

科學圖書大庫

光學儀器叢書

(一~六全一冊)

譯者 王大庚 曹培熙

本叢書含下列各書：

1. 望遠鏡光學
2. 自製望遠鏡
3. 光學遊戲
4. 望遠照相鏡頭大全
5. 準直儀與準直
6. 紅外線及其應用

徐氏基金會出版

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江蘇工業學院圖書館

藏書章

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譯者小言

光與日常生活有着密切的關係，但是由於它來得太自然，太容易，以致於大家都不重視它並未善於利用。今科學界正大力提倡發展我國光學工業，實為促進光學大衆化之先聲。而徐氏基金會鑒於此，特精選美國愛慕德公司出版之光學通俗讀物六種譯成中文以饗讀者，使對光學儀器有所瞭解，進而造成大衆需要光學，社會需要發展光學之情勢。

光學絕不是限於講講照相機，談談望遠鏡，算算透鏡組合就夠了；諸如纖維性光學，雷射，立體照相術，光學薄膜積鍍技術等均有待發展以造福人群。故希望藉徐氏基金會所出版的這幾本書作為開始，逐漸將以上知識大衆化。

現在把這幾本書的特點概述如下：

望遠鏡光學：本書分別說明各型折射式及反射式望遠鏡之自製技術。對目鏡簡直準直儀以及 Barlow 透鏡均有說明。

自製望遠鏡：本書說明三種基本型式的反射式望遠鏡之原理及自製技術。對於反射面鏡之研磨技術更有詳盡之介紹。

光學遊戲：本書講解有關放大鏡，顯微鏡望遠鏡及幻燈機之原理。對自製技術有詳細的說明。對它們之間的關係也有說明。最後並介紹了一種最簡單的自製光譜儀。

望遠照相鏡頭大全：本書介紹四種常有的望遠照相系統——直接物鏡，無焦點，套裝負透鏡及望遠照相投影器等四種。對於喜愛獵取野生動物活動等特寫鏡頭有甚大之幫助。

準直儀與準直：我們在安裝機件時，檢查光學零件之平行垂直性質時都需要這種準直儀。這本書將會告訴你如何去自製並應用。

紅外線及其應用：本書討論一些紅外線的基本電磁性質以及普通紅外線觀測器之原理。對於自製技術有特別報導。最後還列舉以紅外線原理製成防盜防火、通訊、望遠鏡及顯微鏡等系統。

此六書承曹培熙先生分譯，並承焦鵬，吳天敏，黃緯中及蔡開俊諸先生鼎力相助，始克早日脫稿，特此申謝。文中有不當之處還望各方人士指正。

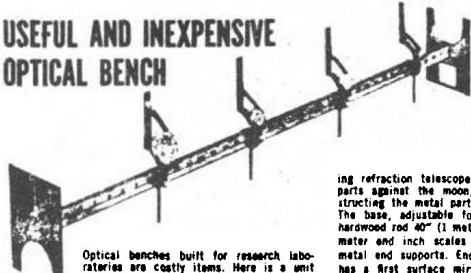
王大庚於台北

民國五十九年四月十五日

望遠鏡光學

曹培熙

USEFUL AND INEXPENSIVE OPTICAL BENCH

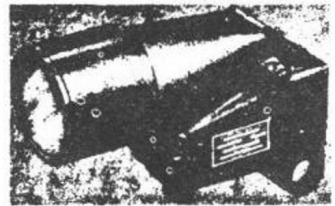


Graduated in millimeters and inches

Optical benches built for research laboratories are costly items. Here is a unit which answers the average needs of hobbyists, camera stores, industrial laboratories and other optical men. With this inexpensive optical bench you can measure the focal length of lenses, check the optical quality of a lens of a complete optical system against test-charts, check the image quality of a projection lens. By placing an objective in one of the holders, it can also be used as a collimator. Hours of work can be saved by using this optical bench for positioning the elements in an optical system. Exact measurements can then be easily made for each of the required spaces. Amateur astronomers, build-

ing refraction telescopes, use this unit to test optical parts against the moon, planets and stars before constructing the metal parts and mounts to house them in. The base, adjustable for height, consists of a sturdy, hardwood rod 40" (1 meter) long, graduated in both millimeter and inch scales which can be mounted on two metal end supports. End support is a reticle plate and has a first surface mirror attached. Four low v-shaped lens holders, which can be adjusted vertically up to 2 1/4" and horizontally are included. Each is supplied with a sliding spring clamp for holding lenses in position. Thumb nuts lock the holders in place. All you need provide to start a fascinating study of optics is the illumination. A 15 watt frosted bulb may be used. Higher wattages are desirable for projection tests. Instructions are included.

No. 80,064
Extra lens holder complete with spring clamp No. 60,069



Collimator or Parallel Light Source

- New, Excellent Condition
- F/2.3 Achromatic Lens
- Excellent for Optical Tooling Applications

THE STORY: This was made for use as a special purpose gunight (N.C). However, it is essentially a collimator or source of parallel light. Unit is 5 1/2" x 5" x 2 1/2" containing opaque metal reticle with precision 0.10" center pinhole and outer ring, 2" diam. by 53K-F.L. achromatic lens (f/2.3), small first surface mirror, silvered reflector glass plate (3 1/2" x 2 1/4" x 1/4") which if you mount over objective lens at 45° angle will project reticle image out into space. Bulb operates on 14V. Use the inexpensive transformer listed below, or convert to 210 V by using Christmas tree bulb. Wt. 2 lbs. Sturdily built, with two sets of convenient mounting lugs. Objective lens is in threaded metal cell adjustable for focus with spanner wrench.

APPLICATIONS in production and research for:

- Collimator and parallel light source.
- Telescope finder for 6" and larger scopes.
- Adjusting telescopic riflesights.
- Determining parallelism of plane surfaces.
- Setting up a form or template.
- Machine shop angular relationships.
- Determining shape or curvature.
- Making directional measurements and adjustments.
- Adjusting or re-aligning binoculars.

Directions included for making bench and vertical collimators, finder telescopes, how to use to adjust gunights, determine curves and template set-ups, align binoculars.

No. 70,774
Similar to Above, but with Movable Reticle. Gunight NSB. More adaptable for applications such as telescope finders, etc. No. 70,806
AUTOTRANSFORMER to operate either light source on 110 volts. Output 21-V, 60-0-21 V AC at 7 amp
No. 60,582
28-V Bulb for above (either). No. 81

TELESCOPING CARDBOARD TUBES

Sturdy Kraft with blackened inside. Each nests into next one. Wall thicknesses 1/4" to 1/8". I.D.'s: 1/2", 3/4", 3/8", 1", 1 1/4", 1 1/2", 1 3/4", 2", 2 1/4", 2 3/4", 3". Twelve 3-1/2" pieces. No. 60,042
Twelve 18" pieces. No. 60,201
Twelve 2' pieces. No. 60,202

TELESCOPE TUBING ALL SIZES

Aluminum, Spiral paper, Phenolic

No.	I. D.	O. D.	Length	Description	Wt. Lbs.
80,026	3/4"	3/4"	32"	Spiral paper	1 1/2
80,038	4 1/8"	5 1/8"	46"	Spiral paper	6
80,081	1 7/8"	2"	48"	Aluminum	3
85,008	6 7/8"	7 3/8"	60"	Spiral paper	10
85,011	2 3/4"	3"	48"	Aluminum	5
85,012	3 3/8"	4"	60"	Aluminum	6
85,013	4 1/4"	5"	48"	Aluminum	5
85,014	6 7/8"	7"	60"	Aluminum	22
85,139	5"	5 3/4"	72"	Spiral paper	22
85,146	5 1/4"	5 3/4"	63"	Phenolic	10

WIDE ANGLE EYEPIECES

For good clear image quality you'll find these fine quality eye pieces hard to beat. And they're all terrific buys at these prices. Big, wide fields give you a tremendous view. Adapters available for using such with standard 1 1/4"-0. D. eyepiece holders.

20MM-F. L. KELLNER IN STANDARD 1 1/4" MOUNT.
This large field (50°) eyepiece with slightly over 1" focal length is best for normal telescope viewing. Big field lens and long eye relief make it very easy to find image. Same two achromatically corrected lenses used in quality military telescopes—put into new metal cell and extension of black anodized aluminum for 1 1/4"-diam. holders. Field lens 29.5mm in diam., eye lens 28mm.

No. 5223

20MM-F. L. ERFLE

- Excellent spherical and chromatic correction
- Very wide, flat field
- Excellent eye relief
- Coated lenses

An eyepiece you'll use more than any you own. Extremely wide 65° field of view and excellent correction of all aberrations.

This precision made, imported Erfle will give you good power for use with refractors, reflectors, rich field telescopes, finder scopes, spotting scopes, etc. Standard 1 1/4" outside diameter. Coated lenses, excellent eye relief. Diameter of eye lens 22mm, field lens 26mm. Streamlined, modern design with handsome chrome and black finish.

20mm. f.l. 95

20mm. f.l. 95

EYEPIECE MOUNTS

1 1/4" RACK AND PINION

A real rack and pinion focusing mount at an amazingly low price. Takes standard 1 1/4" eyepieces. Micrometer-smooth focusing action, travel 2 1/4". Two focusing knobs, variable tension. Four mounting holes for greater rigidity, nuts and bolts included. Black wrinkle finish cast aluminum Chrome tube. Diagonal holder not incl.

No. 50,077



EYEPIECE MOUNTS

REVOLVING TURRET MOUNT

No need to fumble in the dark for stray eyepieces. With this accessory you can "dial in" up to three different powers just by revolving the turret. Turret is equipped with an indant which positively and correctly positions each of the three eyepieces in the field of view. It carries three eyepieces, standard 1 1/4" outside diameter, and will attach to refractor telescope having an eyepiece tube measuring 1 1/4" inside diameter. Made of aluminum and brass with chrome plated eyepiece tubes. Clear aperture 1 1/4".

No. 50,355

EYEPIECE MOUNT

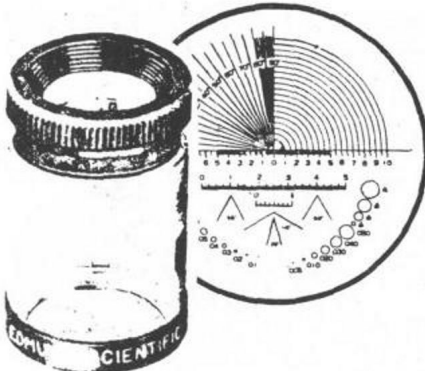
Smooth, trouble-free focusing will help you get professional performance. This mount has smooth rack and pinion focusing with variable tension adjustment. Tube accommodates standard 1 1/4" eyepieces and necessary equipment. Lightweight, aluminum body casting adds a minimum of extra weight to your telescope. Focusing tube and rack of chrome-plated brass, body finished in black wrinkle paint. Generous focus travel of 4 1/4" for viewing close or distant objects with any objective. Clear aperture 1 1/4".

No. 50,103 For Tubes 2 3/8" I.D.
No. 50,108 For Tubes 3 1/4" I.D.

20mm. f.l. 95 Kellner 38mm f.l. Erfle Revolving Turret Eyepiece Mount

Edmund Scientific Co., Barrington, New Jersey 08007

6X EDSCORP POCKET COMPARATOR



- 3 element, cemented triplet.
- Unusually flat field.
- Large choice of reticles.
- Focusing adjustment with lock.
- Leather pocket case.

The Edscorp Pocket Comparator has found hundreds of uses and applications in industry, in the laboratory and at the workbench instantly ready for use. It requires no time-consuming adjustments. Ideal for checking small parts, small linear measurements, angles, hole diameters, thread sizes, etc. Special reticles are listed for geological, sand measuring, metrology, aerial photography and graphic arts work.

The 6X, with triplet lens, lower priced comparators usually have only one lens provides a flat field over entire reticle area - assuring accurate measurements. Light is admitted through the clear plastic reticle (on dark glass use our No. 50076 Illuminator listed below). Pocket size, 2" high x 1 1/4" diam., handy for on-the-job applications and easily portable to any location.

Comparator Magnifier with case (reticle not included).

No. 30,325

Above Comparator Magnifier, complete with Reticle (No. 30,585) leather case. No. 41,055

QUALITY REFRACTOR OBJECTIVES

YOU'LL BE PLEASED WITH THESE LENSES

ACHROMATIC OBJECTIVES

Because the objective lens is the heart of every refractor a good one is essential. These imported achromats are air spaced to give the lens system four surfaces (all have low reflection coatings) on which aberrations can be corrected. They produce clear, sharp color free images (to the C & F lines) and are also free from coma and spherical aberrations. Ideal for visual use, they are also excellent for photographic work provided a yellow filter is added. Each lens is mounted in a black metal cell with threaded retaining rings. Cells will fit our standard aluminum tubing.



Diameter	F. L.	No.	O. D.	I. D.
3"	45"	50,162	3 1/4"	3"
4"	60"	70,120	4 1/4"	4"
5"	71"	70,164	5"	5"

* Mounted in cell with 3 1/2" O.D., 4 1/2" Range. With adapter for mounting in 6 3/4" F.D. tubing.

UNMOUNTED, AIR-SPACED, ACHROMATIC OBJECTIVES

Diameter	Air-Spacing	Stock No.
3"	45"	30,130
4"	60"	50,107
5"	71"	70,163
6"	80"	70,283

LOW-COST, LONG F. L. ACHROMATIC LENS

Build a low-cost refracting telescope. The long 50" focal length of this lens will give you 100 power using a 1/2" focal length eyepiece. This 100X can even be increased by two to three times with the addition of one of our by two to three times with the addition of one of our color-corrected, Barlow lenses. This is a 2" diameter low-reflection coated, airspaced type achromat. Plans for several telescopes you can make using this objective are in our new booklet "Telescopes You Can Build". You can't buy a lens of this quality and focal length for twice our price.

No. 30,187

MOUNTED, WAR SURPLUS ACHROMAT

Mounted in brass cell with retaining ring. Clear aperture 30mm., F. L. 170mm. Used with eyepiece No. 30,194 and mounted porro prism No. 50,197 (this quality achromatic lens makes excellent 7X terrestrial scope).

No. 40,429

LOW-COST ACHROMATIC OBJECTIVES

To solve the problem of good quality low-cost objectives for a beginner's telescope, we have had these achromatic lenses designed and mass produced. They are excellent! Diameter 30mm (1 1/4"), F. L. 31". You get 62X with 1/2" 124X with 1/4" eyepiece.

No. 30,201

Diameter 42mm (1 3/4"), focal length 41". You get 61X with 1" eyepiece; 82X with 1/2" and 164X with 1/4" Airspaced. No. 30,202

7X50 BINOCULAR ERECTING PRISM CLUSTERS



Complete prism assembly ready to mount on your telescope, microscope and other optical systems to give you an erect image. Consists of 2 porro prisms fastened to a prism shelf. Clear aperture is 1". Made for 7 x 50 gov't binoculars and sold at far below the original cost. Approx. Gov't. cost \$20.00

Right Side No. 50,187

Left Side No. 50,188

BINOCULAR REPLACEMENT PRISMS ONLY

Binocular Prism Sizes, mm. Coated No.

7 x 50	8-51.5, C.35, A.25	Yes	5114
6 x 30	8-43, C.26, A.21	Yes <th>5211</th>	5211

AMICI ROOF PRISMS



These are Amici Prisms, also called "roof prisms" and "right angle prisms with roof". They do two things: erect the image and bend the line of sight through a 90° angle. Excellent as in refractor astronomical telescopes as they erect the image permitting use of the telescope for terrestrial viewing in spotting scopes they make viewing possible by merely turning head to one side. Use whenever desirable to take the upside down image from the objective. Turn it right side up and bend it through a 90° angle and still have left and right correct.

Stock No.	B	C	A	Comments
3088	13	11	10	Corrected roof 120° angle
3106	16	15	14	Corrected roof.
3172	34	20	18	
3038	34	20	18	Corrected roof.
3003	41	21	22	Corrected roof.
3002	41	21	22	
3225	48	33	36	Corrected roof 80° angle instead of 90°

ELLIPTICAL MIRROR DIAGONALS

1/4 wave for 8" telescopes. These are ground and polished to 1/4 wave length, aluminized and overcoated. Just the right size for an f/8, 6" diameter telescope using normal focal length eyepieces. Size: major axis 1 1/4", minor axis 1/2". Thickness 1/4".



No. 30,188

1/2 wave for 6" telescopes. Same size as 1/4 wave mirror above, but ground and polished to 1/2 wave length, aluminized and overcoated.

No. 30,205

LARGE SIZE TO 1/2 WAVE LENGTH. Size needed when eyepieces with 1 1/4" F. L. or longer are used. For use with an f/8, 6" diameter mirror. 6" diameter mirrors with normal focal length eyepieces. Size: 1 1/4" minor axis, 2 1/4" major axis. Thickness 1/4".

OTHER SIZES TO 1/4 WAVE OR BETTER

No. 30,250 (1 1/4" x 1 1/4" x 1/4" thick for 3" scope)
No. 30,200 (1 1/4" x 1 1/4" x 1/4" thick for 4 1/4" scope)
No. 30,251 (1 1/4" x 2 1/4" x 1/4" thick for 8" scope)

COLOR-CORRECTED, TWO ELEMENT, MOUNTED BARLOW

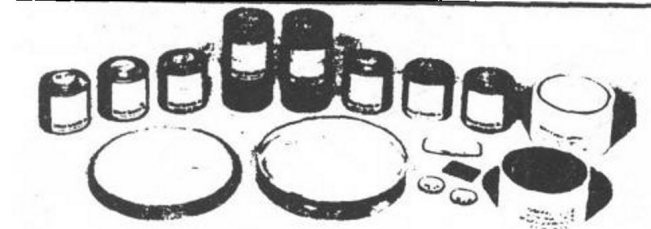


Don't fail to try this. You have no idea, until you have done so, how much more you will enjoy using your telescope with our color corrected, two element mounted Barlow. Position of Barlow lens element can be changed in mount to vary power. It doubles or triples the power and provides increased eye relief-focal length is 46.0mm. Brass mount, glass blank outside, dull black inside, slides into 1 1/4" inside diam. draw tube. It also accepts 1 1/4" standard eyepieces.

No. 40,477

Lens only from above, ready for mounting.

No. 30,448



Complete Mirror Grinding and Polishing Kits ... Include Blank, Tool and Abrasives

Our kits make mirror grinding easy! Each kit contains a Pyrex mirror blank in the size listed, and plate glass tool used to grind the mirror; 2 lenses which only require mounting to give you an excellent 1" F. L. eyepiece; a fine quality finished and aluminized, flat surface mirror diagonal; a magnifying lens for inspection. We also supply 8 assorted abrasives from coarse to fine in shocker tin containers, and tumbled Burgundy pitch. We do not supply instructions, because successful results require detailed directions which can be found

only in books on the subject. See below. Mirror blanks in these kits are new and are fine quality Pyrex. No. 7740.

Stock No.	Dia. Mirror	Thick.	Shag. Wt.
70,083	4 1/4"	3/4"	
70,084	6"	1"	
70,085	8"	1 1/4"	
70,086	10"	1 3/4"	30 lbs.
70,087	12 1/4"	2 1/4"	46 lbs.

See latest Edmund Catalog for Current Prices

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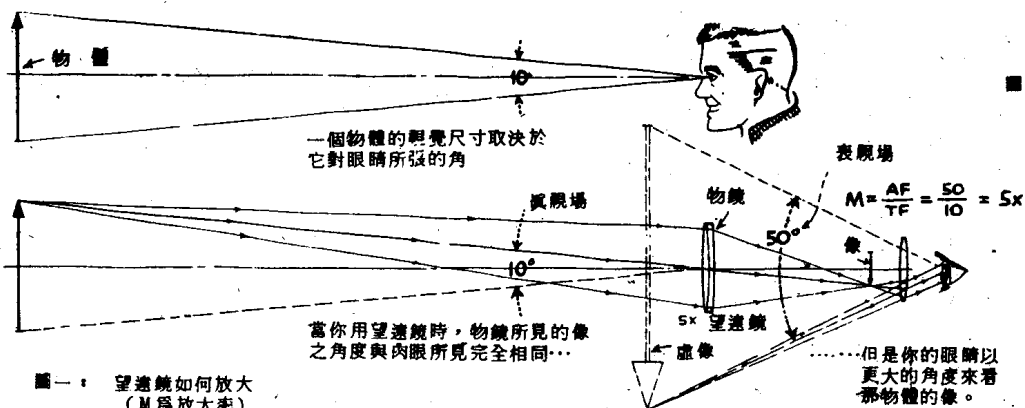
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1. 望遠鏡光學

光學是一門龐大的學科。大多數初學者都避開透鏡設計的工作，因為他們很清楚這工作要用到繁而且多的數學。比較簡單的着手法是把已經做好的透鏡、稜鏡和反射面鏡買來，然後才進行設計。這樣子可以使其中的數學工作簡化為簡單的透鏡方程式之處理。假如你使用品質好的市售光學器材，你可以確信能得到良好的成像。設計望遠鏡的問題，就只是使光通過那儀器，而在某一位置生成某種尺寸的像。

天文望遠鏡是個窄場儀器，它的視場是一度或一度以下。因此，物鏡幾乎不會有軸外像差——彗形像差、像場彎曲、像散現象和畸變。兩種軸像差是色像差和球面像差。或許你已經知道，反射光不會有色像差。簡單地說，假如



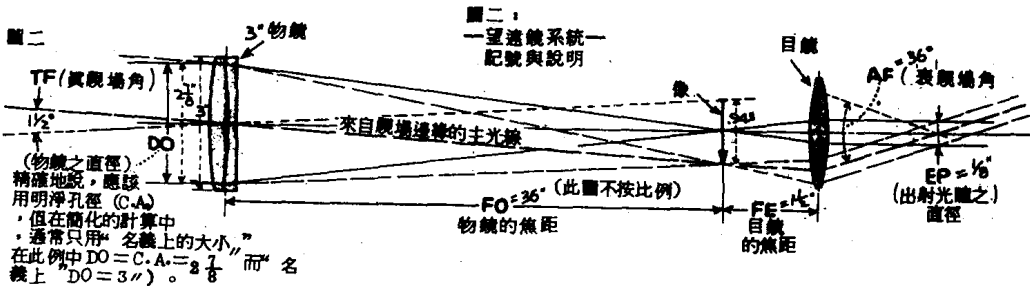
圖一：望遠鏡如何放大 (M 為放大率)

<p>彗形像差</p> <p>彗形像差是一種斜向球面像差。它只發生於軸外情況下，在那兒由於不對稱的變形而產生彗星形狀的像。</p>	<p>像散現象</p> <p>這種缺點使一個像點成爲一條短線；在最佳焦點兩側，這短線由水平變成垂直。</p>	<p>像場彎曲</p> <p>透鏡的自然傾向是在一個彎向透鏡的曲面上形成一個清晰的像。</p>
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2 望遠鏡光學

你的興趣在於反射式望遠鏡，關於像的性質的問題就只有球面像差。即使你自己做反射面鏡，做成一個反射面並修正它的工作，也是一般人能力之內的事。

像在那裡呢？即使在做簡單的觀測時，有時候你也會有這樣的疑問。望遠鏡的各種光學圖都假定：最後的像是成於無窮遠處的虛像。事實上，大多數人都把焦點放在比需要的值稍近眼睛處，使得出射光線稍為發散，而如所需得以在 20 至 40 吋處成一虛像，如下圖所示。不管怎樣，在放大率方面是沒有差別的，放大率嚴格說來是與所張角度有關的，而所張的角則在任何距離處都相同。



2. 望遠鏡算學

就任何望遠鏡來說，最先要知道的事項之一是它的放大率。這是很容易用表中第一個方程式算得的，那方程式對初學者而言也是很熟的。

涉及視場角的諸方程式——3, 8, 9, ——可用於視場的一部分，也可用於全體。例如，若一組雙星相距6秒之弧（其真視場角），而你想看見它成為6分弧之表視場角，就用

表一：計算放大率的三種方法

1	$M = \frac{FO}{FE}$	例 $\frac{36}{1.5} = 24 \times$
2	$M = \frac{DO}{EP}$	$\frac{3}{1/8} = 3 \times \frac{8}{1} = 24 \times$
3	$M = \frac{AF}{TF}$	$\frac{36}{1.5} = 24 \times$
其他的計算中須已知 M		
4	$FO = M \times FE$	$24 \times 1 \frac{1}{2} = 36"$
5	$FE = \frac{FO}{M}$	$\frac{36}{24} = \frac{3}{2} = 1 \frac{1}{2}"$
6	$DO = M \times EP$	$24 \times \frac{1}{8} = 3"$
7	$EP = \frac{DO}{M}$	$\frac{3}{24} = \frac{1}{8}"$
8	$TF = \frac{AF}{M}$	$\frac{36}{24} = \frac{3}{2} = 1 \frac{1}{2}^\circ$
9	$AF = M \times TF$	$24 \times 1 \frac{1}{2} = 36^\circ$

表二：像的半徑與表視場的計算，以度為單位

10	像 (之直徑) = $\frac{AF}{FE} \times FE$	例 (同表之一例) $AF = 36^\circ$ $36^\circ = .628$ 徑 (由表三) 像 = $.628 \times 1.5 = .94"$
11	$\frac{AF}{FE} = \frac{\text{像}}{FE}$	$\frac{AF}{FE} = \frac{.94}{1.5} = .63$.63 徑 = 36° (由表三)

* 徑又稱弧度，為角之量度單位之一。一徑所含圓弧的長度等於該圓半徑。
1 徑 = 57.3

f / 值 ... 焦距與孔徑的比值

12	$f / \text{值} = \frac{FO}{DO}$	13	$DO = \frac{FO}{f / \text{VALUE}}$	14	$FO = f / \times DO$
與上述同例： $f / = \frac{36}{3} = f / 12$ $DO = \frac{36}{12} = 3"$ $FO = 12 \times 3 = 36"$					

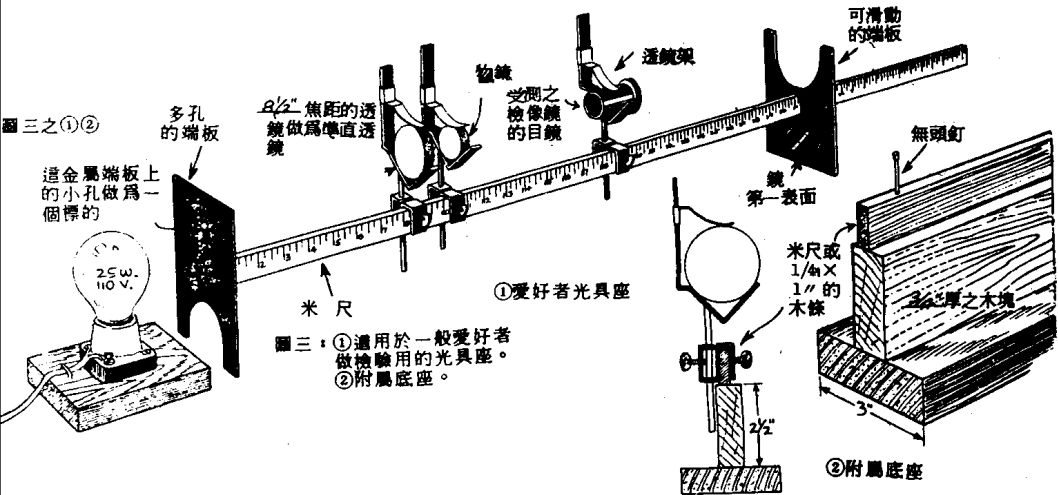
表三：由度換算成徑的對照表

度	徑	度	徑	度	徑
5°	.087 ^R	25°	.436 ^R	41°	.716 ^R
10	.175	26	.454	42	.733
11	.192	27	.471	43	.751
12	.209	28	.489	44	.768
13	.227	29	.506	45	.785
14	.244	30	.524	46	.803
15	.262	31	.541	47	.820
16	.279	32	.559	48	.838
17	.297	33	.576	49	.855
18	.314	34	.593	50	.873
19	.332	35	.611	51	.890
20	.349	36	.628	52	.908
21	.367	37	.646	53	.925
22	.384	38	.663	54	.942
23	.401	39	.681	55	.960
24	.419	40	.698	56	.977
				57	.995 ^R
				58	1.012
				59	1.030
				60	1.047
				61	1.065
				62	1.082
				63	1.100
				64	1.117
				65	1.135
				66	1.152
				67	1.169
				68	1.187
				69	1.204
				70	1.222
				71	1.239
				72	1.257

4 望遠鏡光學

第3個方程式（先把6分化成360秒）。於是由方程式3得到M等於 $360/6$ ，也就是60倍（記號為 $60\times$ ）。當然，你接着得求出目鏡的焦距多少時能得到 $60\times$ ，也就是說，在M和FO都知道時求出FE的值。解法由方程式5表示。

知道表視場角之後，就容易算出像的直徑。方程式10和11則告訴我們：知道像的大小時，表視場的求法。任何常用焦距下，像之線性視場直徑可以直接由討論目鏡的那一章（第8章）中之像表得出。

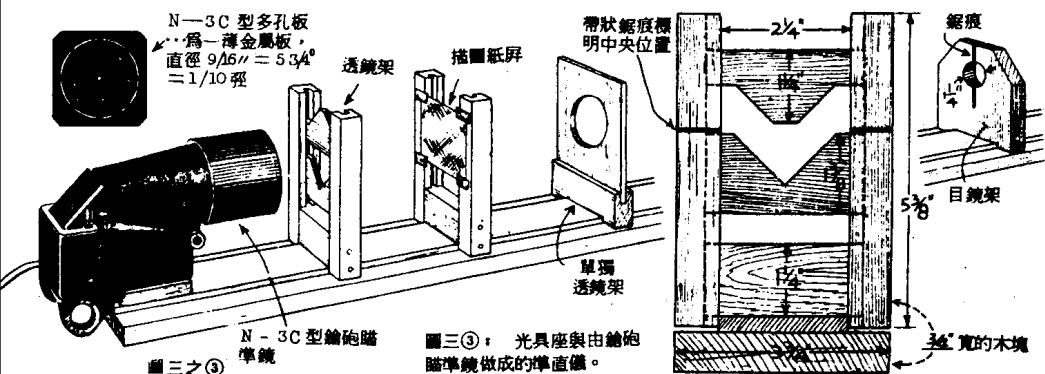


圖三：①適用於一般愛好者做檢驗用的光具座。
②附屬底座。

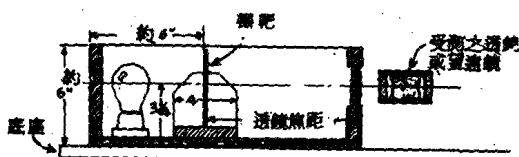
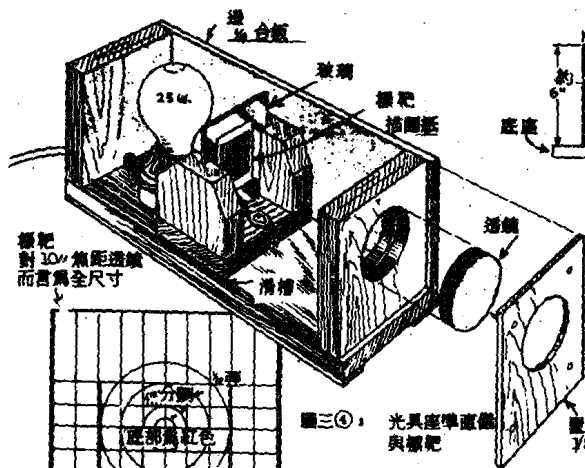
3. 光具座和準直線

光具座是一種可能值五塊錢（美元），也可能要花五千元的設備。你可以買到它，也可以自己造一個。圖三①是你能夠買到的一種適於一般愛好者檢驗用的光具座，它不貴。這光具座裝在一支木製的米尺上。假如你需要更牢穩或更長的底座，可以用圖三②所示的構造。

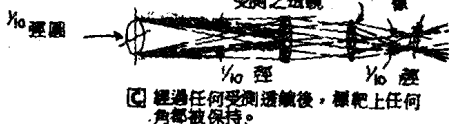
準直儀的構造是：把某種受到照明的多孔板或標的放在一個消色差透鏡的焦平面上。這樣的安排和一個放在遠處的標的是相當的。當要用到準直儀的時候，可以就在光具座上把它架設起來。在上面圖中所示的裝置裡，端板上鑽了一些小洞，這些洞排在一條鉛直線上。這就是你的“標的”。準直儀的透鏡可以用焦距為五吋或更長的質地好的消色差透鏡。它與多孔板的距離正好是一個焦距長，我們可以用“自準直”（見第四章）的方法校驗透鏡的



8 望遠鏡光學



尺寸取決於透鏡焦距



圖三④：光具座準直儀與標靶

準直儀標靶角值與 1/10 徑圓

你想找出	公式	例：焦距20的準直儀透鏡
1/10徑圓之直徑	1徑圓直徑 = $F \times J$	$20 \times J = 2.0"$
等於 1° 之距離	1° 交格 = $F \times 0.0175$	$20 \times 0.0175 = .35"$
望遠鏡之真視場	數度數交格 例：約 41 徑圓之 $F =$ 之直徑	例：焦距為 2 你不知道焦距像之直徑 200 $F = \frac{200}{2} = 2.0"$
受測透鏡之焦距另法，用於焦距大於 5 者	$F = \frac{1^\circ \text{交格之像}}{.017}$	例：焦距 20 之透鏡 (標靶角為 1.50°) $F = \frac{.35}{.017} = 20"$

位置是否正確。在圖三①所示的裝置中，有一個小型覓景鏡在受檢驗，光具座做為架持透鏡的工具，準直儀相當於遠處標的。

圖三③畫的是一種簡單的自製光具座。其中可調整的透鏡架可以架持

直徑大到 $2\frac{1}{8}$ 吋的透鏡，更大的透鏡則可夾入單獨透鏡架。把透鏡夾在有刻槽的架上的那 V 形木塊應該用硬木三夾板做成。準直儀是一種軍用瞄準鏡，只要把它簡單地改成用 110 伏特照明，詳細情形請看成貨的說明書。

光具座與準直儀明顯的缺點是：整個設備的物理尺寸應該接近你打算試驗的最大的望遠鏡之物理尺寸。小型裝置在處理來福槍瞄準鏡、覓景鏡與小型地上或天文望遠鏡時，很稱職。要適於試驗一個六吋反射式望遠鏡的裝置，則有點過份奢費了。不過，你是可以用小型準直儀進行許多種試驗和操作的。

現在我們看看自己如何造個準直儀。你可以把一座準直儀裝入一個盒子裡或一個管子裡。圖三之④陳示一種典型的裝盒工作。準直儀所用的透鏡應當採取具有適當尺寸和焦距之質地良好的消色差透鏡——直徑三吋焦距 24

吋是個好尺寸，適用於孔徑大到 6 吋的望遠鏡之試驗。比這樣小得多的裝置，就某些操作而言已經非常令人滿意了。準直儀標靶是用墨水畫在描圖紙上的。標靶是用膠帶或膠貼在一塊玻璃上的，就如圖中所示。圖中並有些簡單的規則，用以求標靶尺度而適合具有各種焦距之準直儀透鏡。

自遠方物體來的光線，以平行光束形式到達你的眼睛。同樣地，自準直儀射出的光線也成平行光束。也就是說，標靶中心的一個點會像圖三之④的 A 一樣地發出光柱；而在標靶邊緣的點則將如 B 所示，以某特定角度發出光柱。所有的光都各成平行束，但整個光錐則是擴展而發散的。換句話說，“平行光”與“平行光柱”並不表示完全相同的事項。

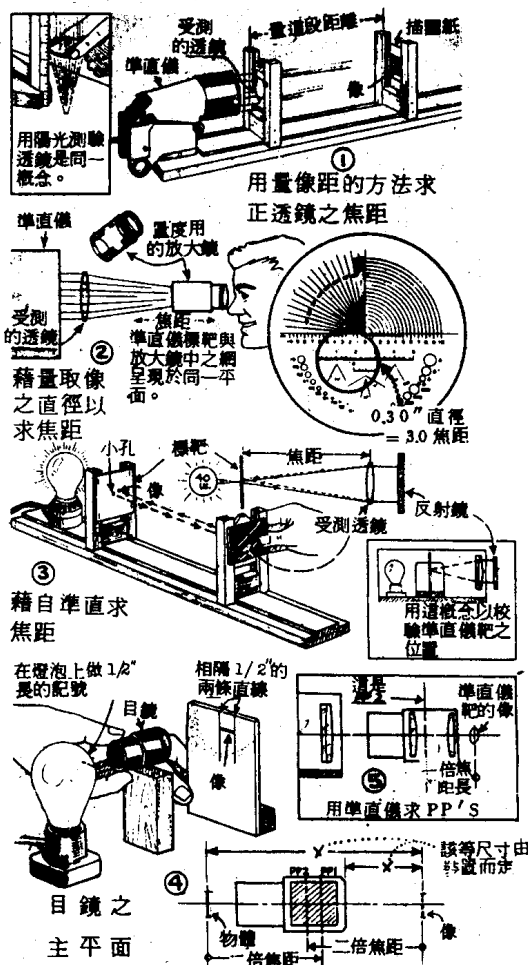
標靶與準直儀透鏡所成的任何角度，將被準直儀前的任何透鏡或望遠鏡予以實在地重現。圖三④C 就展示 $1/10$ 徑圓所呈現的情形。這個特定的單元是用來測定焦距的。任何透鏡、目鏡或望遠鏡所生成 $1/10$ 徑圓之像，將為所述透鏡、目鏡或望遠鏡焦距的十分之一。換句話說，假如你量度任何透鏡所成之像的直徑，你就能立刻知道它的焦距，它就是像之直徑的十倍。對於焦距在 5 吋以下的透鏡來說，一具袖珍比長儀（量度用的放大鏡）很適於量取像的直徑。

4. 光具座操作程序

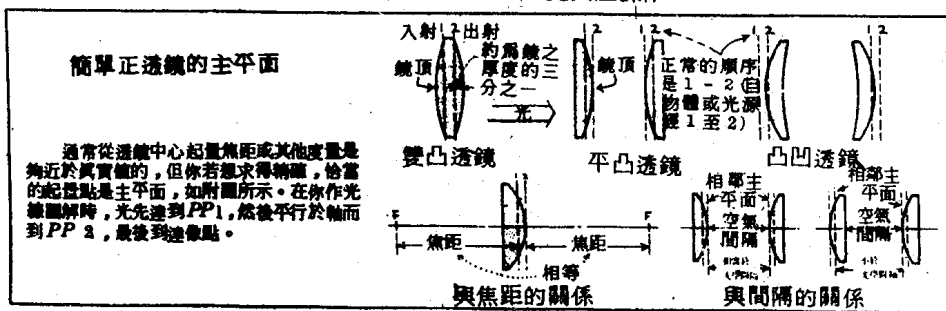
一 求透鏡焦距：當你用望遠鏡或照相機對遠處物體調焦點時，像成於透鏡後一倍焦距處。所以，假如你有一個未知焦距的透鏡，你只要對一遠方物體調焦點，然後量透鏡至像的距離，就求出焦距。在室內，這程序是用任一光具座準直儀做的，如圖四①所示。

二 望遠鏡之視場：若你的準直儀標靶附有度數標示，任何望遠鏡或雙筒鏡的視場可以直接由靶上看出——你只要數你看到的度數。這就是真視場。表視場為TF 乘上M。

三 由像之大小求焦距：這方法特別適合處理目鏡，及兩個或兩個以上透鏡之其他組合。你需要用到一個多孔的1/10 吋標靶，如圖三③所展示的那樣。先



圖四：光具座操作



用一般方式將待測的透鏡或目鏡架好，然後用一精細刻度尺或直讀放大鏡量取它所成的像，這就是圖四②所示。焦距即為像之直徑的10倍。

四 自準直：做“自準直”用時，標靶換成不透明的材料，上面開一個小孔。標靶也做屏幕用，所以它背光的一面應該是白色的。在受測透鏡後面，放上一個普通的平面鏡，照着圖四③所示，當光線適當地聚焦後，靶上小孔會在靶本身處成像。由靶至透鏡的距離即為焦距。

五 主平面：它安排如圖四④的裝置。操作的原則是往返移動目鏡與屏，直到屏上的像確已聚焦清晰，並且正好與靶一樣長； $1/2$ 吋。這時為1倍放大間隔（ $1 \times \text{spacing}$ ），指示出兩個主平面（PP）分別距物與像為二倍焦距。

另外有個方法，用圖四⑤的裝置可以用準直儀找出PP2的位置。把目鏡調反方向，則可得PP1的位置，但通常會達不到像。假如目鏡是對稱的，你所需要的就僅僅是PP2。

5. 由光具座裝置描繪光線

在設計望遠鏡的時候，第一步是要選取適當的透鏡做為目鏡及物鏡。其次，你得做些紙上的分析工作，以得到基本數據。第三步是以某種方式試驗你的設計，假如望遠鏡不太大，通常可用光具座和準直儀靶做這工作。光學設計的最終成品是某種計劃圖，顯示光線如何通過該系統。光徑圖解加上用光具座所做實際的“看與找”的試驗，可以就望遠鏡的合格性，給你充分的保證。

一 紙上工作：第五圖上有一個小型折射望遠鏡。像那樣大小，具有該等放大率的儀器，常被用為較大的望遠鏡之覓景鏡。利用第2章（望遠鏡算術）各表所列的公式可以得到諸項預備數據；第8章（目鏡）則有關於視場角和像之線性直徑的資料。初步的紙上工作呈現在一個過份大的出射光瞳上，該光瞳直徑為 $1/2$ 吋。即使在暗處，你的眼睛瞳孔的直徑也不會大於 $5/16$ 吋。簡單地說，這設計浪費不少的光。所以，假如你正實際裝設這望遠鏡，你可以用具有同樣焦距而直徑為 $1\frac{1}{4}$ 吋的目鏡代替它。這樣可以在保有出射光瞳之最大可用直徑下，一直維持較佳的光學操作。

二 座上試驗：光具座上的第一步操作是將物鏡裝妥並找出像平面的所在，如圖五②所示。你可以用普通的室內光線來工作。在這階段裡，像不受任何方式的限制，它可以散佈在一相當大的區域上。接着，把目鏡架在像的後面，並來回移動，直到你看見像已明顯地焦聚，如圖五③。換句話說，就是你要對望遠鏡調焦——使目鏡的焦平面與物鏡的焦平面重合。在這狀況下，出射光成為平行光束。圖五④為座上試驗的末項；安置出射光瞳。

