Design and Construction of TELESCOPES

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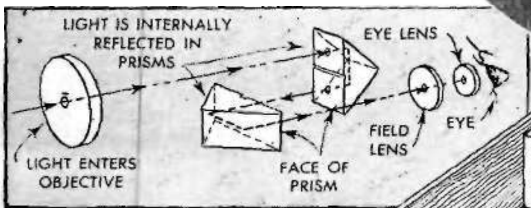
PART III

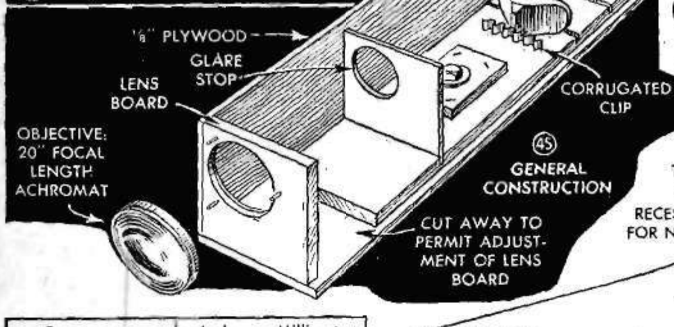
The prismatatic telescope, is an astronomical telescope plus a pair of prisms for erecting the image. The most common example of this type of construction is the binocular instrument. One half of a binocular is a monocular. Some telescopes are used for a specific purpose and are named accordingly; a typical exam-



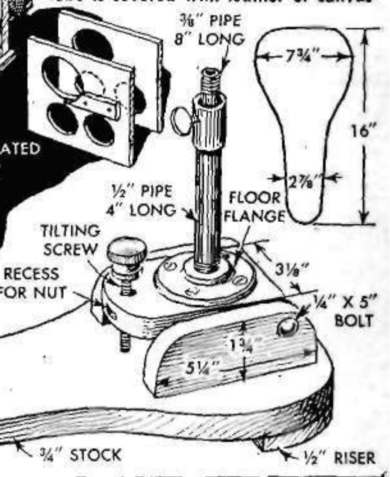
(44) HOW PRISM TELESCOPE WORKS

23X Spotting scope

uses 20-in. focal length objective and has prismatic erecting system. Main tube is covered with leather or canvas



(45) GENERAL CONSTRUCTION



(46) MOUNT HAS HEIGHT AND ANGLE ADJUSTMENTS

Lenses

	Inches		Millimeters	
	Dia.	F.L.	Dia.	F.L.
OBJECTIVE	1¾	20	44	508
FIELD	⅞	2	23	50
EYE	⅝	1⅛	16	28

Data

(47)

EQUIV. FOCUS OF EYEPIECE $= \frac{28 \times 50}{28+50-15} = 22$ MM.

MAGNIFICATION $= 508 \div 22 = 23$X

EXIT PUPIL $= \frac{1}{16}'' = 2$ MM.

EYE RELIEF $= \frac{7}{16}$ IN.

LUMINOSITY $= 13\%$

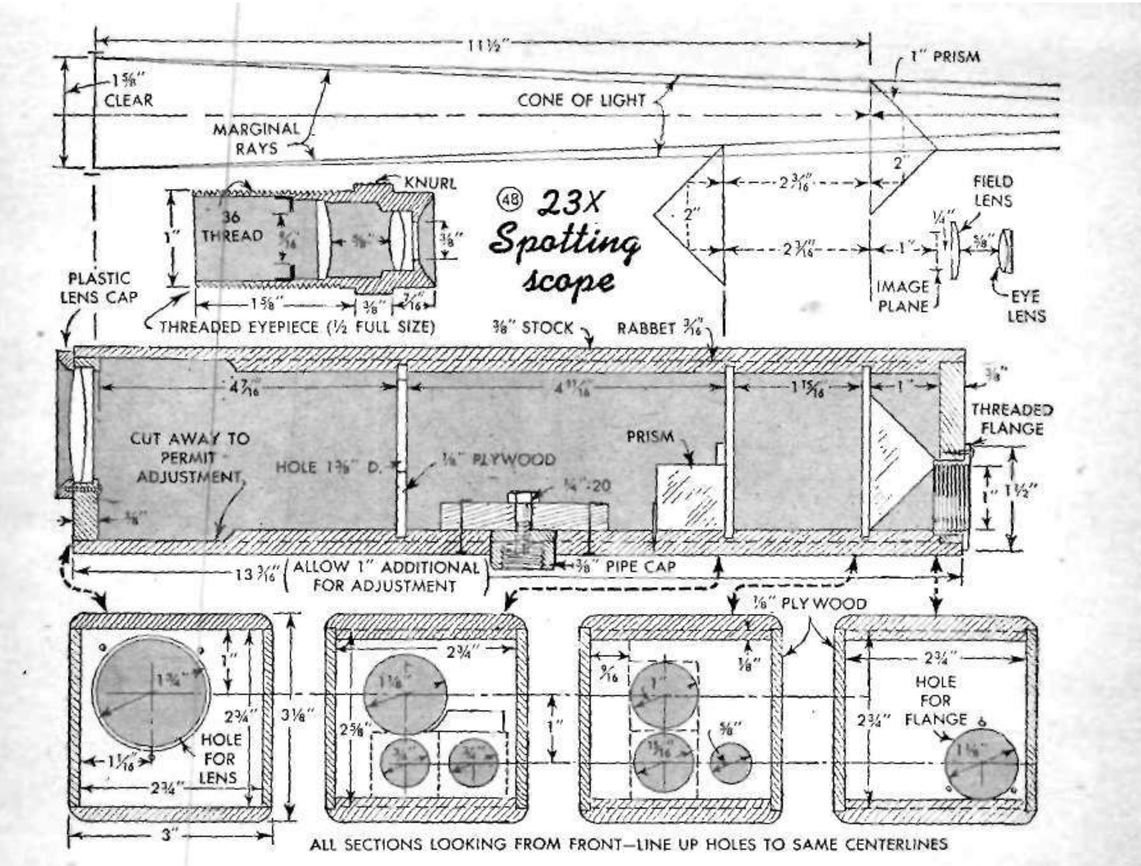
PRISMS—1-IN. FACE

IMAGE SIZE $= 20'' \times .030 = .60'' = \frac{9}{16}''$

FIELD OF VIEW AT 1000 YDS. $= 24$ YDS. (APPROX.)

pie being a spotting scope, which is used to view the target in rifle shooting.

Prisms: Prisms are polished, angular pieces of glass, the kind commonly used in telescopes being 45-45-90-deg. prisms. The long side is the face, while the two short sides are the reflecting surfaces. The size of the prism is the width of the face. Fig. 44 shows how -the prisms are used in a telescope. Made specifically for telescopes, the prisms are grooved across the face in order to make a definite dividing line and avoid ghost images which would be caused by overlapping rays at this point. The ends are usually rounded to conserve space. The two sizes that you will probably work with



are 1 in. and x%6 in. The 1-in. size is from the Navy 7X binocular while the smaller prism is from the Army 6X binocular. These prisms can be used in almost any power or type of prismatic telescope. The prime advantage of the prism erecting system is compactness. It adds somewhat to the bulk of the instrument but shortens the length considerably. The prism glass has an illusive quality of brilliance but actually the light loss through the two prisms is somewhat greater than through the two erecting lenses of a lens erecting system.

The 23X prismatic spotting scope: This design calls for a 20-in. focal length objective, which, with a 22-mm. focal length eyepiece (from Army 6X), gives 23-diameter magnification. Prisms are 1-in. face. Fig. 45 shows the general construction and Fig. 47 gives lens data, while Fig. 48 gives complete dimensions. The scope body is of wood construction in simple box form. The first prism, the one the light strikes first, is located in an upright position at the back of the box; the second prism is mounted flat on the box bottom. Plywood spacers hold the prisms in place and also provide for the passage of the cone of light admitted by the objective. The eyepiece is fitted in a threaded mount. This type of focusing is satisfactory at set distances but is much too slow for general use. If you want this scope for general observation, it should be fitted with spiral focusing like the 10X monocular to be described later. It would also be practical to focus with a simple draw tube system. The principal point of the construction is to get the various holes lined up square. Use prism center lines as a guide and locate all holes from one master pattern drawn on cardboard.

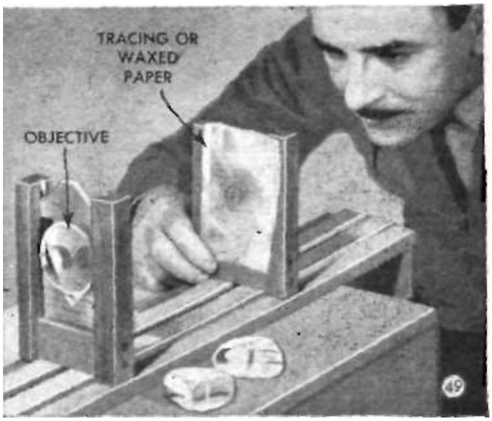
A mount for the spotting scope is shown in Figs. 43 and 46. The %-in. pipe fits into a pipe cap recessed and bolted to the bottom of the telescope as can be seen in Fig. 48. The pipe slides inside the 4-in. length of y2-in. pipe to provide height adjustment from 11 to 17 in. to objective centerline. Base on which the floor flange is mounted pivots on a carriage bolt and is tilted by means of a tilting screw.

Designing- prismatic telescopes: Designing your own prismatic telescopes follows much the same procedure as used for astronomicals and terrestrials. Primary consideration should be given the objective and eyepiece. The prisms contribute nothing to "the magnification; therefore, the power you want must be obtained entirely by the ratio of FO to FE. Prisms should be of such a size or so located as to receive the full cone of light from the objective, although it is practical to sacrifice extreme edge rays.

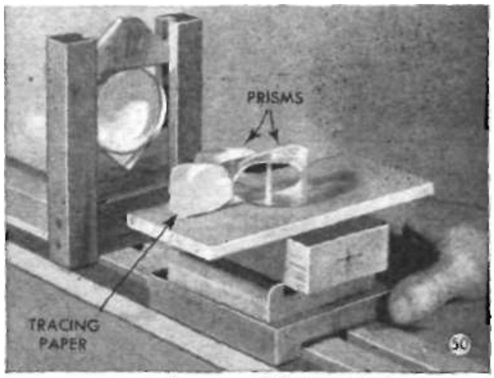
Fig. 52 shows the complete layout and construction pf a 10X monocular. The layout (at top of drawing) is what you make to determinq' size and location of prisms and also the general overall dimensions. In this example, the objective has a 52-mm. diameter by 193-mm. focal length (from Navy 7X binocular) and the prisms are 1-in. face (from Navy 7X). As used by the Navy, this glass has a 27-mm. eyepiece, which gives a magnification of 7 diameters. If you want higher magnification, you have to use a shorter focus eyepiece. The Army 6X binocular eyepiece, 22 mm., could be used and would give you 9X. The eyepiece shown uses an Army binocular eye lens, but a shorter focus field lens, the combination giving 20-mm. focus, hence, about 10X magnification.

The preliminary calculation should determine the exit pupil and luminosity. This glass has excellent illumination at 92 percent. However, don't get the idea that the 13 percent rating of the 23X spotting scope is hopeless—13 percent is a good value for anything over 20X magnification. It is worth mentioning here that prism instruments are often rated for illumination on the basis of the exit pupil squared. Thus, if the scope has a 5-mm. exit pupil, it would be rated 25. Using this calculation, the 100 percent standard would be the normal size of the eye pupil, squared: 25 for daylight and 49 for night.

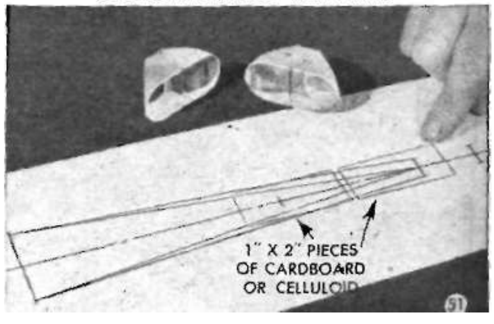
Bench setup: Set up the objective and focus on well-lighted copy or a bare light bulb, not less than 20 ft. from lens. Use tracing or waxed paper as a ground glass to pick up the image as in Fig. 49. Measure the distance from the rear side of the objective to the image plane. Start your layout and transfer this dimension to the layout, as indicated by A, Fig. 52. Next, put the two prisms face to face as in Fig. 50 and move the assembly back and forth until you pick up a sharp image of the copy or light bulb. Measure the distance to the face of the first prism and set off this distance on your layout, indicated by B, Fig. 52. Now, referring to the Fig. 48 layout, you will note that the distance the light travels through a 1-in. prism is 2 in., a total oX 4 in. for both prisms. Set off this distance, C, on your layout to establish the back image plane. Determine the image size. In this instance, the multiplying factor is .070, and this figure multipHed by the focal length of the lens (7% in.) gives .53 in. for the image size. Call this Ha in. for an even figure and mark the image size at



PICK UP IMAGE ON TRACING PAPER

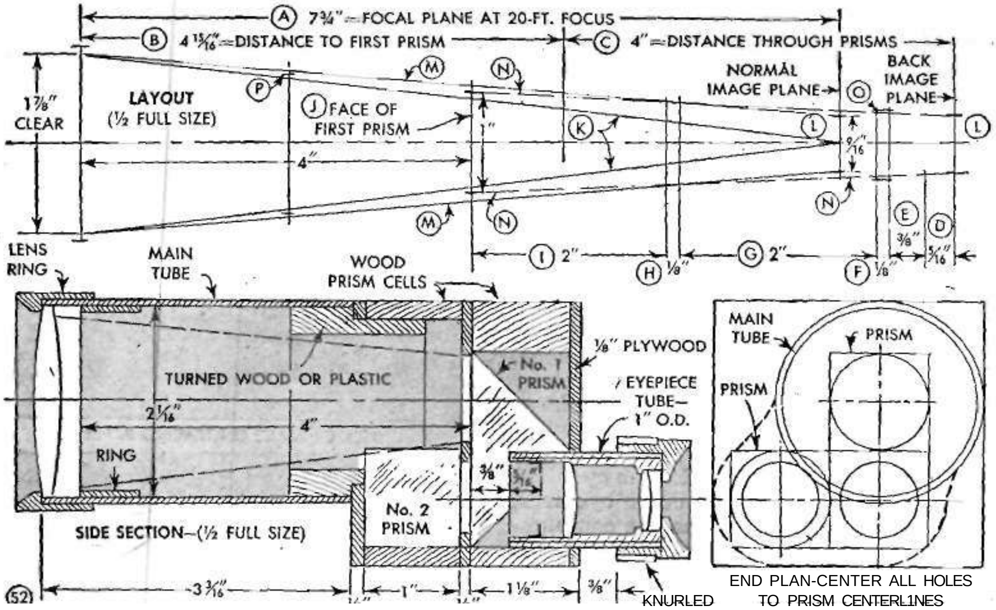


LOCATE IMAGE PLANE WITH PRISMS



MAKE LAYOUT AND MANIPULATE PRISMS TO 5&T

the normal image plane and again at the back image plane, as indicated by L, Fig. 52. Draw lines K and M representing the marginal rays and the full cone of light. Your prisms must catch the marginal rays K and also as much of the weaker edge rays as possible. The best way to determine prism-placement is to make -two 1 by 2-in. oblongs of cardboard or celluloid. Manipulate these over your layout as in Fig. 51. The forward edge of the first oblong represents the face of the first prism. You can tell at a glance how far forward you can push it and still pick up the marginal rays.



(52)

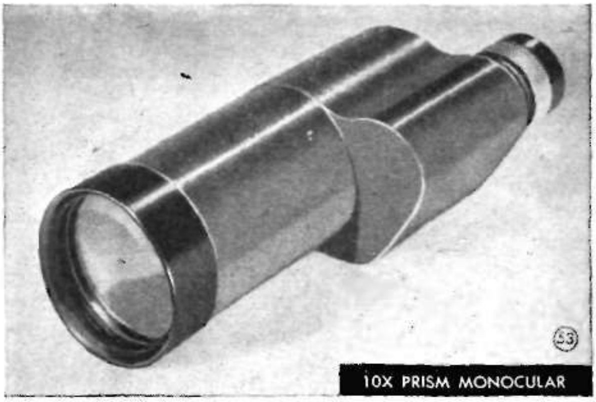
OBJECTIVE: 52X193 MM.	M = 193 ÷ 20 = 10X
PRISMS: 1"	EP = 3/16" STRONG = 5 MM.
FIELD LENS: 21X32 MM.	EYE RELIEF: 7/16"
EYE LENS: 16X25 MM.	LUMINOSITY: 92%
COMBINED FOCUS OF EYEPIECE $= \frac{25 \times 32}{25+32-16} = 20$ MM.	FIELD (From Fig. 24): 70 YDS.
	FIELD (Actual): 62 YDS.
	WEIGHT: 1 LB.

The distance between the two oblongs is the spacing between the prisms. The distance between the back edge of the second oblong and the back image plane must be sufficient to permit focusing. What you finally arrive at in this case is D, %<s-in. allowance for the distance the image plane will set inside the eyepiece tube; E, % in. for focusing travel; F, %-in. prism spacing; G, 2 in.', the distance through the second prism; H, %-in. prism spacing again, coming back; I, 2 in. for the first prism, arriving at J,-the face of the first prism. This may sound compUcated, but it is really very simple if you are actually on the job. If desired, you can now draw an outline of the prisms like Fig. 48. This shows both prisms flat, the same way you test them in the bench setup.

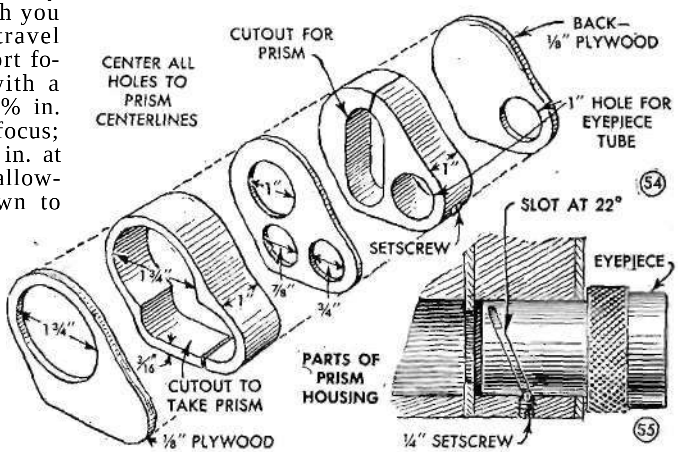
At this point J, it will be noted that the face of the prism catches all of the marginal rays and about halfway out to the lines representing the full cone of light. As mentioned before, it is practical to sacrifice some or all of the weak edge rays, so that this placement of the first prism face is quite satisfactory. What next? Well, you know that the maximum cone of light you can catch on the first prism is 1 in. in diameter at J, so lines drawn from here to image size at the back image plane will establish guide lines for hole diameters needed to pass this same cone of light back to the image plane. These lines are marked N in the drawing, and O, for example, shows the diameter of the hole at the back face of the second prism. If you want to use one or more glare stops ahead of the prisms, the hole diameters are determined in the same way, as at **P.**

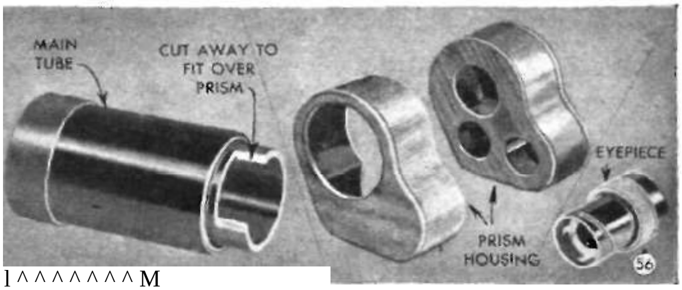
' **Monocular construction:** You will need two wood blocks exactly 1 in. thick to house the prisms, Fig. 54. The *Vs-ia.* spacing between prisms is taken up by a spacer of %-in. plywood, and similar plywood pieces are used at the back and front of the housing. The whole thing is glued up like a triple decker sandwich, the prisms being held securely in the cutouts and between the various layers. Work carefully to prism center lines. Be sure that prisms are exactly at right angles since any rotation here will rotate your image twice as much. Prisms must be spotlessly clean and polished. The eyepiece tube is 1 in. in diameter, this size permitting it to work alongside No. 1 prism; Focusing is by means of a spiral groove cut half way across thp eyepiece tube as in Fig. 55. Fig. 56 shows the monocular partly assembled and also shows how the turning which joins the main tube to the prism housing is cut away to fit over the second prism. Fig. 53 pictures the finished job covered with a gray pebble-grain oilcloth.

General notes: Cut the main tube long when making any prism telescope. Check the final position of the objective by actually using the instrument; run the eyepiece in as far as it will go and then place the objective so that distant objects are in.focus. Then the full focusing ran^e is available for picking up nearer objects. The 23X spotting scop£ will focus down to about 40 ft.; the 10X monocular to about 30 ft. or even 20 if you want to make it that way. If you use spiral focusing, it is necessary to know in advance how much you will need for focusing. This travel will be very short with a short focus lens, but much longer with a long focus objective. Allow % in. for lenses less than 10-in. focus; % in., up to 14-in. focus; 1% in. at 18 and 1% in. at 20. These allowances will let you focus down to 30 or 40 ft. in all cases, - possibly closer. When you make a bench setup at close range, remember that this represents the maximum extension of your telescope. If you make a bench setup by focusing on a distant object (this is advisable if you are using an objective of over 20-in. focal length) the setup will represent the telescope at its shortest draw.



10X PRISM MONOCULAR





The Kellner type of eyepiece gives best results with all prismatic instruments. The objective should always be a cemented achromat. If the lens is not cemented when you get it, you can dummy test it by cementing with glycerine. Final cementing should be done with Canadian balsam; in a pinch you can use a good grade of water white (clear) lacquer. The diameter of the objective controls the luminosity of the telescope. The diameter of the objective does not control the field of view; except in the Galilean instrument, you can see just as much through,a small objective as a large one.

l^^^^^^^M