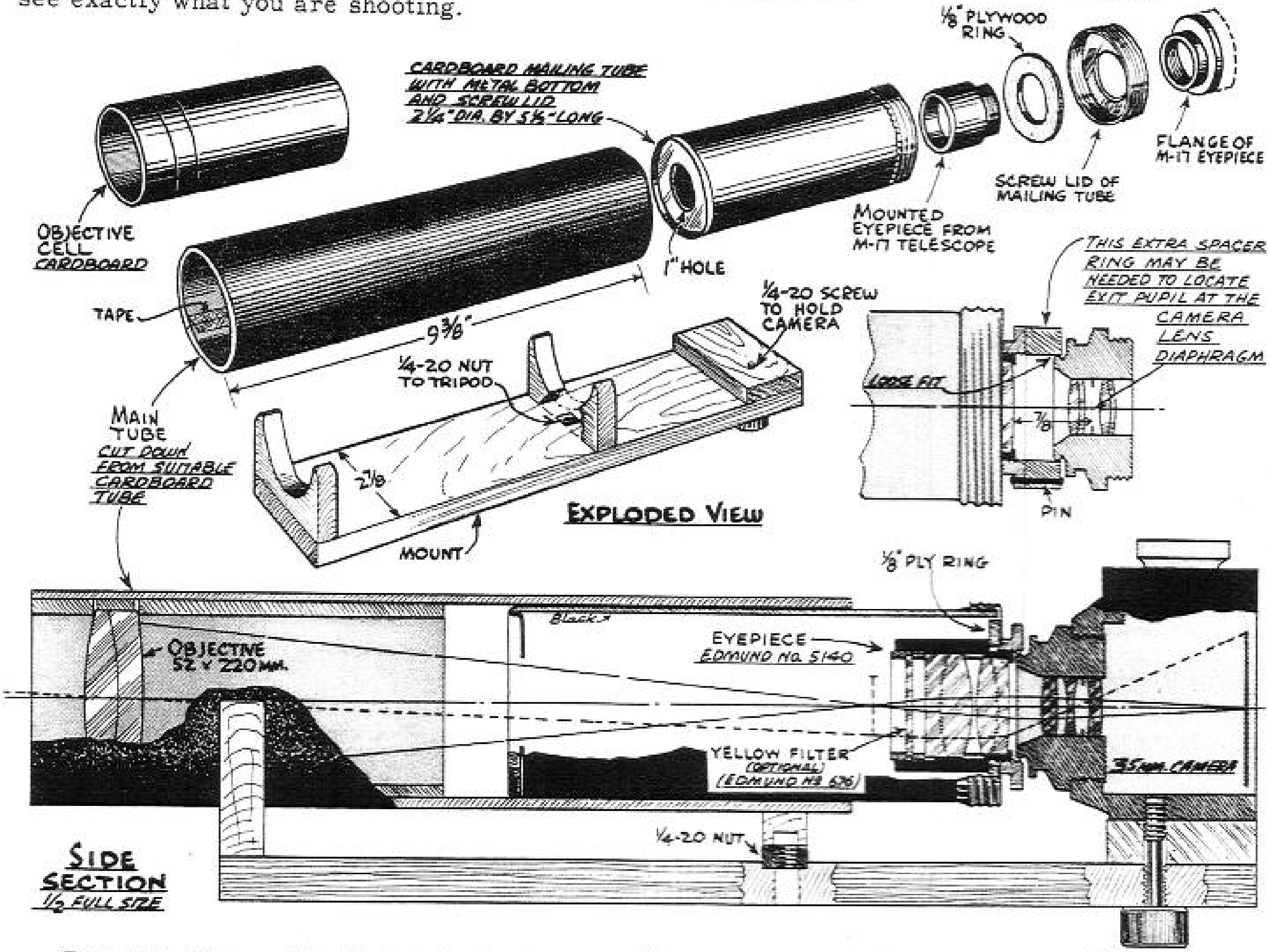
8x TELLY TACH

TRY THIS ON YOUR 35MM. CAMERA OR TWIN LENS REFLEX



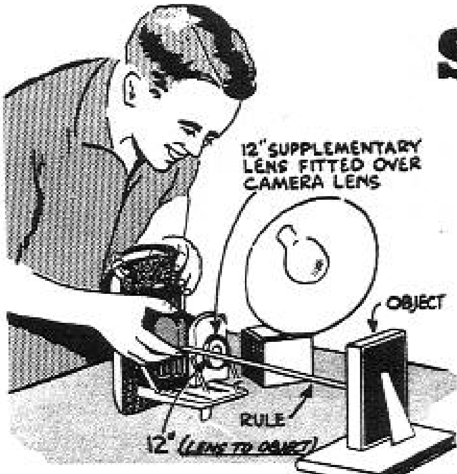
WITH THIS attachment in front of your camera, you get pictures eight times bigger in scale than with the camera lens itself. Telephoto attachments of this kind are simply short astronomical telescopes, and as a matter of fact you can get double use out of the attachment by using it as a visual telescope. The exit pupil of the telescope should be located at or near the camera lens diaphragm. This specification may require the use of a plywood or plastic spacer ring riveted or cemented to the eyepiece, as shown in the drawing.

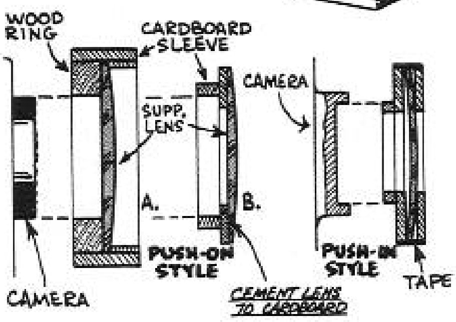
In use, the telescope is focused by eye on the subject and is then placed in front of the camera lens which is set at the infinity position. This secures approximate focus and permits using the attachment on a blind camera. However, best results are obtained with a single lens or twin lens reflex where you can see exactly what you are shooting.



POWER-8x EQUIVALENT FOCAL LENGTH-16" (ON 2" LENS) MAXIMUM SPEED-f9 (ON 2" LENS)

shoot it CLOSE-UP!

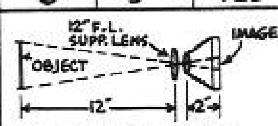




Data — CARDBOARD MOUNTS

DIOPTER-INCHES CONVERSION	DIOPTER POWER	= F.L. INCHES	= F.L. MM.
	1	40	1000
	2	20	500
	3	13	333
F.L. INCHES = $\frac{40}{D}$	4	10	250
	5	8	200
&	6	$6\frac{5}{8}$	166
$D = \frac{40}{F.L. (inches)}$	7	$5\frac{3}{4}$	143
	8	5	125

RATIO SIZE OF IMAGE



RATIO SIZE OF IMAGE EQUALS F.L. OF CAMERA LENS DIVIDED BY F.L. OF SUPPLEMENTARY LENS

EX. ABOVE = $\frac{2}{12} = \frac{1}{6}$ (IMAGE IS 1/6 ACTUAL SIZE)

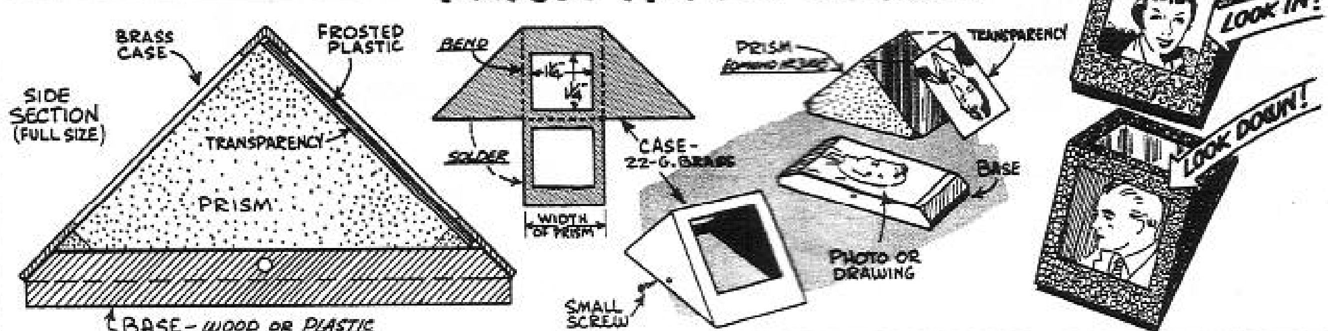
QUITE OFTEN you may want to take a picture closer than the focusing range of your camera allows. One popular and practical way of doing this is by using a supplementary lens in front of the regular lens. The suplementary lens can be any kind of simple positive lens, usually plano-convex or meniscus. You select a lens with a focal length equal to the distance at which you want to shoot. Then, with the camera focusing scale set at infinity, the subject will be in sharp focus when the distance from lens to subject is the same as the focal length of the lens. The supplementary lens does not change the f/value of your regular camera lens--exposure time is normal, that is, just the same as for a "long" shot with the same amount of light.

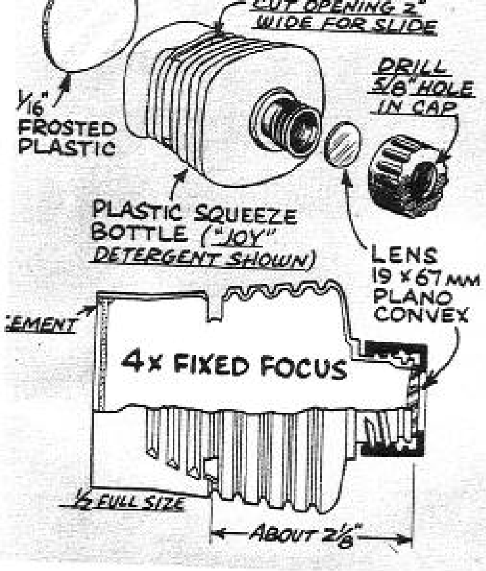
A convenient way of mounting the supplementary lens is by means of a filter holder. You can also make up cardboard mounts to suit available lenses. It is practical to simply fasten the supplementary lens directly in place with masking tape.

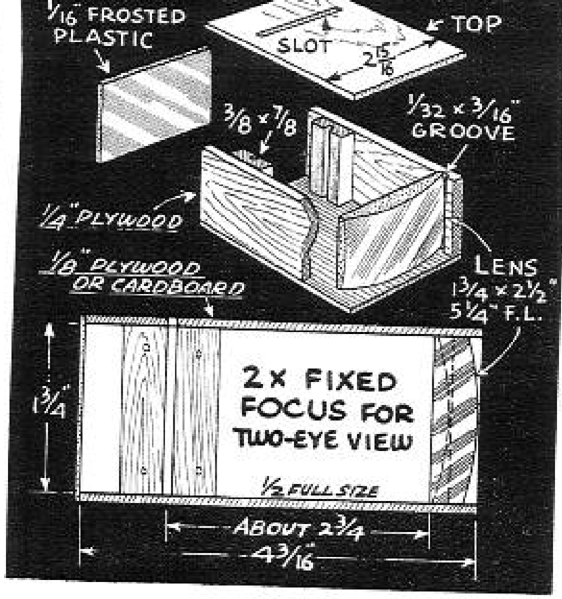
Many of the supplementary lenses used for close-up photography are eyeglass lenses, and as such retain the dioptric system of marking used in the spectacle trade. Popular sets include one each of Plus 1, 2, 3, and 4 diopters. The "Plus" indicates a positive lens, while the dioptric rating has an equivalent focal length in inches, as shown in the table. It can be seen that a set of Plus 1, 2, 3 and 4 diopters offers a choice of 40, 20, 13 and 10 inches focal length. While this range covers most situations, it is often more convenient to use other focal lengths.

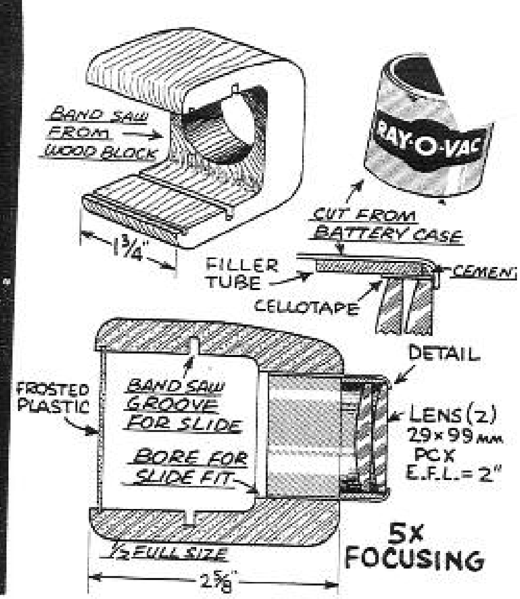
The best camera for shooting close-ups with a supplementary lens is a single lens reflex--you can see on the ground glass exactly what you are getting. If you are using a blind box, it is a good idea to first make a test of the field and focus by fitting a piece of ground glass or tracing paper in the film plane. Tracing paper is cheap, easily fixed in place with small pieces of masking tape. Check the focus on this screen, stopping down if needed for a sharp image. Mark the camera position so that you can return it to same exact location for shooting the actual picture.

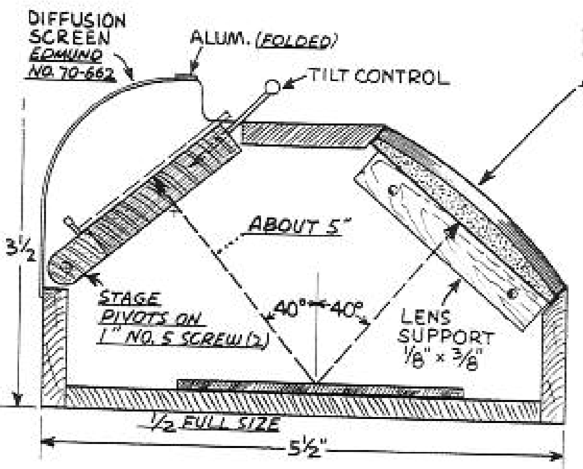
TWO-WAY PICTURE PRISM PAPER WEIGHT

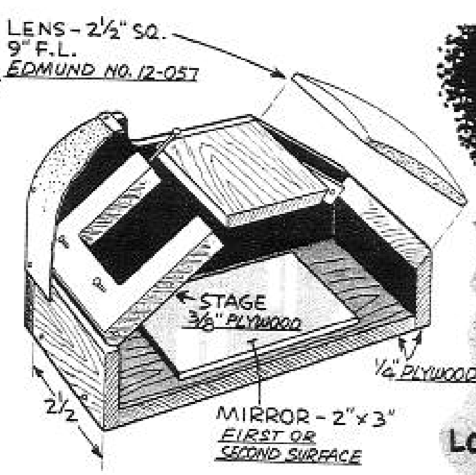


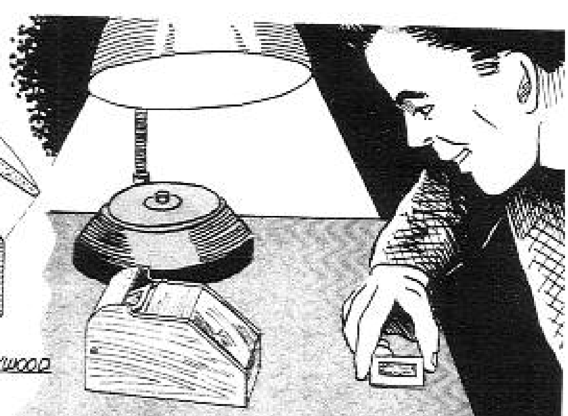






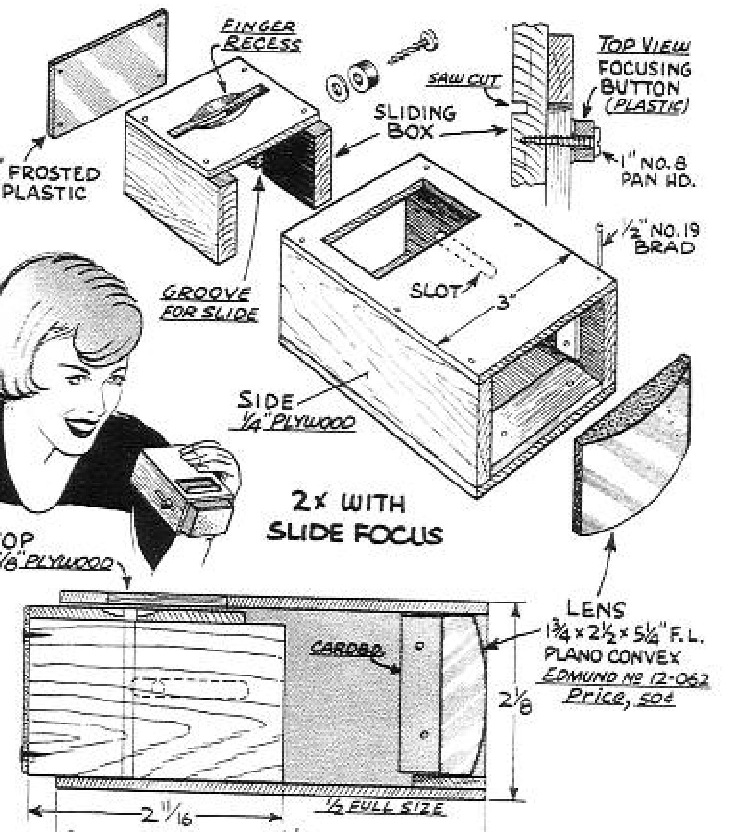






LOW-POWER REFLEX-About 1.6x

SLIDE VIEWERS



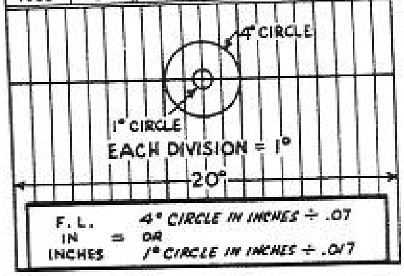
A SIMPLE yet attractive viewer for 35mm slides can be made from the top and cap of a plastic squeeze bottle, as shown at upper left. More conventional construction is the plywood box at top center. This is fixed focus; it is a good idea to check the lens-to-slide distance by an actual test before you build.

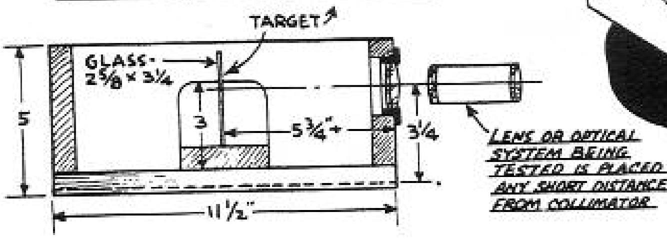
If you want high-power, it is obtained in the usual manner of all magnifiers by using a lens of short focal length. The needed short f.l. for the 5x job shown at upper right is obtained by combining two lenses.

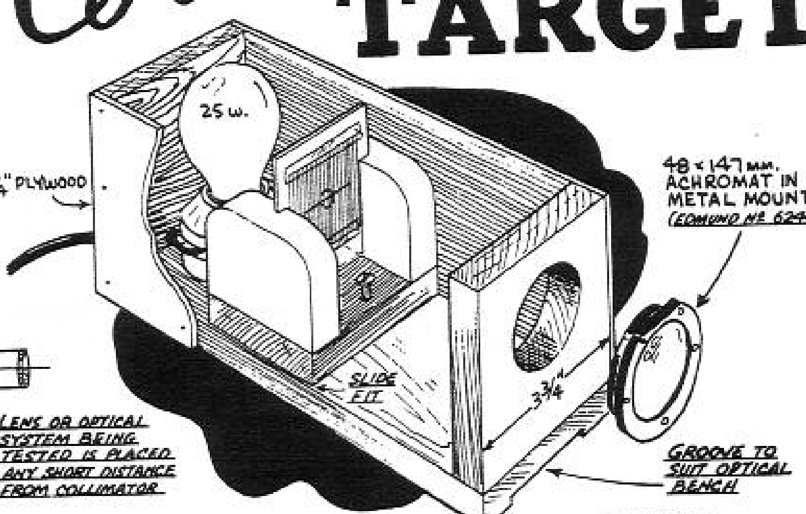
Two-eye viewers must be made with lenses of fairly long focal length, 5 in. being about the minimum. With long eye position, even a 10 in. f.l. lens will magnify 1-1/2x or more, although by the conventional rating system it has no power. You can compact a long f.l. lens system by using a mirror, as shown by center example. A focusing viewer, as at left, assures maximum sharpness for all eyes. Lenses other than those specified can be used by simply changing the lens to slide distance to suit your eyes.

DIRECT-READING ANGULAR SCALE *Collimator* TARGET

4" CIRCLE	F.L.	4" CIRCLE	F.L.	4" CIRCLE	F.L.
.009"	1/8"	.044"	5/8"	.078"	1 1/8"
.017	1/4	.052	3/4	.087	1 1/4
.026	3/8	.061	7/8	.105	1 1/2
.035	1/2	.070	1	.140	2

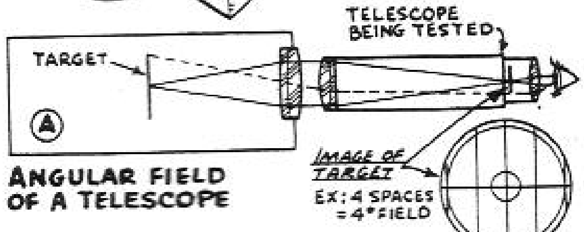




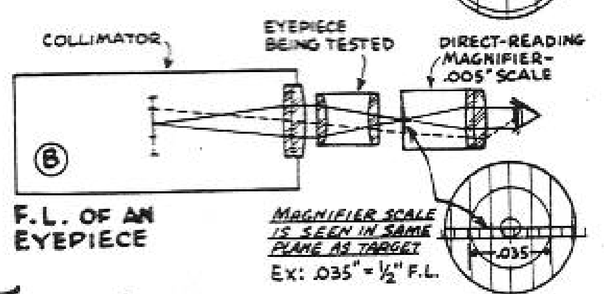


THE COLLIMATOR TARGET is a handy gadget for the telescope builder, providing as it does the equivalent of a distant target--right at the work bench. This one is also scaled so that you can read the angular field of any telescope by simply counting the degree marks.

The construction is simply a wooden box with the target taped to a piece of glass. The target must be located in the exact focal plane of the lens. This will be about 5-3/4 inch plus 1/32 inch from the front of the box. You can check exactly by using the collimator as a camera, pointing the lens toward a distant object. Then, adjust target until image of distant object is sharp on the target.



ANGULAR FIELD OF A TELESCOPE



F.L. OF AN EYEPIECE

How to Use the Collimator Target

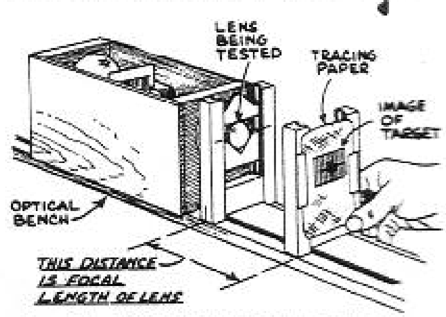
INFINITY TARGET

SET UP YOUR TELESCOPE, CAMERA OR OTHER OPTICAL SYSTEM FACING COLLIMATOR LENS, AS SHOWN IN DIAGRAMS. FOCUS ON COLLIMATOR TARGET - IT SERVES THE SAME PURPOSE AS A DISTANT TARGET

ANGULAR FIELD (DIAGRAM A)

READ THE TRUE ANGULAR FIELD DIRECTLY BY COUNTING NUMBER OF LINES WHICH ARE VISIBLE. EACH DEGREE OF FIELD IS EQUAL TO ABOUT 17 YDS. OF LINEAR FIELD AT 1000 YDS.

THE APPARENT FIELD (ANGLE COVERED BY TELESCOPE EYEPIECE) IS THE TRUE FIELD TIMES THE MAGNIFICATION OF THE TELESCOPE



FOCAL LENGTH OF A LENS

SET UP LENS AS ABOVE. MOVE TRACING PAPER SCREEN ALONG OPTICAL BENCH TO PICK UP A SHARP IMAGE OF COLLIMATOR TARGET. DISTANCE FROM SCREEN TO CENTER OF LENS IS THE FOCAL LENGTH OF LENS

F.L. OF LENS SYSTEM (DIAGRAM B)

IN THIS SETUP, THE IMAGE OF THE TARGET PRODUCED BY THE LENS SYSTEM BEING TESTED MAY BE VERY SMALL. IF SO, IMAGE MUST BE VIEWED AND MEASURED WITH A DIRECT-READING SCALE MAGNIFIER. MEASURE DIAMETER OF 4° CIRCLE. REFER TO TABLE ON TARGET TO OBTAIN CORRESPONDING F.L. OF LENS SYSTEM

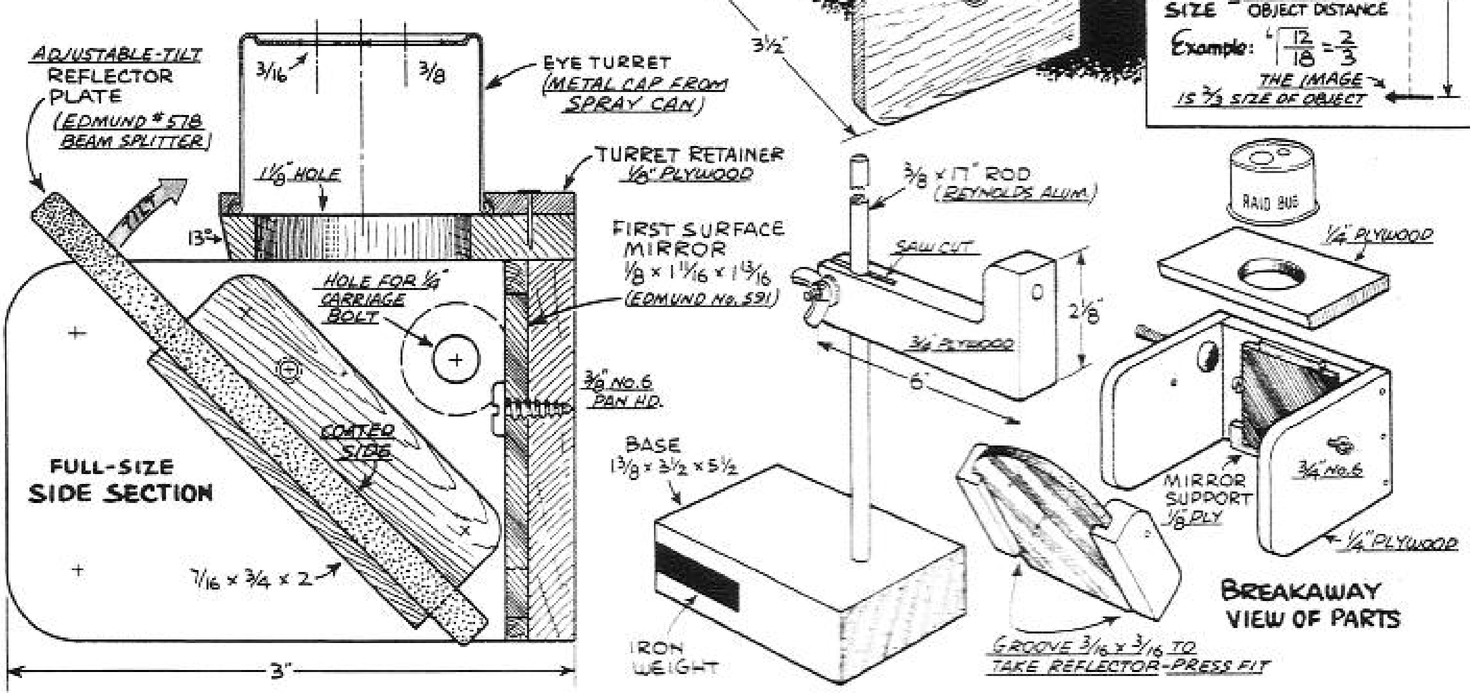
FOR FOCAL LENGTHS NOT GIVEN IN TABLE, CALCULATE BY USING FACTORS AT BOTTOM OF TARGET

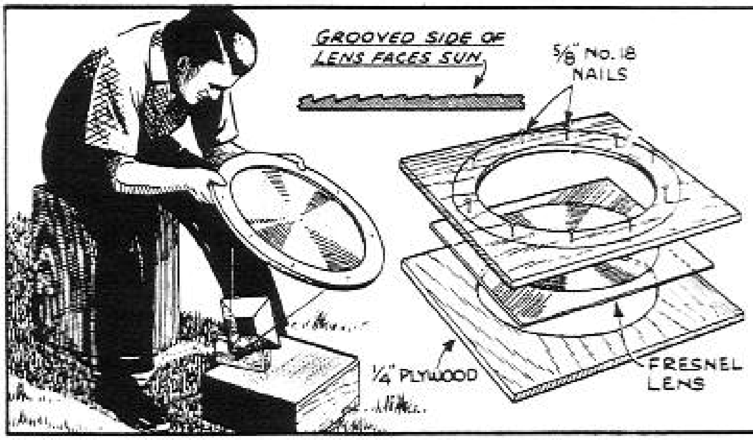
EX: TESTING A 6" F.L. SYSTEM:
4° CIRCLE MEASURES .42"

6"
.07) .42
42

"LUCY" makes you an ARTIST!

THE REFLECTING camera lucida works something like an ordinary looking glass in producing a virtual image, the difference being that the "lucy" projects the image downward to a drawing board where it can be traced. The reflector plate is supported by two wooden sidepieces, the whole pivoted on screws to provide a tilt adjustment which is very useful when you want a view looking down on the object. The revolving eye turret has two holes, the larger giving the brighter view while the smaller serves to anchor your eye and prevent image movement. The Lucy Camera is especially good for full-size sketches of small objects, this scale being obtained at various distances providing only that object distance and image distance are the same.

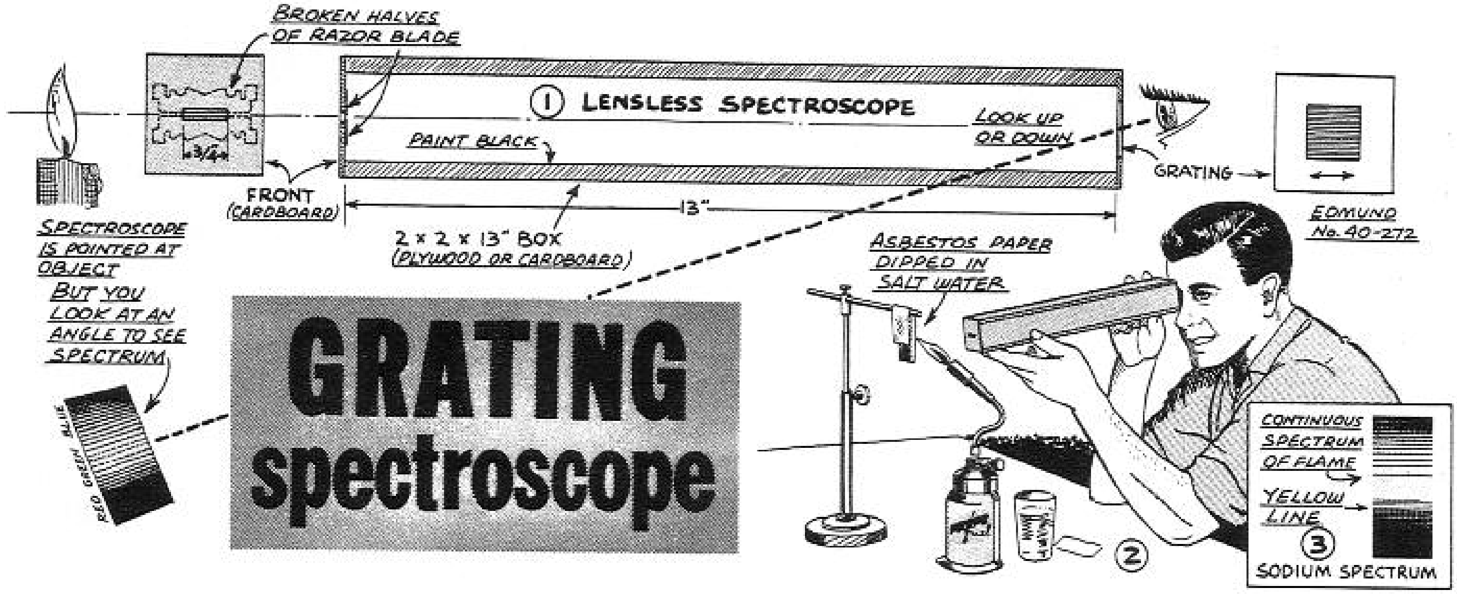




"JUMBO" Burning Glass

Capturing fifty times more sunlight than a 2-inch burning glass, this big burner will start a fire in seconds. It provides enough heat for soldering or enameling, providing the work area is small. For soldering, the burning glass is used like a torch--you heat the work, not the solder. Snippets of 1/16-inch wire solder will melt and flow when the metal gets hot.

GRATING spectroscope

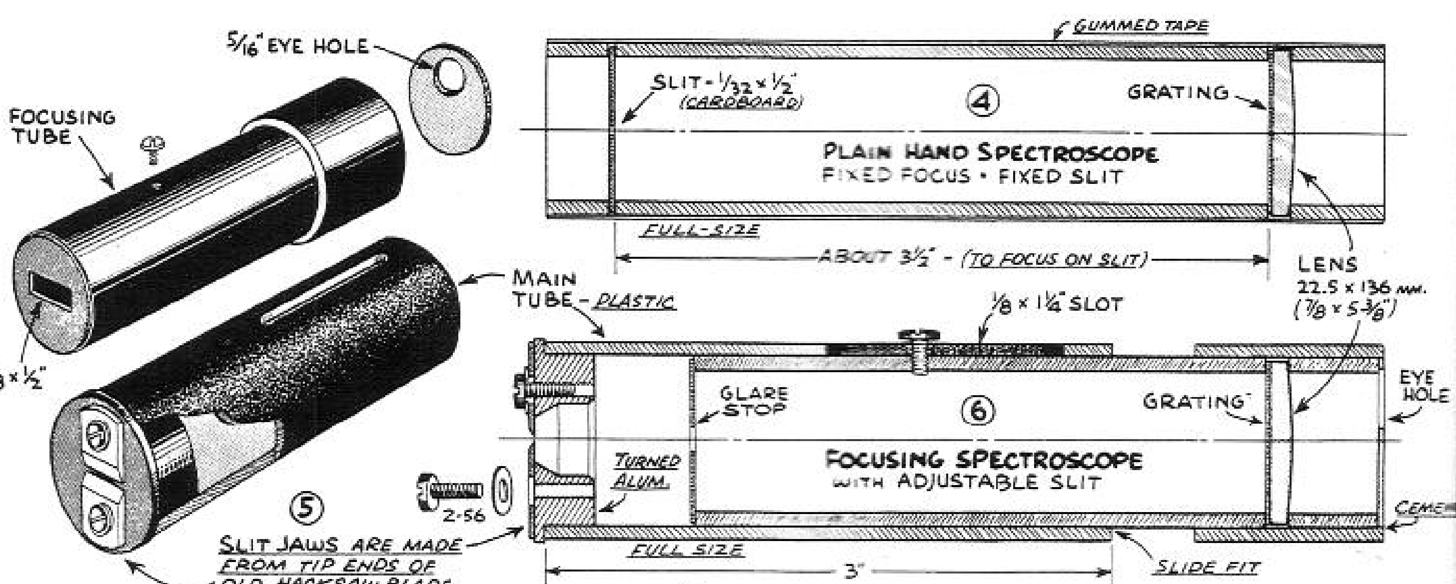


FEW OPTICAL instruments can be made as cheaply as a grating spectroscope--all it takes is a plywood or cardboard box and a 25¢ piece of diffraction grating in cardboard redi-mount. Although low-cost, the performance is excellent, surpassing in some respects the more expensive prism spectroscope.

A lensless spectroscope needs a box or tube 12 or 13 inches long, as shown in Fig. 1, with the grating taped or tacked to one end and the slit similarly mounted at the other end. A good slit width is about .015 inch, equal to the thickness of three or four sheets of paper. Fit the grating last; a quick look-and-see will tell you if the grating lines are parallel with the slit as they should be.

By far the best object to look at with your homemade spectroscope is a fluorescent lamp. This will show a continuous color spectrum from the light of the lamp itself, while mercury and argon inside the tube reveal their presence with characteristic bright lines in green, orange and blue-violet. Salts of many elements are readily available and their spectra observed by vaporizing solutions in the flame of a torch. Sodium, Fig. 3, is popular since sodium chloride is ordinary table salt.

What you see in any spectroscope is a multiple image of the slit. This means the slit itself must be in sharp focus, hence the 12-13 inch length of the lensless model. If you want a shorter spectroscope, all you have to do is use a lens to shorten the viewing distance. Any simple lens from about 4 to 6 inches focal length will do nicely. Fig. 4 shows a simple type of contruction with fixed slit and fixed focus. Figs. 5 and 6 detail an improved pocket spectroscope which provides for focusing and adjustment of slit width. Optional in either model is a glare stop to eliminate stray light; the offset eye hole is for same purpose. Slot in focusing tube is needed to keep grating lines parallel with slit.

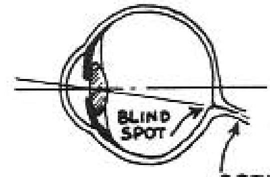


OPTICAL ILLUSIONS

THE VANISHING IMP!

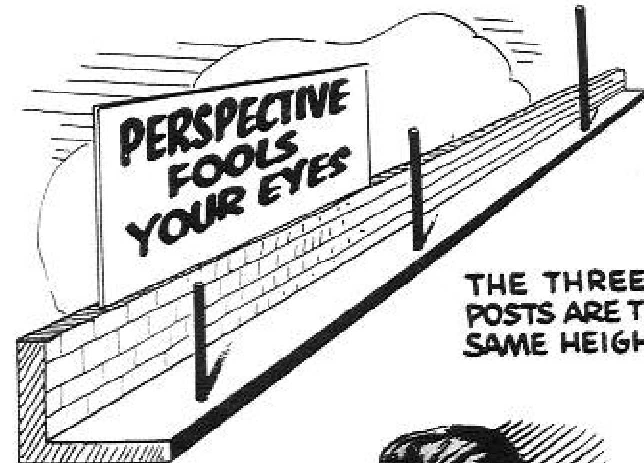
HOLD THIS PAGE ABOUT 16" AWAY AND CLOSE LEFT EYE. STARE AT CROSS WITH RIGHT EYE. MOVE PAGE CLOSER AND WATCH THE LITTLE IMP VANISH

WHY: *EYE IS BLIND AT POINT WHERE THE OPTIC NERVE ATTACHES. TWO-EYE VISION OVERLAPS AND ELIMINATES THE BLIND SPOT*



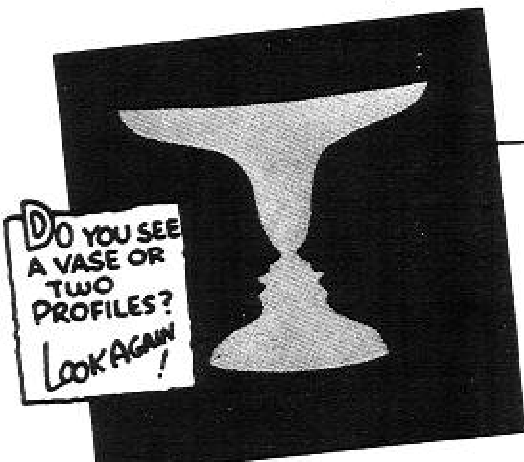
CAGE THE **BIRD!**

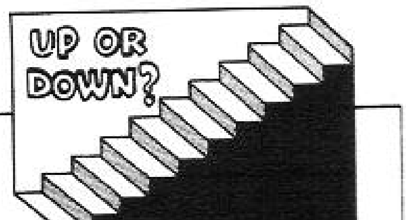
PUT YOUR NOSE ON THE DOTTED LINE

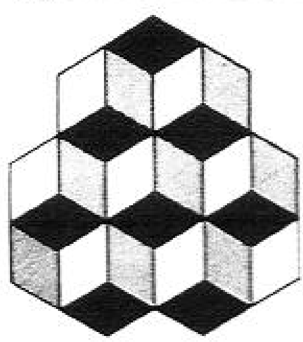


THE THREE POSTS ARE THE SAME HEIGHT

HOLD A PENCIL OR CIGARETTE ABOUT 12" AWAY AND STARE AT A DISTANT OBJECT ON SAME LINE. YOU WILL SEE **DOUBLE!!**

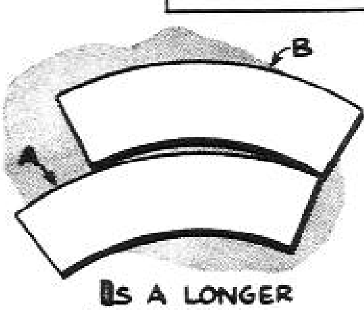




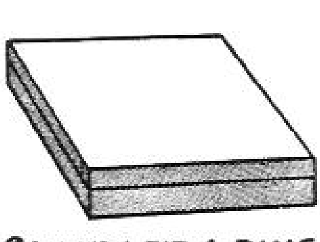


STARE AT ANY OF THE THREE DRAWINGS SHOWN HERE AND YOU WILL SEE THE SHAPE CHANGE

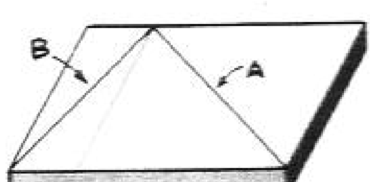
COUNT THE BLOCKS



IS A LONGER THAN B?



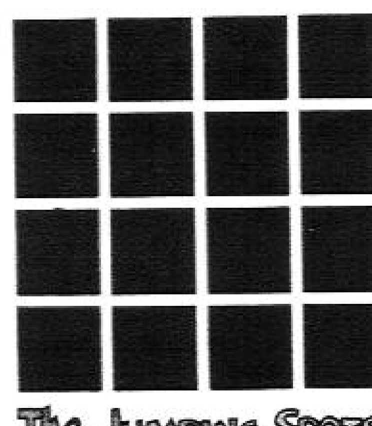
CAN YOU FIT A DIME INSIDE THIS BOX?



IS A LONGER THAN B?

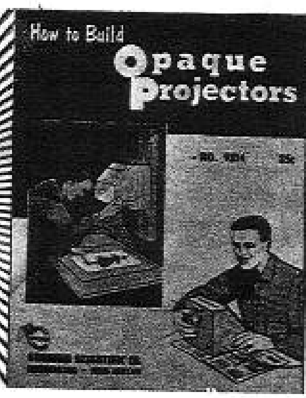
MEASURE THEM AND SEE!

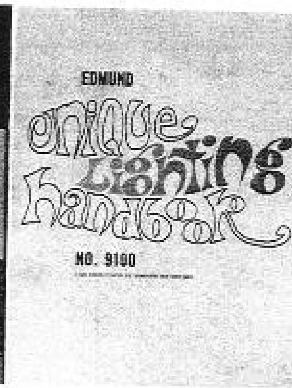
TRY THESE FOR SIZE!



THE JUMPING SPOTS

DON'T BE ALARMED IF YOU SEE JUMPING GRAY SPOTS AT THE CORNERS OF SQUARES – IT'S JUST A CASE OF **BRIGHTNESS CONTRAST**





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INFORMATION AND INSTRUCTIONS

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PHOTOGRAPHIC / BARLOW ADAPTER KIT
NO. 2004 and 2005

The kit you have purchased is designed to allow you to take photographs through any telescope equipped with a standard 1¼" inside diameter eyepiece focusing mount. Featuring a separate Barlow lens, it also allows you to perform direct, double-power observing with your eyepiece.

The Kit Contains:

(1) "T"-mount to 1¼" Photo-Adapter (No. 40,975)

(1) Barlow lens and tube (No. 40,477)
OR (1) Goodwin Barlow lens and tube

(1) Clamp ring with thumb screw

The photo-adapter is designed to match standard 1¼" I.D. focusing mounts. The camera end of the adapter is equipped with a standard male "T"-mount thread (42mm O.D. x .75mm). The photo-adapter fits into the Barlow tube and the clamp ring prevents the camera's weight from disturbing the focus.

When a modern 35mm Single Lens Reflex (SLR) camera is used on a telescope equipped with a 1¼" I.D. focusing tube, not all of the 35mm film frame is illuminated at prime focus unless a lens is placed somewhere in the tube to expand the field. **See Figure 1.** (Reference: "All About Telescopes" by Sam Brown, 1975, Edmund Scientific Co., Section 3, Page 51.)

The simplest way to obtain proper field is to use a negative lens or Barlow to expand the effective focal length of the objective. **See Figure 2.** (Reference: same as above).

DIRECT OBJECTIVE
Light goes direct from objective (lens or mirror) to film.

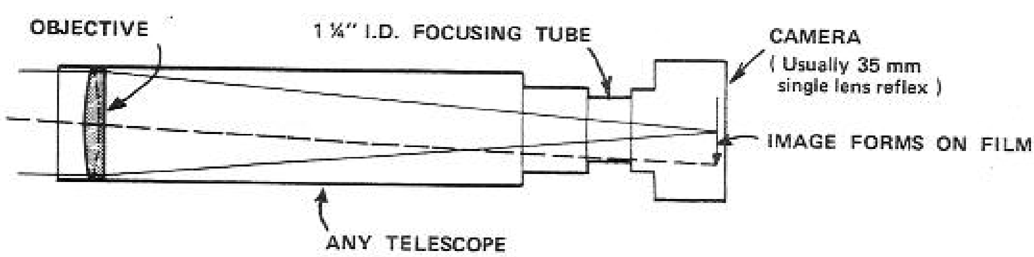


FIGURE 1. Prime Focus Photography without Lens.

PROJECTION with a NEGATIVE LENS
A negative lens intercepts the light rays and extends them to form an enlarged image.

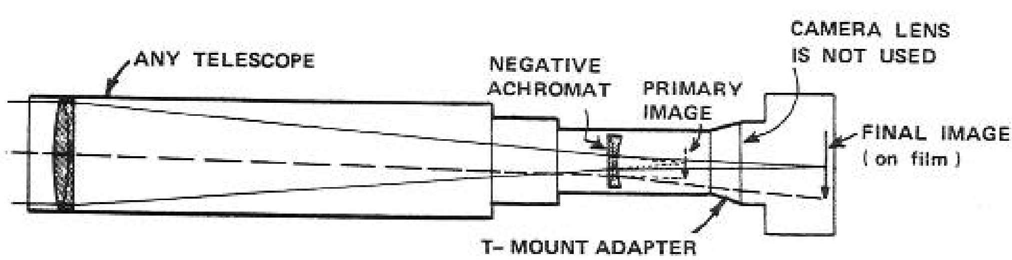


FIGURE 2. Projection of Image with Lens.

Using The Photographic Adapter

To use this system, the first requirement is to fit your SLR camera with a "T"-mount adapter. If you don't already have one, you may order one for your particular camera from Edmund Scientific.

CAMERA	SIZE	STOCK NO.
Pentax	49mm	40,960
Minolta	55mm	40,957
Nikon	52mm	40,956
Canon	55mm	41,819
Olympus	49mm	42,335

Other adapters are available. Contact our Sales Engineering Dept.

If you have the proper "T"-mount adapter for your camera, begin by removing the camera lens from the camera body. Replace the lens with the "T"-mount adapter.

Next, attach the photo-adapter (No. 40,975) to the "T"-mount adapter you have placed on the camera.

Now remove the eyepiece from the telescope's focusing tube and slip the clamp ring over the tube and lock it by tightening the thumb screw. This allows you to secure your focus position while you make exposures.

Finally, place the Barlow tube (No. 40,477) into the focusing tube and then insert the photo-adapter and camera into the Barlow tube. You are now ready to shoot.

Simply loosen the clamp ring, focus, tighten the clamp ring against the base of the tube to lock the focus and shoot!

Magnification

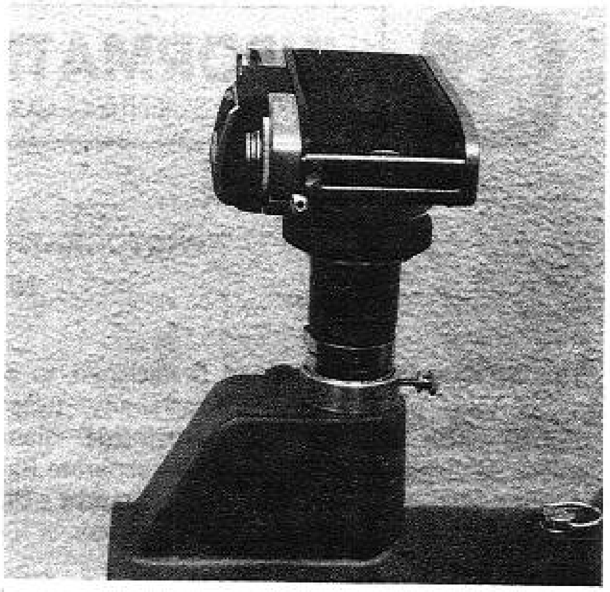
Note that the lens cell in the Barlow tube is held in position with phenolic spring rings which can be removed along the longitudinal axis of the tube. Magnification can be calculated by the following formula:

$$M = \frac{S + F}{F}$$

Where: **M = Magnification in diameters;**
S = Spacing between focal plane of camera and focal plane of objective;
F = Focal length of negative lens.

(All dimensions are in same units; the focal length of the negative achromat supplied with this adapter is 49mm (1.93").)

From this formula you can see that minimum power is achieved with minimum spacing and maximum power is achieved with maximum spacing. With a 17" focal length objective (such as the one in our No. 2001 Wide-Field Telescope), this represents a power increase of 1.1 from the minimum spacing position to about 1.7 in the maximum power spacing position.



As power is increased, the effective f/value is increased as well. For example: if the negative lens is placed at 1.5 power, the nominal f/4 value of the No. 2001 Wide-Field Telescope would be f/6. If the negative lens is placed at 1.7 power, then this telescope would be about f/6.8.

EXPOSURE

Another advantage of full-field illumination with a modern SLR camera that's equipped with "through the lens" (TTL) metering is that the built-in light meter will function properly. Thus, you can still use the meter if there is sufficient light to activate it.

The problem in astrophotography or other low-light, long-exposure photography is that the meter won't register light at all. In those cases, you will have to experiment.

One technique is to try shooting three exposures with each successive shot twice the length of the one before. For example: 5 seconds, then 10 seconds, and then 20 seconds. Or, try 1 minute, 2 minutes and 4 minutes. This technique can be used on night scenes that assume the telescope is stationary. A tripod is recommended.

For tracking celestial objects, a clock drive mount for the telescope will be needed to hold the scene still while the earth turns.

DIRECT OBSERVATION

Using the Barlow lens and tube alone, you can as much as double magnification in direct viewing with your eyepiece.

To use the Barlow alone, simply remove the eyepiece from the telescope's focusing tube, insert the Barlow tube into the focusing tube and place the eyepiece into the Barlow tube. You may then focus as you would normally.

Magnification with the Barlow remains the same as discussed earlier.

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INFORMATION AND INSTRUCTIONS

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BARLOW

NO. 40,477

In the early nineteenth century, Peter Barlow, English physicist and mathematician, discovered that a negative lens placed just inside the focal plane of a telescope could double or triple the magnification. Since then Barlow lenses have been widely used to increase the magnification and therefore the resolving power of both refracting and reflecting telescopes. Another feature that adds to the popularity of the Barlow is its effect of increasing eye relief. Figure 1 shows the optical principles involved in the use of the Barlow.

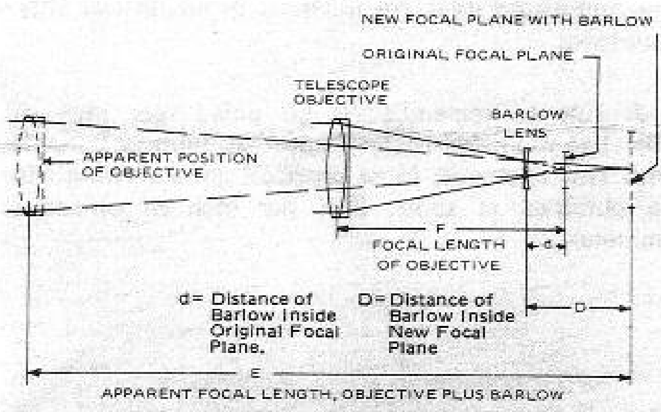


Fig. 1 OPTICAL SYSTEM OF TELESCOPE WITH BARLOW

The standard Barlow, however, has the disadvantage of all simple lenses of introducing aberrations which reduce the quality of the image. This can be overcome by using a well designed achromat in place of the simple lens.

Our Barlow consists of a cemented (two-element) achromat especially made for this use. It has an effective focal length of 47mm (approximately 1.85"). The coated achromat is mounted in a cell which is held by spring tension inside a 4" long blackened adapter tube for standard (1-¼" O.D.) eyepieces. The position of the achromat inside the tube is easily changed to fit the characteristics of individual telescopes. Figure 2 shows the construction.

CLEANING THE ACHROMAT

Ordinarily the only cleaning the lens will require is the removal of loose surface dust. This can be done best by gentle dusting with a soft camel hair brush or a blowing off the dust with a rubber ear syringe which can be purchased at any drug store. At long intervals more thorough cleaning may be necessary. Remove the surface dust by brushing or blowing. Then take good quality lens tissue and moisten it slightly with lens cleaning fluid. Wipe the exposed surfaces of the lens gently. It is best always to try to avoid touching the lens surfaces with the fingers.

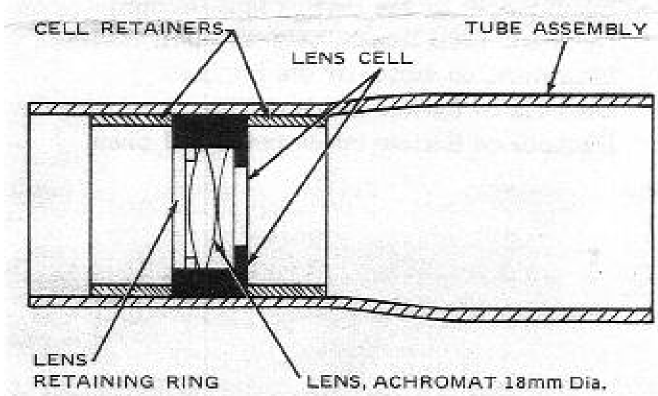


Fig. 2

TESTING THE BARLOW

First make certain that the telescope is properly collimated. Remember that you are about to increase magnification and that inaccuracies of adjustment will be magnified just as much as anything else.

Choose a night when seeing is good. Check for turbulence by observing critical objects through your telescope without the Barlow. If conditions are poor, wait for a night when seeing is good.

Focus your telescope on some critical object and test various positions of the Barlow in its tube to find the one that gives you optimum performance. The greater the distance between the Barlow and the eyepiece, the greater will be the magnification. There will be, however, an optimum position beyond which star images will loose crispness and definition. This position depends on specific optical characteristics of the individual telescope. Attempting to stretch magnification beyond this point would be completely meaningless.

When you have determined the optimum position for your Barlow, you may wish to compute the optical characteristics of your telescope with the Barlow in position. To do so, consult Figure 1 and use the formulas given below.

FORMULAS FOR COMPUTING OPTICAL CHARACTERISTICS

$$E = \frac{Ff}{f - d} \qquad M = \frac{E}{F} = \frac{f}{f - d} \qquad D = f\,(M - 1)$$

- F - Focal length of objectives
- f - Focal length of the Barlow lens (47mm)
- E - Apparent focal length, objective plus Barlow
- M - Magnification factor of the Barlow
- d - Distance of Barlow inside original focal plane
- D - Distance of Barlow inside new focal plane

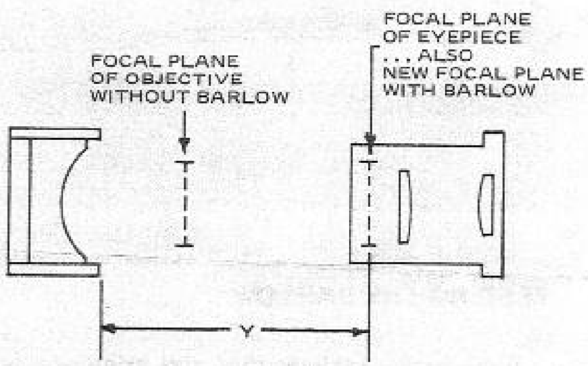
For a quick check of the magnification factor of your Barlow at the optimum position you have chosen, measure the distance between the end of the lens cell and the image plane of your eyepiece. (In the Edmund 28mm Kellner eyepiece, for example, the image plane of the eyepiece is 7/8" back from the small end of the eyepiece tube.) Consult the following diagram and chart to find the magnification.

USING THE BARLOW WITH OTHER EYEPIECES

When you have found the optimum position for use of the Barlow with your long focal length eyepiece, you will find that this position will give good results with other eyepieces as well. Although there might be a slight difference in optimum position for different eyepieces, this is usually so small as to be insignificant.

When properly used, the Barlow will give you superb results. Do not, however, expect it or any other supplementary lens to extend your telescope beyond the limitations that are inherent in its optical characteristics.

A rule to remember is 50 power per inch of objective diameter is the theoretical limit obtainable with any telescope. Most practical good viewing will be obtained at about 25X per inch of objective diameter.



Approximate Y Distance	Approximate Magnification
0"	1.25 X
1/16"	1.5 X
7/8"	1.75 X
1-5/16"	2.0 X
1-3/4"	2.25 X
2-3/16"	2.5 X
2-5/8"	2.75 X
3-1/16"	3.0 X

Fig. 3

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