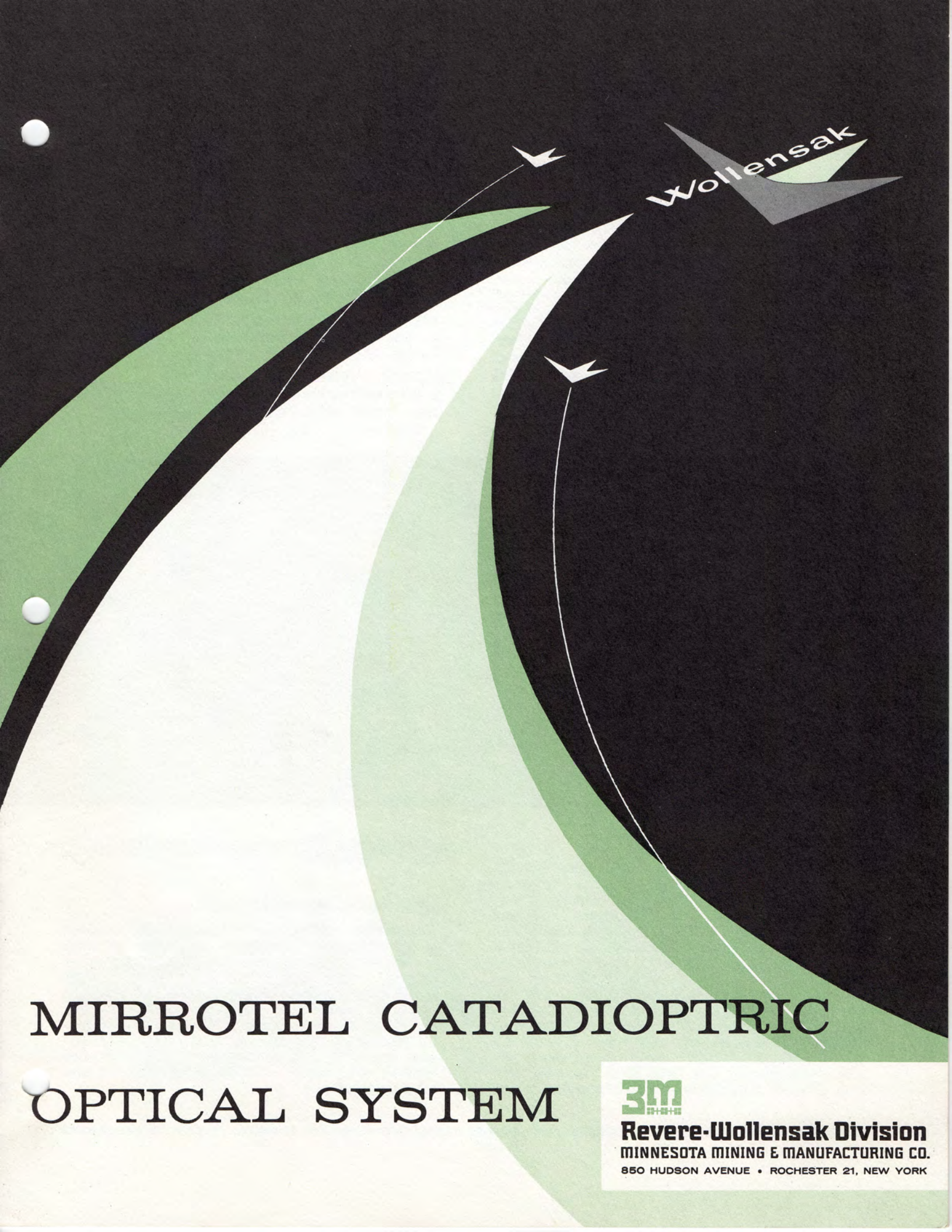




Wollensak

MIRROTEL CATADIOPTIC OPTICAL SYSTEM



Revere-Wollensak Division
MINNESOTA MINING & MANUFACTURING CO.
850 HUDSON AVENUE • ROCHESTER 21, NEW YORK

WOLLENSAK MIRROTELS

Reflective Optical Systems utilizing aspheric mirrors and, in certain restricted systems, spherical mirrors have long been known. The spherical mirror alone has objectionable spherical aberration, though this aberration is eight times smaller than that of a single refracting lens of equal aperture and focal length. (This is true even when the refracting lens has the most favorable bending for minimum spherical aberration.) Since high resolution and highest-quality performance are essential, spherical aberration is not tolerable. Therefore, in the past, mirrors were parabolized by hand correction (a highly skilled, time-consuming process involving elaborate and painstaking testing methods). In addition to the primary paraboloidal mirror, a hyperboloidal or ellipsoidal secondary mirror was necessary to assure spherical aberration

correction while relaying the image out of the system for observation or recording on film. Hand-correcting the secondary mirror was also a tedious and highly skilled art.

However, the advantages of optical mirror systems were considered so desirable that other ways to achieve an aberration-free system were studied and devised through the years. The Newtonian system, one of the simplest, was followed by the improved Cassegrain system and the improved but more complex Gregorian system. In 1930, Schmidt corrected the spherical aberration of the spherical mirror with one aspheric corrector plate. Within recent years the ultimate goal to produce a catadioptric telephoto objective, perfectly corrected, at a more reasonable cost, has been achieved with the introduction of Wollensak Mirrotels.

OPTIONAL FEATURES OF THE MIRROTEL

Mirrotels can be supplied as a basic fixed focus design or with combinations of the following features:

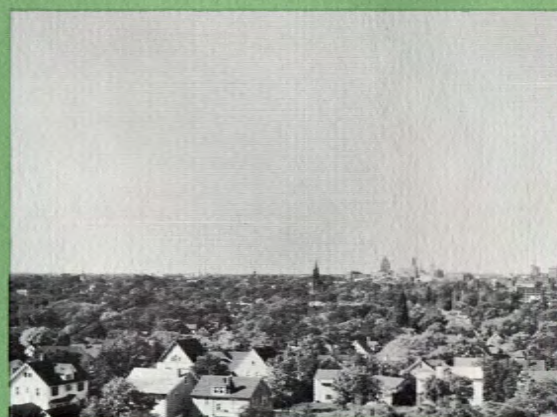
1. Single Filter Turret
2. Double Filter Turret
3. Focusing
4. Reticle Printer
5. Fiducial Marker
6. Reflex Finder
7. Automatic Sun Shutter
8. Sun Radiation Shield
9. Beamsplitter output, coupling both film and TV cameras to same lens.
10. Beamsplitter output to couple shorter focal length lenses to same camera system.
11. Automatic diversion shutters

12. Plain lens-camera base.
13. Elevation-azimuth fine adjustment lens-camera base
14. Various camera adapters
15. Special correctors of infra-red or ultra-violet transmitting materials
16. Eyepiece and erecting prism conversion units

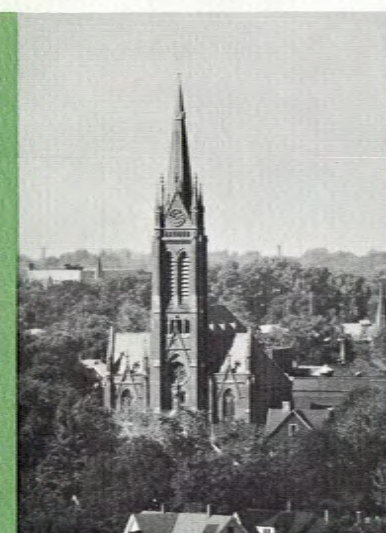
The basic unit is mounted in an aged aluminum housing* heat treated to insure maximum possible temperature stability and minimum deformation due to sag. The lens and mirror elements are INVAR rod spaced to insure maximum stability despite temperature change. This is particularly significant in assuring maintenance of resolution, and in radar boresights, line of sight accuracy, when subjected to environmental change due to temperature, shock, and/or vibration. All units are sealed and normally supplied with replaceable desiccant cartridges. For certain purposes, units are supplied sealed and flushed with dry Nitrogen under 3-5 pounds pressure. Such custom designs have stainless steel supply valves and a pressure gauge.

*Accuracy requirements sometimes dictate use of INVAR castings.

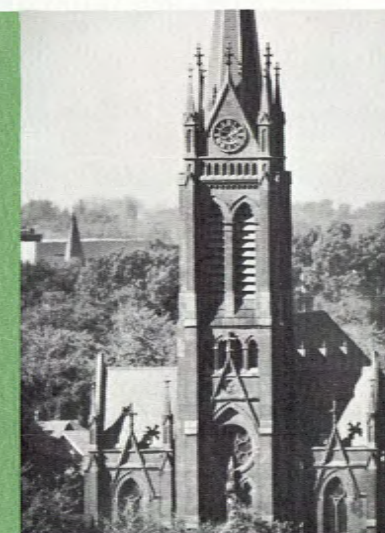
WOLLENSAK MIRROTELS



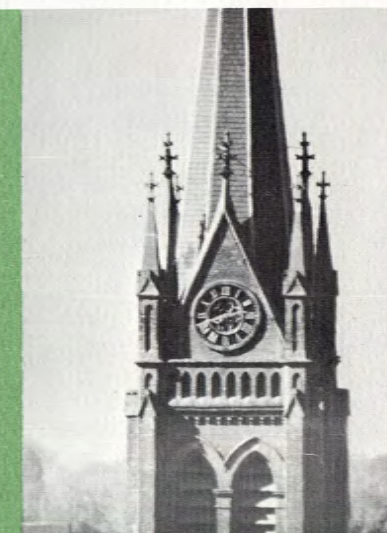
View taken with a 2" objective



Same view taken at the same time from the same viewpoint with 20" Mirrotel



Same view taken at the same time from the same viewpoint with 40" Mirrotel



Same view taken at the same time from the same viewpoint with 80" Mirrotel

ADVANTAGES

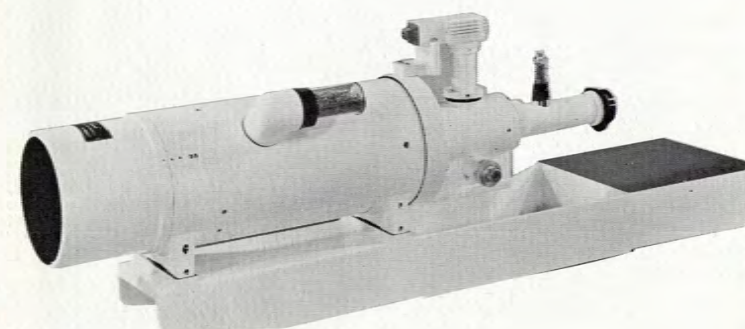
Probably the most important and obvious advantage of an optical mirror system is the complete absence of chromatic aberration (no special focusing for infra-red). There is no secondary color and no lateral color to "fuzz" up the image. There is no coma, astigmatism, or distortion in Mirrotels and, because the light path is "folded" three times within the system, the length and weight are less than one-third those of an equivalent refractive telephoto objective, thereby attaining greater physical stability (extremely important for long-focus objectives) and superior performance. Example: a conventional 80" EFL refractive telephoto objective would be 68" long from focal plane to front lens. The 80" Mirrotel is only 20" from focal plane

to front lens. This ratio is also true for the 20" and 40" Mirrotels.

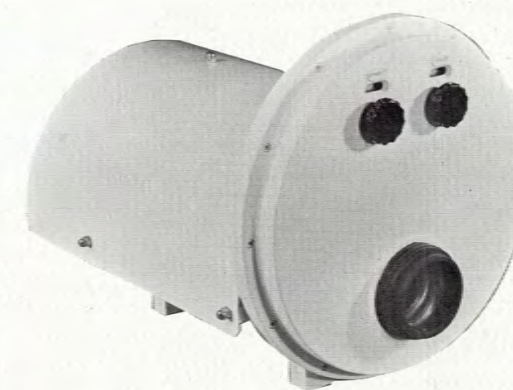
WOCOTING THE MIRROTEL

The mirror surfaces and all glass-to-air surfaces are treated with Wollensak anti-reflection hard coating, WOCOTE. This coating effectively reduces internal reflections, bouncing light, and flare . . . greatly increases image contrast and brilliance . . . sharpens detail . . . produces purer, richer colors in full-color photography. WOCOTING is done by Wollensak, in the Wollensak factory, with the best precision equipment under rigidly controlled conditions to assure uniformity and highest possible performance.

STANDARD MODULAR RADAR BORESIGHTS (examples)

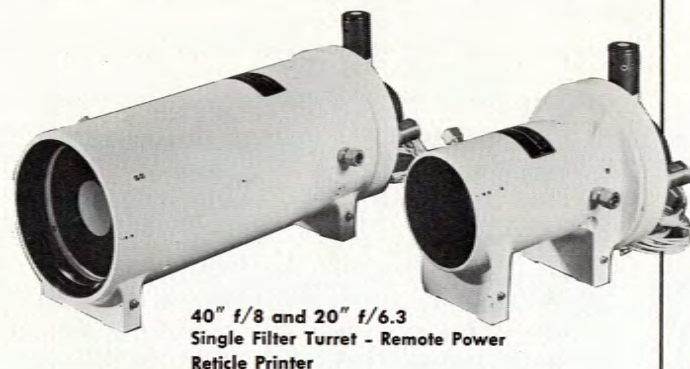


40" f/8
Single Filter Turret - Manual; Continuous Focus - Manual;
Reticle Printer; Plain Base

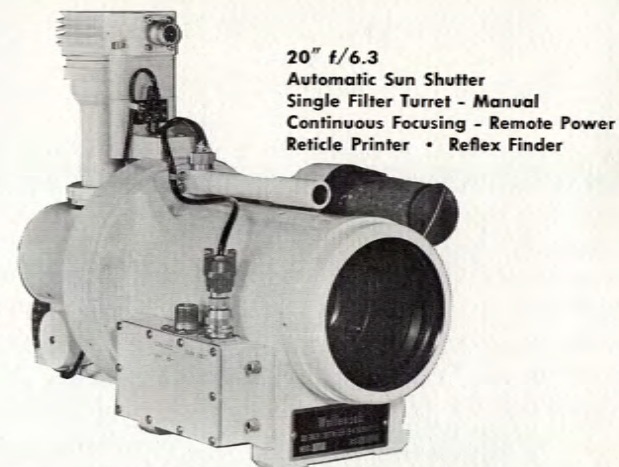


80" f/12.5
Double Filter Turret - Manual

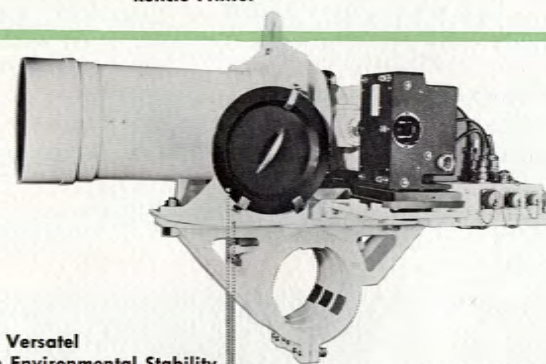
CUSTOM RADAR BORESIGHTS (examples)



40" f/8 and 20" f/6.3
Single Filter Turret - Remote Power
Reticle Printer

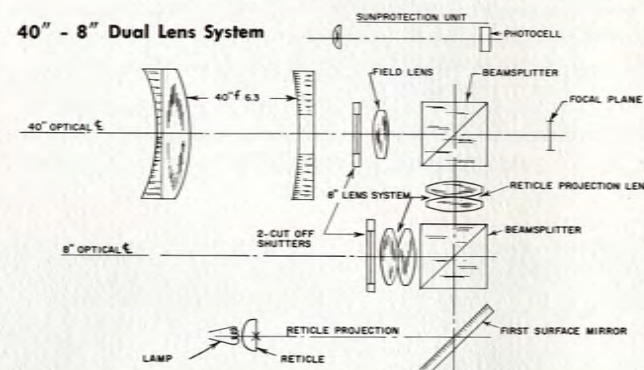


20" f/6.3
Automatic Sun Shutter
Single Filter Turret - Manual
Continuous Focusing - Remote Power
Reticle Printer • Reflex Finder



40"/80" Versatel
Maximum Environmental Stability
Acquisition System and Focusing - Remote Power
Simultaneous Recording both TV & Film Cameras

40" - 8" Dual Lens System



CUSTOM INFRA-RED OR ULTRA-VIOLET TRANSMITTING SYSTEMS

Special Mirrotel and Mirrotel-Mangin designs to meet custom requirements are under continuous development. The following examples are representative:

96mm	f/1.9	12½° total angle of coverage	20"	f/2.0	Single frame coverage
127mm	f/2.8	12½° total angle of coverage	24"	f/3.0	Double frame 35mm on CRT
6"	f/2.0	12½° total angle of coverage	27"	f/0.85	Double frame 35mm on CRT
12"	f/1.5	Double frame 35mm on CRT			

Systems of differing focal length, greater coverage, or larger aperture for visible or infra-red can be made to order.

FEATURE DESCRIPTION

FILTERS

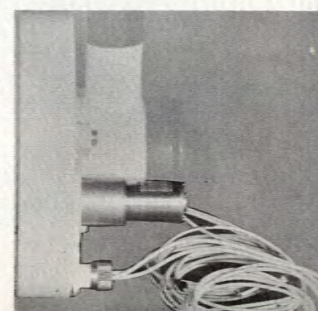
Single Filter Turret — Filters are housed in a turret at the rear of the lens. The turret rotates and is indexed to locate four filter positions. The filter in use is identified on the filter dial. The standard optical-glass filters supplied are Red (A-25), Yellow (K-2), Orange, and Neutral (Haze). The Neutral filter is a Haze filter and an optical-path compensating filter. The Neutral filter should be used for focusing and for any shots where a colored filter is not desired. It must not be removed for any reason or the focus setting will not remain constant from one filter position to another. Supplied either for manual or power operation.

Double Filter Turret — Color filters are housed in a turret at the rear of the lens. The turret rotates and is indexed to locate four filter positions. The filter in use is identified on the filter dial. The standard optical-glass filters supplied are Red (A-25), Yellow (K-2), Orange, and Neutral (Haze). The Neutral filter is a Haze filter and an optical-path compensating filter. The Neutral filter should be used for focusing

and for any shots where a colored filter is not desired. It must not be removed for any reason or the focus setting will not remain constant from one filter position to another.

Neutral-density filters are housed in a second turret also at the rear of the lens and adjacent to the color-filter turret. The neutral-density filter operates in the same manner as the color-filter turret. Four neutral-density filters are supplied: 100%, 50%, 25%, 12.5%. Neutral-density filters reduce exposure value in three steps—from ½ to ¼ to ⅛ times the normal.

Turrets are manually operated or power can be supplied to one for remote operation. Provisions can be made either for simple sequencing or actual selection of the desired filter.



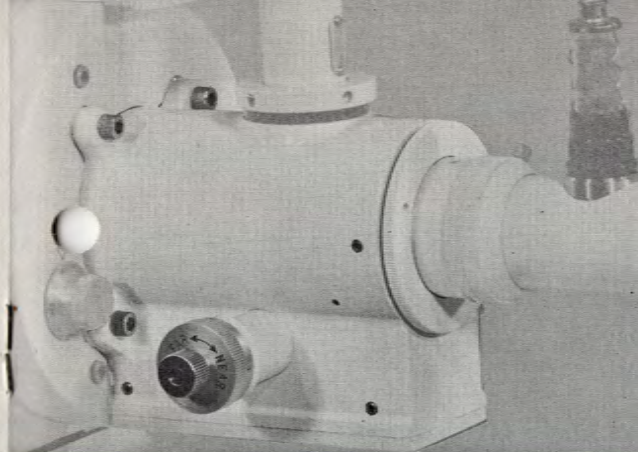
REMOTE POWER

FOCUSING —

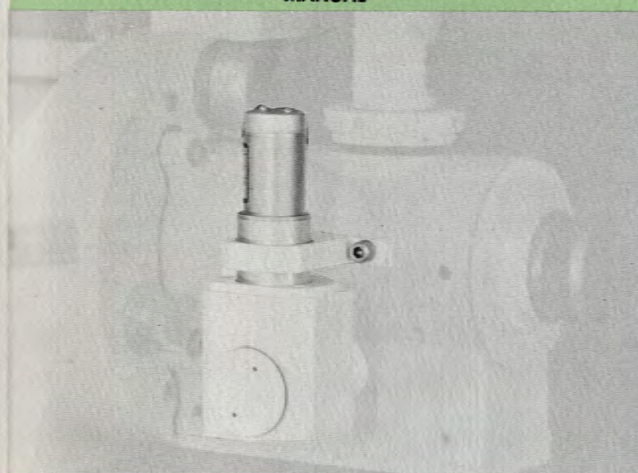
Three methods have and are being supplied.

Internal Continuous Focusing — Mirrotels can be supplied with an internal continuous focusing device. This feature allows focusing at various distances, depending upon target locations. The complete lens system becomes a self-contained integral unit, interchangeable with like assemblies. Internal focusing permits greater boresighting alignment accuracy than external focusing methods. It provides stable performance under environmental changes. Slight focal-length changes occur when focusing from the near distance to infinity. The internal continuous-focusing device is sealed against moisture and dust.

This can be furnished either for manual (above) or remote power (below) operation.



MANUAL

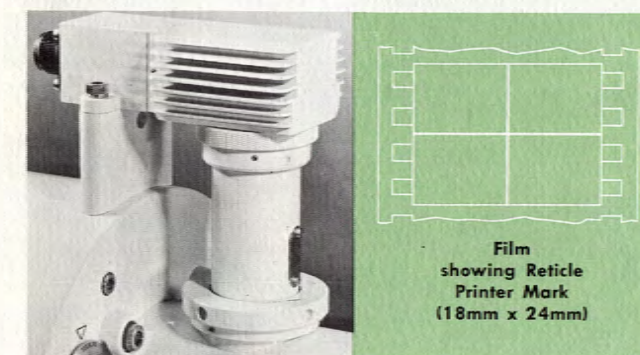


REMOTE POWER

Step Focusing (Optical Compensating Block)—

To focus for boresighting and pointing purposes, Mirrotels can be furnished focused at infinity and also at any one other practical distance specified. The focal length of the lens is not affected.

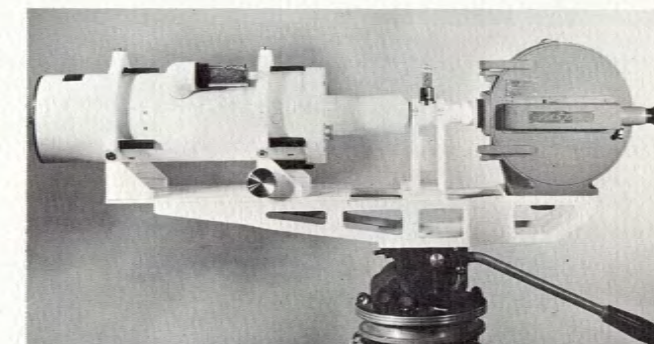
This is accomplished by introducing a precise plano-parallel block of polished glass of the correct thickness to compensate for the difference in the optical path between infinity and the closer distance selected for boresighting. More than one optical compensating block can be furnished for other selected distances and normally would be located in a turret similar to that used for filters.



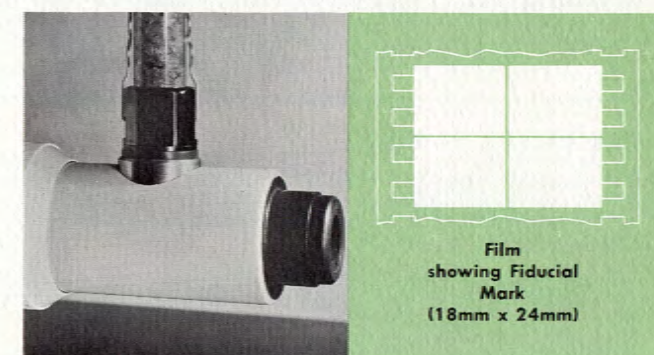
Film
showing Reticle
Printer Mark
(18mm x 24mm)

RETICLE PRINTER

The Reticle Printer Assembly is supplied to expose a reference reticle pattern (cross hair) on the film when photographing dark objects. Pattern appears dark on the negative.



External Continuous Focusing — Should it be required, external continuous-focusing devices can be supplied with Mirrotels. Focusing can be accomplished either by moving the lens or camera. The external continuous-focusing device can be used where boresight pointing accuracy is not critical and environmental effect on alignment are not a factor.



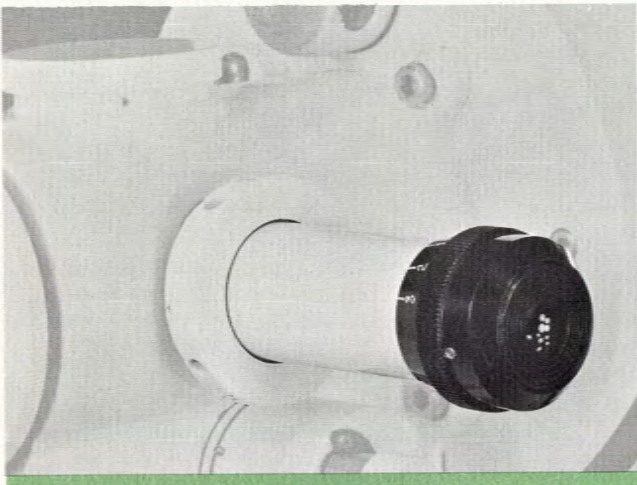
Film
showing Fiducial
Mark
(18mm x 24mm)

FIDUCIAL MARKER

The Fiducial Marker Assembly is supplied to expose a reference reticle pattern (cross hair) on the film when photographing light objects. Pattern appears transparent on the negative.

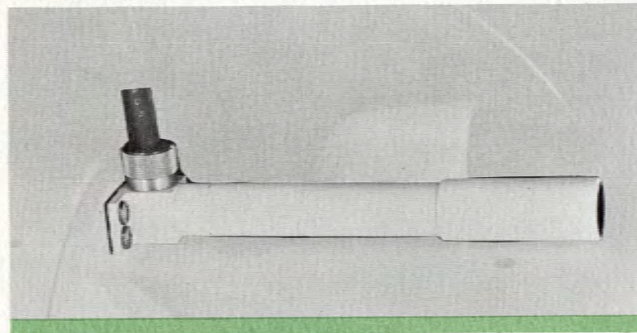
REFLEX FINDER

Various types of reflex finders are furnished, depending on the application and combination of features desired.



AUTOMATIC SUN SHUTTER

This is a protective device introduced to prevent damage to the cathode ray tube of a TV camera. It is normally in the closed position when the camera system is not in use. When power is applied, and depending on the light input intensity to a lens photocell system, the shutter opens and remains open until light of near damaging intensity is experienced, whereupon it closes. The shutter may consist of either a very dense filter or a mechanical blade movement solenoid activated. Coverage of the optical pickup system to the photocell is designed for compatibility to the primary objective.

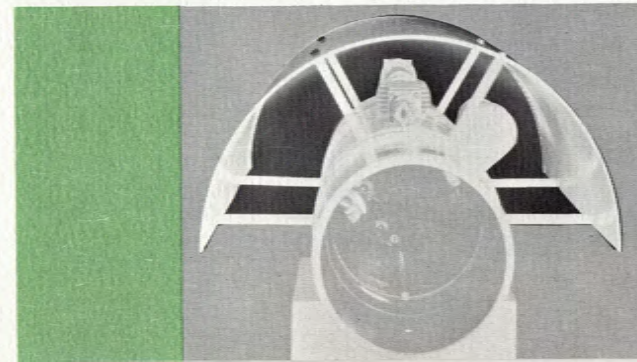


AUTOMATIC EXPOSURE CONTROL

A 1:1 relay system is provided which includes an iris diaphragm. This diaphragm can be activated by an externally mounted automatic exposure control commercially obtainable or of our own design. This represents the optimum method without distortion or depreciation of the basic image being formed.

SUN RADIATION SHIELD

Shielding the lens from the direct rays of the sun assists greatly in stabilization of the optical system from detrimental movement due to uneven expansion or contraction of the mounting materials.



BEAMSPLITTER COUPLING

Almost all such features are part of custom integrated systems. They are required for coupling either another type of camera to the basic lens or to join another lens of different focal length to the same camera.

An example of the first is the 80"/40" Versatel which serves as an objective for both a film camera and a closed circuit TV camera — the one for data correction as a radar boresight and the other for visual monitoring the target during operation at a distant control point.

The second type is used for easier target acquisition and tracking by switching the image as required from a lower focal length, wider angle lens while the target is close in, to the longer focal length narrow coverage Mirrotel as the subject moves away in space. For approaching targets reverse switching of lenses may be indicated.

DIVERSION SHUTTERS

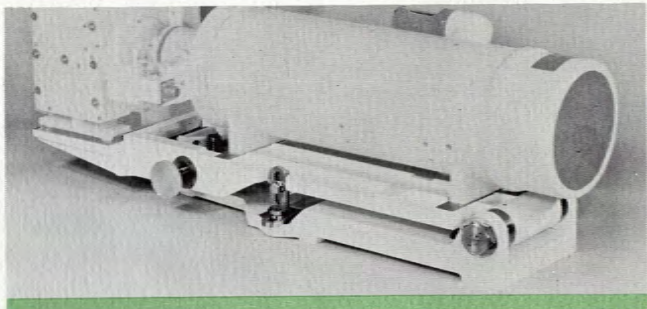
In beamsplitter coupled lens systems of two different focal lengths a shutter in each system controls which is to form the image at the focal plane. One is always closed when the other is open.

PLAIN BASE

A rugged cast aluminum base which firmly mounts both the lens and camera and holds each in precise alignment.

ELEVATION — AZIMUTH BASE

A complex base for mounting both lens and camera and which permits critical adjustment of the line of sight in elevation and azimuth.



CAMERA ADAPTERS

Camera adapters to connect the Mirrotel to any camera system is supplied as required.

CORRECTION LENSES

Special correctors of materials, such as Aluminum Sulphide, Sapphire, Manganese Fluoride, Quartz, Arsenic Trisulphide, Silicon, Germanium, etc., for their infra-red and/or ultra-violet transmitting qualities can be supplied.

LENS-TELESCOPE CONVERSION

Designs for surveillance tasks where rapid conversion of camera lens to telescope is necessary have been furnished. Units can be supplied with instant disconnect eyepiece and erecting prism assemblies and corresponding still or motion picture camera connecting links for photography of subject being studied.



SPECIFICATIONS

OPTICAL DATA

	20" (35mm)	40" (35mm)	80" (35mm)	40" (70mm)	80" (70mm)	200" (35mm)
Nominal Focal Length	20"	40"	80"	40"	80"	200"
Relative Aperture	f/6.3	f/8	f/14	f/6.3	f/12.5	f/17
Hyperfocal Distance based on Circle of Confusion of 1/1000" (Critical Definition)	1.0 Miles	3.2 Miles	7.2 Miles	4.0 Miles	8.0 Miles	37.0 Miles
Hyperfocal Distance based on Circle of Confusion of 1/500" (Normal Definition)	0.5 Miles	1.6 Miles	3.6 Miles	2.0 Miles	4.0 Miles	18.5 Miles
Flange Focal Distance	1.375**	3.543" (9cm)	3.543" (9cm)	3.937"	3.937"	
Maximum Coverage (Single-Turret Type)	24mm x 36mm	24mm x 36mm	24mm x 36mm			24mm x 36mm
Maximum Coverage (Double Turret-Type)	18mm x 24mm	18mm x 24mm	18mm x 24mm			18mm x 24mm
Maximum Coverage (for Single- or Double-Filter-Turret Mirrotels)				60mm x 60mm	60mm x 60mm	
Total Field of View (24mm x 36mm)	5°	2.52°	1.62°	—	—	—
Total Field of View (18mm x 24mm)	3.4°	1.72°	.86°	—	—	—
Total Field of View (60mm x 60mm)				4.78°	2.39°	0.5°
Photographic Resolving Power on Kodak Plus X Film - Minimum	50/LPM	45/LPM	40/LPM	45/LPM	40/LPM	37/LPM*
Visual Resolution	226/LPM (2 sec. of arc)	213/LPM (1 sec. of arc)	106/LPM (1 sec. of arc)	182.7/LPM (1.1 sec. of arc)	93/LPM (1.1 sec. of arc)	(0.9 sec. of arc)
Filter Turret (Single)	Yes	Yes	Yes	Yes	Yes	
Filter Turret (Double)*	Yes	Yes	Yes	Yes	Yes	

*Available when specified.

**Flange focal distance with single filter turret.

*On Microfile

MECHANICAL DATA

Sealed Unit	Yes	Yes	Yes	Yes	Yes	Yes
Adapter†	†	†	†	†	†	†
Total Length	10-1/32"	13.6"	21 1/8"	20 3/8"	21"	54"
Weight	Aprox. 6 1/2 lbs.	Aprox. 12 1/2 lbs.	Aprox. 16 lbs.	Aprox. 51 lbs.	Aprox. 53 lbs.	Aprox. 200 lbs.
Diameter Turret)	6 3/8"	6 3/8"	6 5/8"	14 3/8"	14 3/8"	—
Diameter (Lens)	4 1/8"	5 7/8"	6 1/2"	7 3/4"	7 3/4"	14 3/4"
2 Dust Covers supplied	Yes	Yes	Yes	Yes	Yes	Yes

†Specify make and model of camera when ordering.

EXPOSURE CONTROL

Exposure control is effected through neutral-density filters with 12 1/2 % transmission, 25 % transmission, 50 % transmission, 100 % transmission.

20" f/6.3 (35mm) with ND filter	40" f/8 (35mm) with ND filter	80" f/14 (35mm) with ND filter	40" f/6.3 (70mm) with ND filter	80" f/12.5 (70mm) with ND filter
100% T.....f/6.3	100% T.....f/8	100% T.....f/14	100% T.....f/6.3	100% T.....f/12.5
50% T.....f/9	50% T.....f/11	50% T.....f/19.8	50% T.....f/9	50% T.....f/17.7
25% T.....f/12.6	25% T.....f/16	25% T.....f/28	25% T.....f/12.6	25% T.....f/25
12 1/2 % T.....f/17.8	12 1/2 % T.....f/22	12 1/2 % T.....f/40	12 1/2 % T.....f/17.8	12 1/2 % T.....f/35.36

An iris can be supplied on special order where a fiducial marker attachment is required. It is not recommended that the fiducial marker be requested just to obtain an iris control.

Other means for exposure or light transmission control may be desirable for your special applications. Submit your inquiries to Wollensak. Specifications are subject to change without notice



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