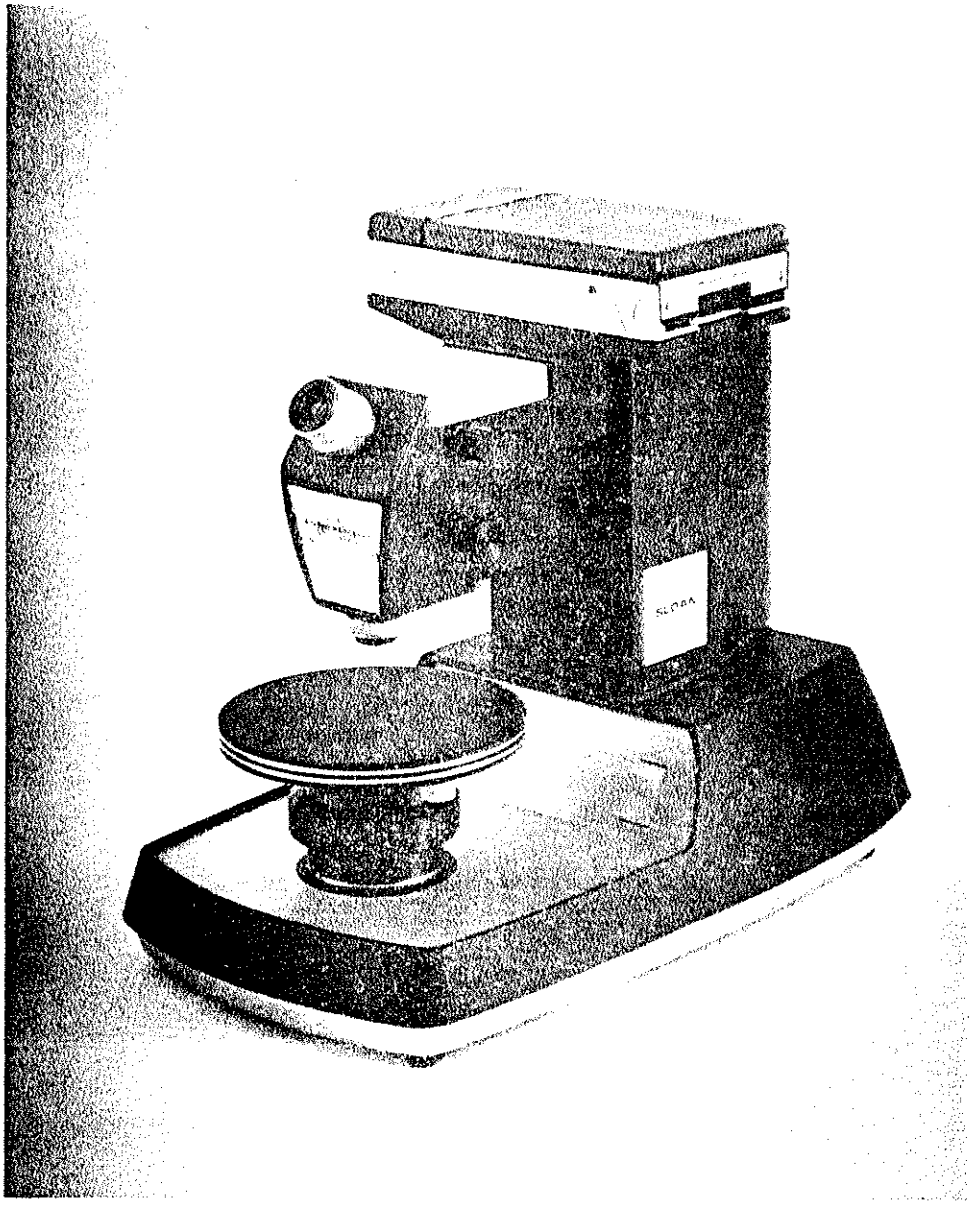


Sloan

M-100

ÅNGSTROMETER

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

SECTION I - TECHNICAL SUMMARY

GENERAL INFORMATION

The Sloan Instruments Angstrometer, Model M-100, is a source imaging multiple beam interferometer used for the precise measurement of thin films, the examination of surface contours, and other interferometric measurements described by Tolansky.

It is a modification of the Fizeau Interferometer and was designed to give optimum sensitivity, good fringe contrast and bright object field. It employs a low power microscope to permit use of small test samples and examination of microscopic irregularities.

DESCRIPTION

The Angstrometer, Model M-100, consists of a monochromatic light source, source imaging optics, a Fizeau reference flat and appropriate optical facilities for viewing and photographic recording.

The light source consists of a stable, high intensity, sodium vapor tube, which emits essentially monochromatic radiation in the range of 5890 Angstrom units. The source reference plane is an aperture located approximately 1" away from the lamp center, which is uniformly illuminated.

This source plane is passed through an optical system and is caused to be imaged directly on the back of a precision Fizeau Flat. This "source imaged" technique is a term very specifically associated with the Angstrometer, Model M-100, and yields the extremely bright field associated with this instrument. It is discussed in some further detail below.

When the Fizeau Flat is brought in contact with a reflecting sample in such a way that a minutely thin air wedge is established, a series of parallel lines representing regions of constructive reinforcement is displayed. From simple geometric considerations it can be seen that horizontal spacing between these parallel lines represents a vertical distance of 1/2 wave length of incident light.

Any displacement of parallelodisity denotes a change in surface elevation. As such, then, the Fizeau Fringes represent lines of equal elevation similar to topographic contour lines. The resolution of vertical displacement in the case of precision Fizeau-Tolansky type interferometers is exactly in the range of the electron microscope.

Since, as described above, the distance between the fringe lines represents $\frac{\lambda}{2}$ or in this case 2945 Angstrom units, there is a built-in irrefutable reference to which displacements due to steps in the film can be compared. By measuring the observed step height and the fringe spacing, one can determine the exact step height. A permanent record of these values can be made by employing the integral camera system.

SOURCE IMAGING

As mentioned above, source imaging is a term very specifically associated with the Angstrometer, Model M-100. On considering the above, it is obvious all of the interaction between the transmitted and reflected beams takes place in the region of semi-transmitting surface film on the Fizeau reference flat. The semi-transmitting film reflects of the order of 93% of the incident light but allows 7% of the light to be transmitted to the sample surface. This in turn is reflected from the sample and back to the Fizeau film. If these two rays are in phase, there is a constructive reinforcement, but at all other points there is destructive interference.

When the total distance travelled down through the air wedge and back is exactly one wave length, or integral number of wave lengths of light, the transmitted beam returns from the sample surface in phase with the incoming light. The entire interaction does take place directly on the face of the reflecting film. By careful optical design and manufacture it has been found practical to bring the image of an intense planar source and the plane of the eye into coincidence directly on this surface--thus yielding an extremely bright object field.

Usual interferometers employ collimating optics which find optimum performance by employing point sources during collimation generally results in low unit density of illumination at the object field. As a result, most collimated beam interferometers require operation under subdued light. Source imaging permits the use of the Angstrometer in virtually any ambient light environment.

SECTION II - UNPACKING AND CHECKOUT INSTRUCTIONS

UNPACKING INSTRUCTIONS

The Angstrometer, Model M-100, is shipped mounted in its carrying case. On opening the shipping carton the unit can be removed simply by opening the top of the shipping crate and sliding the unit directly upward. If on arrival there are signs of heavy damage to the case, it should be reported immediately to the manufacturer. Serious damage to this carrying case can only be caused by improper handling and will probably involve some instrument damage. (See Warranty Section)

Place the carrying case on a stable flat surface such as a desk top, unlatch the clasps and lift the case directly upward. The instrument will then remain mounted on the wooden base of the carrying case. If desired this base can be demounted by removing the three restraining screws on the underside of the base. Two of these are just outboard of the rear feet of the instrument.

With one hand grasping the inner extremity of the cantilevered portion of the optical housing, place the index finger against the vertical portion of housing and the hand will automatically cup around the recessed portion of the cantilever. The center of gravity of the instrument has been designed to fall 3/4" from the vertical housing so that most of the weight falls on the index finger permitting stability.

In the upper portion of the carrying case and to one end is a drawer containing the following accessory items for the M-100:

1 Stage Platen
1 Bottle of Plastilube Stage Grease
1 Power Cord
1 Plug Grounding Adapter
1 Test Optical Flat
1 Eyepiece Guard
1 Pack Polaroid Film
1 Test Photograph

After unpacking, coat the underside of the stage platen with a thin film of Plastilube; then place platen on gliding stage mount making sure surface is clean. The Plastilube serves both as a lubricant and attachment medium. Remove cover from Fizeau lens mount (under optical head) and thread in Fizeau lens. Do not touch coated surface.

The M-100 is now ready for operation.

CHECKOUT INSTRUCTIONS

The Angstrometer, Model M-100, contains a monochromatic light source and a secondary illumination system which is a microscopic viewing aid. Power is supplied to the sodium vapor source merely by pushing the yellow button on the right forward section of the Angstrometer. This, being a vapor lamp, requires approximately five minutes of warmup before full intensity is achieved. While this warmup process is taking place, simply push the lefthand blue button and the secondary blue source should be observed through the eyepiece. Due to the low transmission of the Fizeau Flat this secondary illuminator is quite inadequate for true microscopic study. It is included only as an optical aid in locating the area of interest on the sample prior to bringing the sample in contact with the flat.

The stage can be raised or lowered by turning the large knurled knob beneath the platen. It should also be noted that the entire stage assembly is spring loaded for approximately 1/8" travel.

The two tilt adjusting screws are located approximately 120° apart beneath the forward edge of the stage platen. These screws should be adjusted so that the stage platen is approximately parallel to the Fizeau Flat.

SECTION III - OPERATION

FOCUSING

Since the camera lens system is par-focal to the viewing microscope it is essential that the following procedure be followed. Focus the eyepiece to the reticle by turning the outermost portion of the eyepiece. The reticle image should appear sharp and black across the entire field. The fringe image can now be focused on the reticle plane by adjusting the knob at the lower righthand side of the optical head. The camera lens is pre-focused and should provide a sharp photographic image if the above procedure is followed.

SETTING UP THE SAMPLE

When sufficient time has passed to allow the sodium vapor source to come to full intensity, a sample is placed in the center of the translatable stage platen. By clockwise rotation of the large knurled lift mechanism at the base of the sub-stage, the platen is raised. The sample is brought to a point where it just contacts the Fizeau Flat. The entire stage assembly is spring loaded so that only light loads can be applied to the Fizeau Flat. If the stage is driven beyond desired point, the entire drive assembly will move downward on to a relief spring.

To define the exact location of the film step to be measured, the stage is depressed slightly, bringing the sample out of contact with the reference flat allowing movement of the rotable/transtable stage. In this with-drawn position the stage can be manually moved to the desired location. Illuminate the field with the secondary light source by pushing the blue panel button. As can be noted, the yellow illumination is automatically shuttered as a secondary light source is lit.

MAKING MEASUREMENTS--THE GENERAL CASE

To make measurements of usual thickness films (100Å to 20,000Å) the following stepwise procedure is recommended:

1. Turn off the secondary light source--the sodium light should re-appear and fringes should be present.

2. Drive the tilting screws under the stage to orient the fringe lines normal to the film step.

3. Adjust the fringe space by appropriate adjustment of the tilt adjustment screws. For very thick films one normally desires a large number of fringe lines and for thin films, a limited number of fringe lines is normally desired. The distance between these fringe lines is exactly 2945Å units. This is the absolute reference to which the step height is referred. By orienting and adjusting an eyepiece reticle, the fringe line spacing and step height measurement can be made in arbitrary units. These can be converted to the actual measurement by calculating:

$$\frac{\text{step height}}{\text{fringe-to-fringe distance}} \times 2945\text{Å} = \text{film thickness in Å units}$$

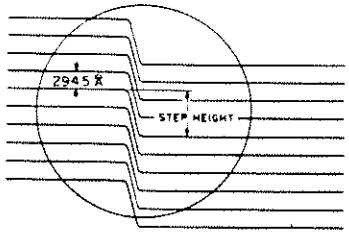


Figure 1

Typical Fringe Pattern

SAMPLE PREPARATION

Generally a standard microscope glass slide can be used for monitoring purposes, however, if extreme accuracy is desired the use of an optically flat sample plate such as the Sloan P/N 107-368 Quartz Flat is recommended.

Any one of several methods of masking the monitor slide may be employed to produce the step as shown in Figure 2.

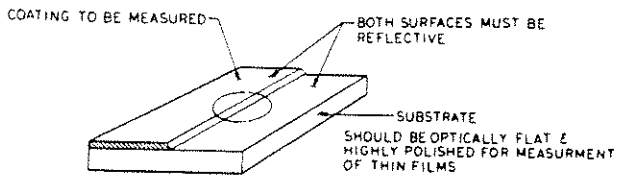


Figure 2

However, for thicker film measurement (>2500Å) it is necessary to locate the mask above the monitor slide in such a manner to provide a graded step such as illustrated in Figure 3B

Figure 3A

Figure 3B

As can be seen in Figure 3B, it is necessary to count the number of offset fringe lines to calculate total thickness.

A simple and effective method of masking is shown in Figure 4 employing only a piece of wire. This technique allows greater accuracy of measurement both visually with the micrometer eye-piece and on film, particularly if the specimen is not optically flat thus producing curved fringe lines.

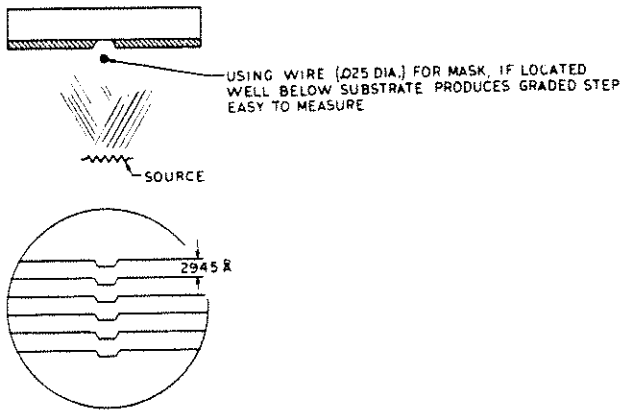


Figure 4

MEASUREMENT OF EXTREMELY THIN FILMS--THE LINE WIDTH TECHNIQUE

When films below 100Å units are to be measured, a simple technique can be employed whereby extremely accurate and simple measurements can be made. One needs simply to accurately define the width of the Fizeau fringe line as compared to the fringe-to-fringe distance. Depending on the reflectivity of the sample, this line width will be of the order of 100-125Å units wide.

The exact definition of the line width is accomplished by photographing a flat fringe pattern and carefully measuring line width. This line width can next be used as a standard for the accurate measurements of films whose thickness causes a displacement smaller than the width of the line. A very thin step will generally appear to be a discontinuity in line position.

By careful adjustment of the air wedge, the field can be generally reduced to one or two fringe lines. By establishing or measuring the fraction of displacement of this line width, measurement of extremely thin films can be made with simplicity.

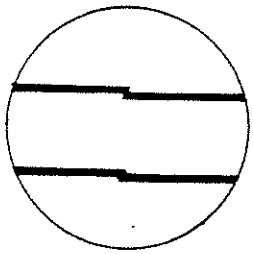


Figure 5

Line Width Technique

USE OF CAMERA

All of the camera optics are built into the Angstrometer and the standard instrument employs a Polaroid Land Film Pack Adapter which uses 100-Series Film Packs. Loading and operating instructions for the camera back are included on each pack of film.

After loading the camera, focus the desired field of view in the eyepiece. Since the camera optics are par-focusing with the eyepiece reticle, this automatically brings the camera into focus. The very bright field yielded by the source image optics in the Angstrometer makes extremely short exposure times possible. The exposures are generally in the range of 1/10 second. In order to make a permanent record of the sample, simply follow the below stepwise procedure:

1. Set the exposure adjustment to 1/10 second (inside upper cover).

2. Set iris control (lefthand side of optical head) to ≈ 2.

3. Depress the beam diversion lever directly above the focusing knob on the righthand side of the optic head. The first function performed here is to bring the beam diversion mirror into place. On continuing further, depression of the lever, the shutter is actuated. On releasing the lever, a spring returns the optics to the "view" condition.

4. Pull the film tab on the righthand side of the camera pack--this starts the film development process.

5. Wait 10 seconds, then pull photograph directly out the righthand side of the camera.

6. Remove photograph from backing paper and apply fixative similar to the instructions supplied with the film.

7. If film is too dark, open exposure aperture. Note: zero is maximum aperture opening.

SECTION IV - CALIBRATION AND MAINTENANCE

Cleaning

As with any fine optical instrument, dust and foreign particles create the major cause for maintenance. Removal of dust from the lens and mirrors should be accomplished by use of an anti-static, soft brush to avoid scratching the coatings. The lens and mirrors may be cleaned with a soft lens tissue and cleaning solution such as Kodak Lens Cleaner or mild solution of liquid soap and water.

The accumulation of film developer can be removed from the camera by using a cloth or tissue dampened with isopropyl alcohol.

Lubrication

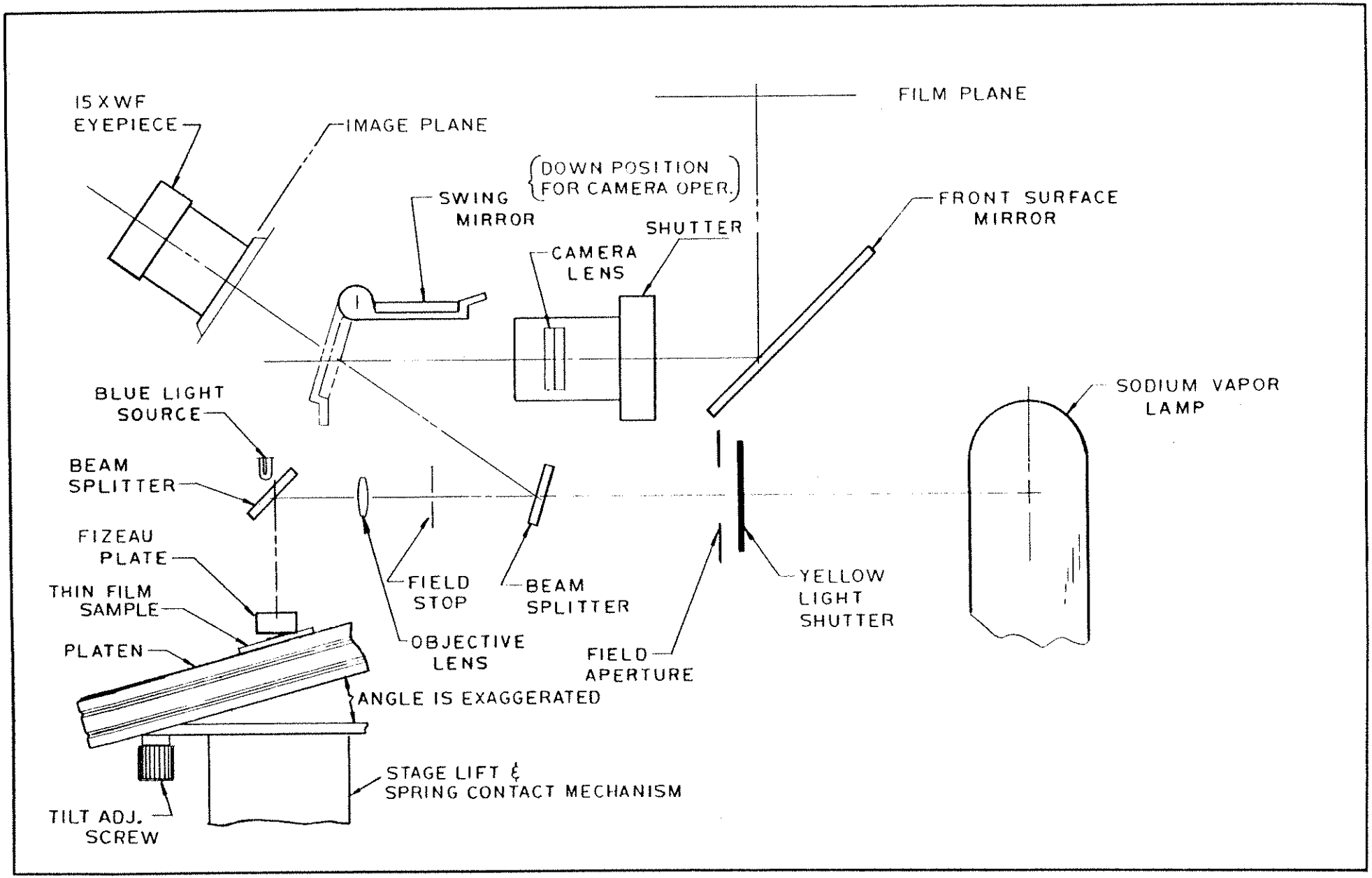
It is recommended that the stage platen be removed and the entire assembly be cleaned with alcohol and re-lubricated with the Plastilube. This also applies to the column of the stage assembly as well as the stage tilt screws and eyepiece threads. All other moving parts can be oiled with a light machine oil (use sparingly) every six months (more regularily if instrument is subject to constant daily use).

Lamp Replacement

Sodium--remove the cover by unscrewing the knurled screw and swinging it to the rear and up. The flask hold-down can be released by unhooking the spring at the casting. This will allow the flask to be lifted up and at an angle to the rear.

When replacing flask, take care to seat seal off tip of flask into the machined relief slot and keep silicon rubber gasket in place. Avoid placing any fingerprints on either the flask or Sodium lamp in the area directly in line with the optical axis.

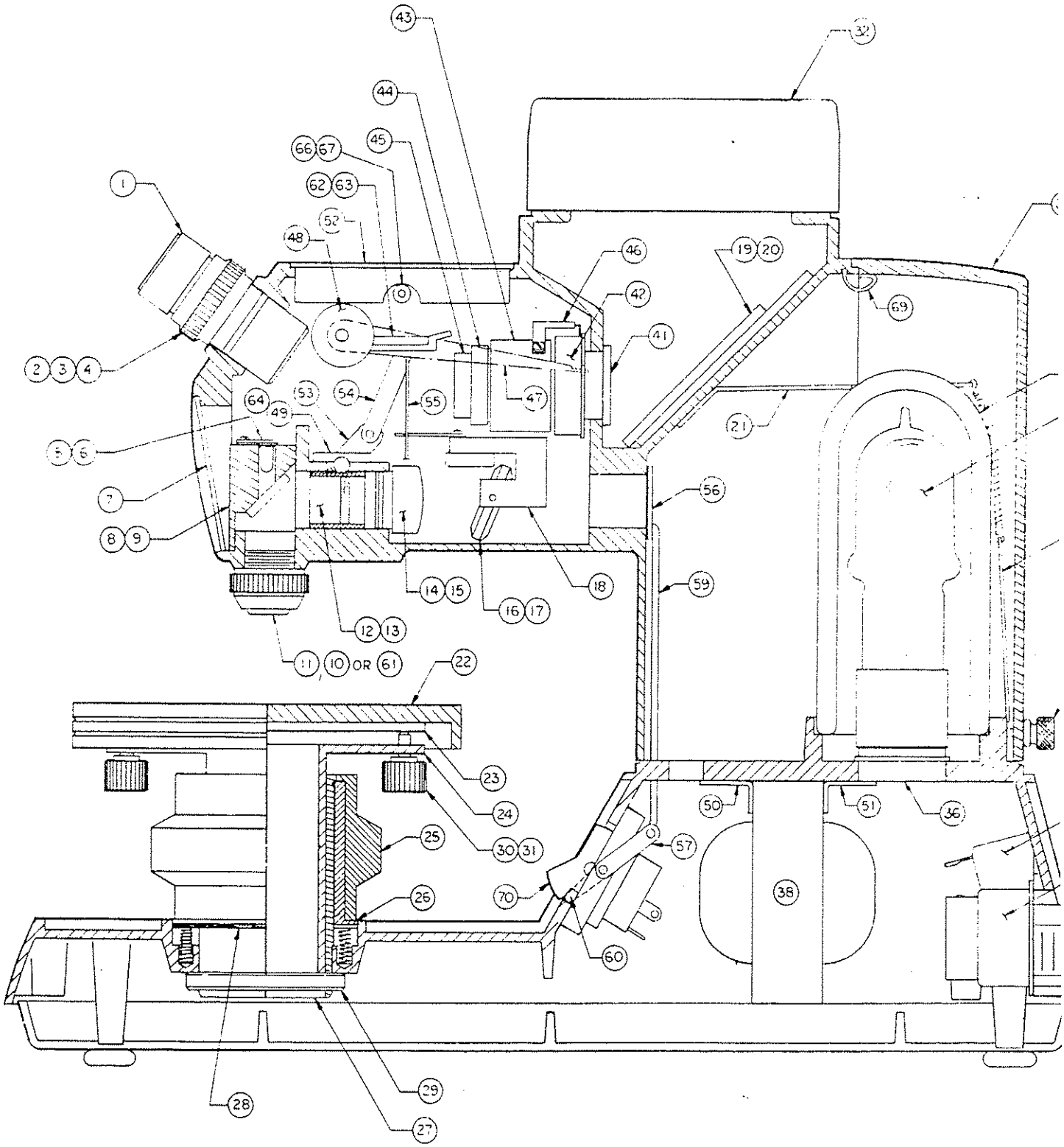
Incadescent--remove the eyepiece by pulling outward rather briskly. The front cover is removed next (two screws) exposing the objective 45° mirror. (Refer to Figure 6) Loosen the screw on the contact assembly approximately one turn, then the contact assembly can be swung to the right or left for removal of the bulb. Caution! Care should be taken in working around the 45° objective mirror not to disturb the optical alignment. Also in replacing the contact assembly to its proper position to avoid short circuiting it.


15 X WF
EYEPIECE
IMAGE PLANE
FILM PLANE
DOWN POSITION
FOR CAMERA OPER.
SWING
MIRROR
SHUTTER
CAMERA
LENS
FRONT SURFACE
MIRROR
BLUE LIGHT
SOURCE
SODIUM VAPOR
LAMP
BEAM
SPLITTER
FIZEAU
PLATE
THIN FILM
SAMPLE
PLATEN
FIELD
STOP
BEAM
SPLITTER
OBJECTIVE
LENS
FIELD
APERTURE
YELLOW
LIGHT
SHUTTER
ANGLE IS EXAGGERATED
STAGE LIFT &
SPRING CONTACT MECHANISM
TILT ADJ.
SCREW

SECTION VI - MECHANICAL ASSEMBLY AND PARTS LIST

Accessory List

Part Number	Item
107-143	Fizeau Flat (Mounted) Standard 93%R
107-145	Fizeau Flat (Mounted) Wide Range 50%R
107-144	Fizeau Flat (Mounted) 10X
NA-1	Bulb, Sodium
CM8443	Bulb, Incadescent 5v .22a
103-701	Cord, Electrical Power, 8'
107-601	Test Flat, Quartz, 1" x 1" x 1/4"
#1	Plastilube, 2 ounce jar
107	Film, Polaroid, ASA 3000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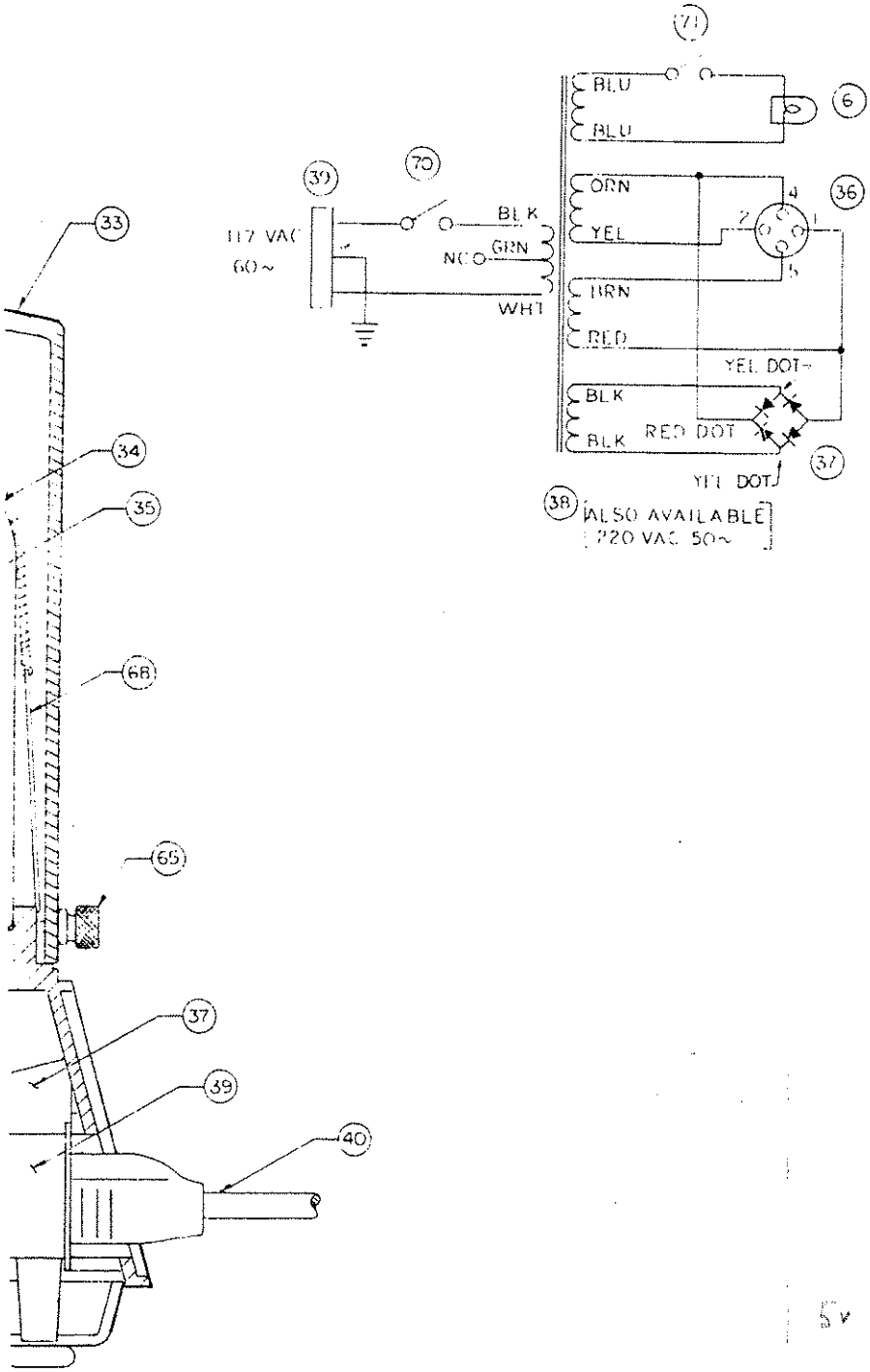

71	107-376	SWITCH, BLUE
70	107-377	SWITCH, YELLOW
69	107-363	CLIP
68	107-314	WIRE FORM
67	107-338	TUBE, COVER RETAINING
66	107-338	PIN COVER RETAINING
65	107-388	SCREW, THUMB 6-32
64	107-343	SHAFT, PINION
63	107-114	MOUNT SWING MIRROR
62	107-103	MIRROR, SWING
61	107-144	FIZEAU 10X
60	107-353	ARM
59	107-357	LINKAGE
58	107-355	BLOCK
57	107-351	LEVER
56	107-352	PLATE
55	107-316	WIRE FORM
54	107-327	LINK IRIS ADJ.
53	107-326	BLOCK IRIS ADJ.
52	107 332	COVER, TOP
51	107-139	BRACKET, XFMR
50	107-138	BRACKET, XFMR
49	107 344	BLOCK, SHAFT HOLDOWN
48	107-322	CAM, SHUTTER ACTUATING
47	107-321	LEVER " "
46	107-349	BRACKET
45	107-141	CAMERA LENS
44	107-128	ADAPTOR
43	107-350	BUSHING, SHUTTER SPEED
42	107-387	SHUTTER, CAMERA
41	107-337	BUSHING, SHUTTER MNTG
40	103-701	CORD, POWER
39	107-386	RECEPTACLE
38	107-372	TRANSFORMER 60~
37	107-385	RECTIFIER, BRIDGE
36	107-364	TUBE SOCKET
35	NA-1	LAMP, SODIUM VAPOR G.E.
34	107-382	FLASK, VACUUM
33	107-135	HOUSING, LAMP
32	107-381	CAMERA, FILM BACK PACK
31	107-318	KNOB
30	107-309	SCREW, TILT
29	107-304	NUT
28	107-307	SPRING SUPPORT
27	107-302	GUIDE
26	107-303	CAM
25	107-305	KNOB
24	107-375	COLUMN
23	107-312	PLATE TILT
22	107-323	PLATEN
21	107-364	SPRING, FLASK RETAINING
20	107-126	MOUNT, CAMERA MIRROR
19	107-112	MIRROR CAMERA
18	107-328	BLOCK
17	107-102	50-50 BEAM SPLITTER
16	107-358	MOUNT " "
15	107-379	IRIS
14	107-347	MOUNT, IRIS
13	107-140	LENS, OBJECTIVE
12	107-365	MOUNT "
11	107-143	FIZEAU, STANDARD
10	107-145	FIZEAU, WIDE RANGE
9	107-101	MIRROR 45° OBJECTIVE
8	107 324	BLOCK, MIRROR MNTG
7	107-331	DOOR, FRONT ACCESS
6	CM-8443	LAMP-CHICAGO MINATURE
5	107-345	CONTACT
4	107-378	O-RING
3	107-368	RETICLE 0-10 MM
2	107-374	ADAPTER
1	107-373	EYE PIECE 15XWF

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ANGSTROMETER MODEL M-100		SLOAN INSTRUMENTS CORP Santa Barbara California
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APPROVED		REV NO
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