xx.

Osborne

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LICK OBSERVATORY TECHNICAL REPORTS

No. 5

THE CROSSLEY TELESCOPE
REVISED EDITION

Instructions for Its Use in the Photometric, Spectrophotometric and Polarimetric Modes, With All Manner of Helpful Suggestions and Technical Appendices; Profusely Illustrated

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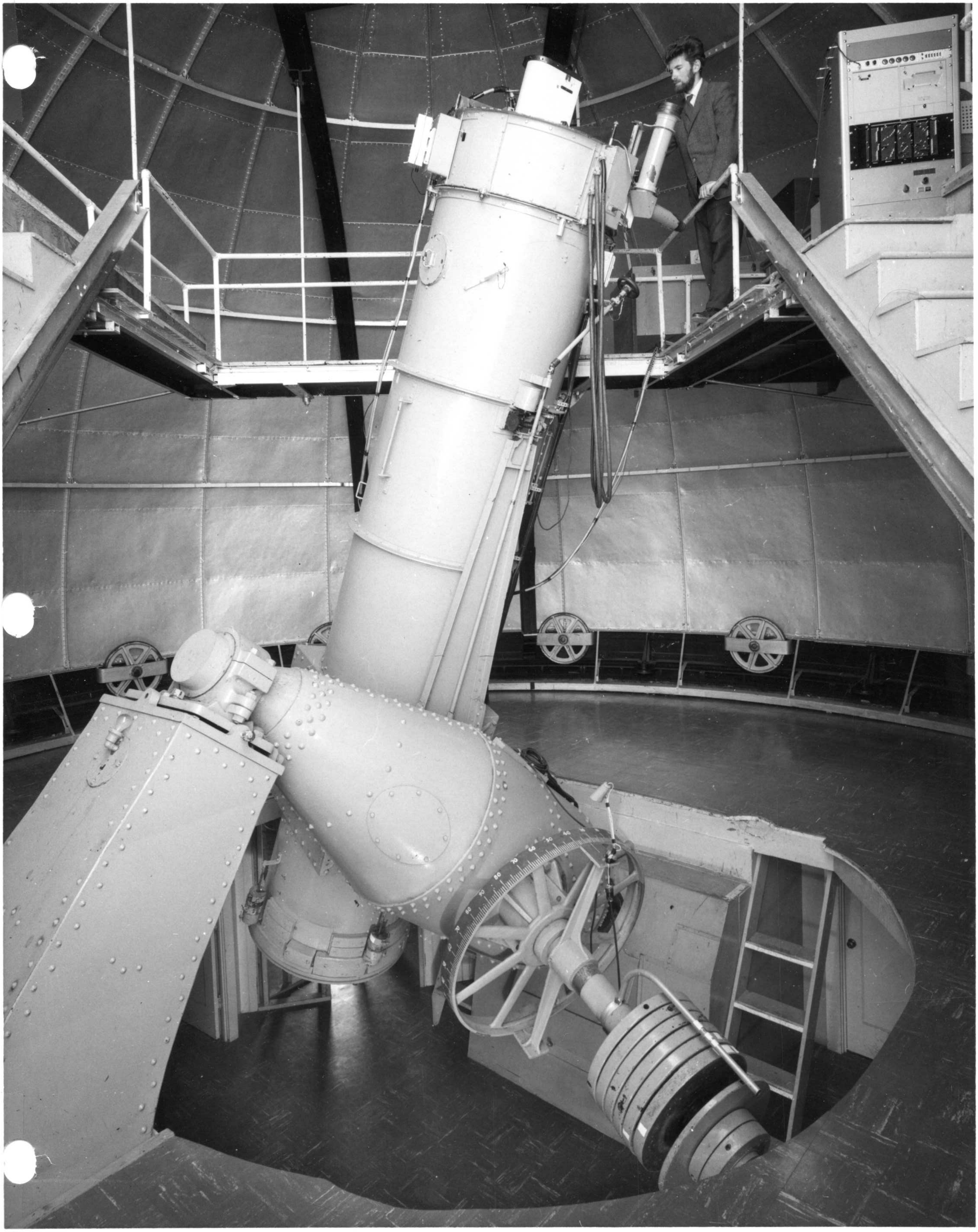
Santa Cruz, California
June 1975



PREFACE TO REVISED EDITION 1977

In addition to a few minor corrections, two major changes have been made. First, the High-Speed Photometer is no longer available and consequently all of Chapter V has been deleted. Secondly, our cold boxes have been revised and are no longer as sensitive to power interruptions or icing procedure as they used to be, so the formerly recommended procedure of warming up a cold box and reicing subsequent to a power failure is no longer a desirable one and that section has been deleted.

Rem Stone
9 March 1977

PREFACE

These notes are written with the case in mind of a graduate student who has perhaps only observed a few times with a sleek, efficient new telescope and who may be nonplussed by an older and less gainly instrument. The detail is, of course, excessive from the standpoint of the experienced observer, whose indulgence is solicited.

It is hoped that this manual will remain basically correct and helpful for many years. However, changes do occur, and an attempt will be made to record these in a "Master Copy" to be kept in the office of the Crossley dome.

Special thanks are due to J. Baldwin, the Bros. Bregman, J. S. Miller, D. Soderblom and E. J. Wampler for their careful reading of the manuscript and many helpful suggestions; to Bob Wilson of the Lick Observatory Photographic Laboratory for the many fine photographs taken especially for this manual (to which the means of reproduction, dictated by economic necessity, do not nearly do justice); to Rete Greeby for her usual excellent line drawings and for editorial supervision, and to Linda Koski for doing most of the work!

First Instruction for Using the Crossley:

"See if you can do it at Kitt Peak."

– D. Rank, 1974

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No Longer Available

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CHAPTER I

THE DOME: LAYOUT AND FACILITIES

A. General

You will need a "master key" from the diner to admit yourself to the dome. Park your car by the door, in front of the steps and well over to the left. Please do not block the drive which goes on around the dome.

B. Ground level (Fig. 1)

As you come in the inside door, there are two light switches on the inside of the door jamb to your left, higher up than usual. The bottom one is for red lights at the ground level; the other is for a white light on the north pier at the mezzanine level. (There is another switch for the white light on the pier itself, just a few inches below the light.)

The office is used by many observers. Please assist by keeping it neat and clean. All lunch remains must be deposited in the covered garbage can in the entrance way; otherwise rodents and insects will find their way into the dome. If you open any windows, be sure to close and lock them when you leave the dome!

There is a bathroom on the east side of the dome and water in the darkroom in the southeast. DO NOT under any circumstances change the settings of the heat exchanger in the darkroom.

Outlets for the telephone are located in the office just above the desk, beside the main stairs to the mezzanine,and on the telescope itself to the right of the dec clamp wheel.

Beside the mezzanine stairs near the phone jack are two switches. One is for the ground level red lights and the other controls a small red bulb at the top of the mezzanine stairs. Because the construction of this dome presents unique orientation problems, the mezzanine stairs present a dangerous hazard and it is suggested that this small red light be left on whenever possible, at least until you are very familiar with the dome. Notice the two alternate sets of stairs on either side of the south polar axle. These are for use when the mezzanine stairs are covered.

Under the stairs by the office door is an air compressor for the dec preload. It comes on automatically and unpredictably whenever the pressure drops below a certain level, so expect to be startled by it occasionally. It's pretty loud.

C. Mezzanine

As you come up the stairs from the ground floor, the circuit breaker panel (Fig. 2) will be directly ahead of you (if the dome is stowed in its proper position) attached to the dome wall to the left of the slit. The main dome light switches are in the bottom center portion of this panel just above the shutter "Open," "Close" and "Stop" switches (Fig. 3). There are three light switches; the left two are for the dome lights and the right one is for a red light above the circuit breaker panel. The dome lights may also be controlled by two guarded switches on the rail at the top of the platform stairs (Fig. 4).

The dome shutter is opened and closed by the pushbuttons just below the light switches on the circuit breaker panel. These buttons do not need to be held down. If you desire to stop the shutter before it reaches the end of its travel, use the red button. Normally the shutter limit switches stop the motion when fully open or closed. The shutter sometimes binds up, especially when it's very cold and there is ice on the shutter tracks, so it is suggested you stay near the red stop button until the shutter has completed its travel. When all the way open or closed it will (should!) stop by itself. If it has snowed recently, do not attempt to open the shutter unless maintenance (days ext. 51/53; nights ext. 60/61) tells you it is okay. Before the shutter can be opened safely, snow and ice must be removed from the shutter tracks to prevent it from piling up under the wheels and damaging the mechanism. Do not open if there is loose snow on top of the dome which might blow in on the mirror while you work. If in any doubt, check with maintenance.

If the shutter buttons should fail to work, either to open or close, the cause will probably be a rocker limit switch/interlock which has failed to trip. These are located at the bottom of the slit (Fig. 5). The usual failure leaves the center switch level when the dome is open so the shutter does not close. Simply lower the windscreen so you can reach over it and tip the center rocker switch to your left (as you face out the slit), then you should be able to close the dome in the normal manner. If you note these failures in the maintenance log (the log is discussed in Section D below), the maintenance people will know an adjustment is required.

Once you have opened the dome, keep a sharp eye on the weather, which on Mt. Hamilton may go from completely clear to foggy in very little time indeed! Once you have opened the dome, responsibility for protecting the telescope lies wholly with you. For photoelectric work there is usually less reason to worry about stabilizing the mirror temperature than there is for long exposure photographic work, simply because convenient opportunities for refocusing arise more often. Therefore the risk of leaving the mirror exposed and perhaps unwatched for the late afternoon hours is not usually worth it. However, if for some reason you feel you must have the mirror exposed for a few hours before observing, stay alert and in a place where you can observe any changes in the weather; i.e., do not go back to your room and fall asleep! The safest policy is simply not to leave the dome with the shutter open.

The proper stow position for the dome is with the slit pointing roughly southeast, the east dome drive motor within the area marked off with white lines on the floor at the top of the mezzanine stairs, and with the black tape on the dome near the floor (between the dome drive motor and the circuit breaker panel) lined up with the black tape on the east mezzanine floor (Fig. 6).

D. The dome and the platforms

Now we come to the reason for all the fuss about the light at the top of the mezzanine stairs. There is a raised platform in front of the dome slit which moves with the dome and in some orientations may cover all or part of the stairs. Many observers have inadvertently discovered the hazard this presents going either up or down. Legend has it that at least one fairly serious injury has been caused by the long step off of the stairs from the lower platform and down the partially covered stairwell instead of onto the expected solid floor. The writer can attest that walking up the stairs into the bottom of the aforementioned platform will wake one up, no matter how tired and cold. Therefore, it is again suggested you leave on the small red light at the head of the mezzanine stairs, and use the alternate stairs at the south end of the polar axle when necessary.

In addition to the fixed platform just above the mezzanine floor there are two other platforms (see Figs. 22-25). One is fixed at a high level of the dome away from the dome slit. The third platform is movable and runs up and down on an inclined track between the other two. The movable platform (usually just called "the floor" or "the platform") is the one from which the actual observing is usually conducted. All three floors move with the dome when the dome is rotated.

There are various HAZARDS associated with this movable floor, as follows:

1. When "lowering the floor", be sure nothing is on the lower fixed platform, such as your lunch or observing assistant, since the clearance is only a

couple of inches with the floor all the way down.

2. Be very aware that with the floor lowered part way it is a long step into the ensuing abyss between it and the upper platform, or vice versa. Use of the stairs is suggested. It is further recommended that the four nylon ropes provided be used to rope off the passageways at both ends of both the movable floor and the upper fixed floor (Fig. 7). It takes much less time to hook up these ropes than to recover from a broken neck, and what looks like an obvious hazard at 6 p.m. when you're warm may recede from consciousness at 3 a.m. when you're cold. Avoid a permanent recession from consciousness. Hook up the ropes. BUT - don't inadvertently rope the movable floor to the upper fixed floor! It's been done more than once.
3. Guard against lowering the floor from the full up position with the telescope very close to the edge of the movable floor. There is a flange on the telescope tube about five feet down from the top which just fits under the floor (Fig. 8), so if the floor is lowered all that weight is momentarily placed on the tube (bad) and then the floor slips off with a frightening (in the dark) crash and may result in catastrophic failure of the elevator mechanism, if not your heart.
4. When rotating the dome, avoid scraping the tube of the telescope with either the movable or upper fixed platform. The geometry is a bit deceptive, but there's really no excuse for not being careful about such an obvious thing.
5. Since the movable floor is in fact a funicular railroad (really true; examine it closely!) there is a limit to the number of people which can be safely carried on it, namely three. This limit applies only when the floor is in motion. To exceed this number is to court mechanical failure.

There is a black sheetmetal rainscreen at the apex of the dome. It may be moved by the white rope around a big cast iron wheel on the upper fixed platform. Be certain to put the rainscreen back in position above the telescope each morning, as well as covering the top of the telescope itself with a plastic sheet or telescope cover, because the dome leaks badly during storms (Fig. 9).

The windscreen, dome rotation and movable platform are all electrically controlled by a single paddle (the "dome paddle") on the movable platform (Fig. 10). The six buttons on the paddle are well marked in pairs, and are for windscreen up/down, floor up/down and dome left/right (i.e., left and right as you face out the slit). All of these buttons operate only when held down. There are limit switches at the extremes of operation of the windscreen and platform. Always let the dome come to a complete stop before reversing directions. Avoid hanging this paddle on the telescope, thereby connecting the telescope to the movable floor. The paddle usually hangs on a screw beside the logbook counter.

Above the logbook counter on the movable platform is a small control panel with two large rheostats and a number of buttons and switches (Fig. 11). On the right are three white switches. The first (left to right) turns on a red light illuminating the sidereal and PST clocks to the left of the slit. The second enables the two large rheostats on the panel, which independently control red and white lights which illuminate the logbook counter. The third white switch has no function. At the top of the panel are some dome rotation controls. When pressed, these cause the dome to rotate continuously until stopped by the red stop button. Please use these with caution. The relative geometry of the floors and telescope changes in peculiar and sometimes unexpected ways, so it is advisable to use only the dome rotation buttons on the paddle so you maintain better control. On the left are floor up and down buttons which are disabled, and a panel control switch which should be taped "on". Please leave the panel control switch on at all times. It controls the power to all of the other switches on the panel as well as to the dome paddle. If the dome paddle doesn't work, check to be sure this control switch is on before calling maintenance.

Notice that the shelf across the front of the movable platform may be lowered by pulling the handle on the center underside of the shelf toward you. The shelf then rotates back (toward the slit) to two intermediate positions and all the way to the floor, if necessary for access to very low objects (Fig. 12).

On the upper platform is a long plank which may be used to bridge the gap between the upper and movable floors in order to get access to the eyepieces when the telescope is nearly vertical and the slit is east or west.

Finally, each night be sure to fill out the black "Crossley Telescope Maintenance Logbook" kept on the movable platform. This is how the Maintenance Department knows if anything requires repair. If everything works well, so note. At the beginning of your run it may help to read the last few entries so you know what has recently caused problems.

CHAPTER II

THE TELESCOPE

A. General

The Crossley is a 36-inch prime focus reflector ~~(to be increased to 38" in 1975)~~ with an English equatorial mounting. The telescope tube may be on either the east or west side of the polar axle. The "normal" configuration is with the tube on the east side, which is assumed in what follows unless otherwise specified (frontispiece). The nominal scale at the prime focus is 38.6 seconds of arc per millimeter, f ratio 5.8.

B. Balance

The telescope should be balanced (or at least checked) by each observer at the beginning of his/her run. The balance should be checked with the RA and dec motions unclamped and all equipment (cold boxes and such) in position. Balance is checked by pushing and pulling the tube along the appropriate axes and judging if the force is equal or not in both directions. Proper balance is achieved when (1) it is balanced in the dec motion at the zenith, and at the equator it is balanced in (2) dec motion and (3) RA motion. If the telescope is not balanced properly, it will be necessary to adjust the weight distribution. There are photographs in the desk drawer in the office as well as in Figs. 72-77 of this manual which show approximate weight distributions for each instrument. You will often find that the maintenance department has balanced the telescope satisfactorily, but balance is the responsibility of the observer.

Spring scale ?

C. Head rotation

The top 18" or so (the "head") of the telescope tube may be rotated 270°+ clockwise and 90°+ counter clockwise. There is a degree scale along the flange at the bottom of the rotating section and a bright metal index marker on the south side of the tube (Fig. 13). The "normal" orientation of the head of the telescope is with the index marker at 270° on the scale; that is, with the eyepieces south (tube east of the polar axle). Please faithfully return the head to exactly position angle 270° at the conclusion of your run so as not to confuse the following observer. In order to turn the head, there is a locking lever inside the tube at the level of the degree scale, approximately a foot to the right of the eyepieces (Fig. 14). Left is locked, so turn the lever all the way to the right (clockwise) to unlock it and rotate the head to the desired position angle by hand. Relock by moving the lever all the way left.

D. Finder

The finder telescope is a 4" elbow refractor with a field of approximately 2°. It has a press-on dust cover. DO NOT push on the finder to move the larger telescope. East is left and north is down in the finder.

E. Motions

There are no slew motors for either dec or RA; the telescope must be slewed by hand. The dec lock is the 6" metal wheel below the finder telescope (Fig. 15). It requires only a half turn counterclockwise to unlock, and an easy clockwise turn to clamp. The RA clamp is electrically controlled from its own paddle which is usually hanging near the top of the telescope to the right of the eyepieces (Fig. 15). The paddle has two buttons labelled "R.A. CL" (for clamp) and "R.A. UNCL" (unclamp). You must hold these buttons down for 4 or 5 seconds to fully clamp or unclamp the RA. If you listen closely you can hear the clamp operating as you hold the buttons.

The set and guide motions are controlled by yet another paddle (the "guiding paddle" or the "telescope paddle") usually hanging below the eyepieces (Figs. 15 and 16). The guiding paddle is metal and octagonal in shape, with N, S, E and W buttons for guiding and a center button for set rate.

On the sides of the guide paddle are two more buttons for adjusting the RA drive rate (Fig. 16). If the E button is consistently required to keep the object entered, a tap or two on the side button near the E button will slow the right ascension drive oscillator rate; tapping the button on the side of the paddle near the W button speeds up the oscillator.

There is an auxiliary guiding paddle in the upper left corner of the east wall of the office to be used with remote guiding systems (none presently available). If the switch on the wall near the paddle marked "aux" and "main" is in the "aux" position, the regular paddle is disabled and vice versa.

F. Dec tangent arm

The declination motion is limited by a screw which travels in a pillow at the top of the declination tangent arm. This screw is on the polar axle side of the tube about 10' above the polar axle at the top of the tangent arm (Fig. 17). When it reaches a limit in its travel you will get no response from one of the declination buttons. Once this happens, you will have to run the telescope in the opposite direction (i.e., the direction of the only working

TRAVEL=?

dec button) for a long enough time to recenter the worm in its block - perhaps a minute - then approximately recenter the object by unlocking the dec clamp and moving the telescope by hand. Once recentered, one usually doesn't run out of dec travel for another couple of nights. Checking the centering at the beginning of the night may prevent interrupting an observation later.

G. Telescope position indicators

The RA and dec dial indicators are a double bank of dials mounted on the telescope head to the left of the eyepieces beside the finder telescope (Fig. 18). The hour angle dials are similar, and are to the right of the eyepieces (Fig. 19). Each bank of dials has its own rheostat for the dial lights, located on the bottom (that is, underneath) and to the right. Notice that the minutes dial in each case turns one complete revolution in only 30 minutes, not 60. On the dec degrees dial, white markings are for northerly declinations and red is used for declinations south of the equator. On the RA dial, the outside scale is used with the tube east of the polar axle (the usual case) and the inside scale is used with the tube west.

After you have set on a focus star and checked the coordinates, you may find that the RA dials are farther off than is reasonable (perhaps more than a couple of minutes). In this case, you may reset the RA dials by using the portable rheostat on the shelf below the logbook counter. One cord plugs into the 110v. outlet at the bottom of that counter and the other plugs into an Amphenol receptacle at the outside top rim of the telescope about two feet to the right of the eyepieces (Fig. 20). After it's plugged in, be sure the rheostat is all the way down (to zero) then turn on the rheostat power to "low" (upper left switch on the rheostat box) and select "up" or "down" with the upper right switch. Watch the RA dials as you turn the rheostat up from zero; if they don't turn the direction you desire set the "up-down" switch to the other position. Set the dials to the ephemeris coordinates for the star on which you are centered, then turn the rheostat back to zero, power off, unplug and store neatly back on its shelf.

H. Mirror cover

CAUTION CAUTION CAUTION

Never hold things over the top of the telescope with the mirror cover open. It may save 60 seconds not to close the cover when changing diaphragms, exit slots or whatever but the risk is not worth it.

The mirror cover is a plywood slab about 4' above the mirror level. It is operated by 2 buttons (one to open, the other to close) in the center of a grey junction box just to the right of the hour angle dials (Fig. 21). The mirror cover moves only when the buttons are depressed, and the entire motion takes perhaps 5 seconds. If you listen closely you will hear the mirror cover motor. It is advisable to visually verify that the cover has opened/closed completely. If the lights are on you can watch the movement of the mirror cover counterweight arm which is outside the tube on the NE corner at the level of the mirror cover.

I. Reversal

If you wish to observe in the north, you must do something to make the eyepieces accessible, since they are on the south side of the tube when the tube is on the east side of the polar axle. You have two choices. You may rotate the head of the telescope, but for some configurations (e.g., the scanner) this is somewhat inconvenient because of the many cables which tend to get hung up during the rotation. Or you may "reverse the telescope," which means to move the tube from the east to the west side of the polar axle. One effect of this maneuver is to rotate the entire tube 180° clockwise about its long axis so the eyepieces are on the north side.

Reversal is most safely done with the dome lights on, and lights are therefore recommended as part of the normal procedure. The reason is that care must be exercised to avoid pulling out cables, especially on the many protuberances of the north polar axle and north pier. Be careful also not to let the cables break the north pier light.

To reverse the telescope the dome is moved from south through west as the telescope is brought down to nearly six hours west at the equator, so it is nearly parallel to the floor, and lying across the top of and perpendicular to the polar axle (Fig. 22). (Do not actually go to a zenith distance greater than 75° or the mirror may tip and a supporting pad may fall out - it has happened and tends to ruin the rest of your run since a good focus is then impossible.) Next, as you rotate the dome west through north, rotate the telescope tube about the declination axle only, so that when the dome is north the tube is right on top of and parallel to the polar axle (Fig. 23). Continue to rotate about only the dec axle for another 30° or so toward the east to get a large enough angle between the tube and the polar axle so you have some leverage, then push the tube so as to rotate the polar axle toward the west (Fig. 24). This will bring the telescope down on the west side of the polar axle (Fig. 25) and reversal is complete.

In addition to the hazard pointed out above concerning the cables, be careful not to start any movement in RA when the tube is parallel or nearly parallel to the polar axle, because you may have insufficient leverage to stop such a movement. This is especially true if the telescope is improperly balanced.

Many observers experience some disorientation the first time they use the Crossley, particularly during reversal. The polar axle provides a ready reference since the high (north) end always points toward Polaris. Remember to use the inside scale of the RA hours dial when the telescope is reversed. Any time you get confused about which scales to use or which way to read them, simply move the telescope a small amount in a predetermined sense, say north and west, and notice which scales indicate the motion correctly.

Although reversal perhaps sounds complicated, after you've done it once or twice it's easy and you will probably find that with some instrument configurations it's faster than fighting tight cables to rotate the head.

J. Is the telescope pointing out the slit?

The Crossley mounting often makes it difficult to tell if the telescope is being occulted by the edge of the dome slit. The safest way to assure yourself all is well is to go down and sight up the telescope tube from the bottom. If you do this a few times you will soon acquire confidence in your sense of where the telescope is pointing as seen from the top. Another way to tell is to sight out of the slit along an edge of one of the junction boxes at the top of the telescope, if that edge is itself parallel to the telescope tube. Since the telescope drives east to west, sight along a parallel edge on the east side of the tube and put the east side of the dome slit close to the tube. This gives you the maximum clear slit to drive toward in case you get busy and forget to recenter the dome.

K. Access ports

If you should drop something down the tube onto the mirror cover (which you were very careful to close before you got to a place where you even might drop something down there), you may reach in through the access ports located in the square section of the tube about 5 feet above the bottom and above the mirror cover (Fig. 26).

On rare occasions the mirror itself will frost over. DO NOT UNDER ANY CIRCUMSTANCES TRY TO WIPE ANY MIRRORED SURFACE WITH ANYTHING. But you may open the mirror cover and open all the access ports on the lower portion of the telescope to encourage circulation and consequent evaporation of the frost.

Use of a portable blower or a fan will speed the evaporation, but avoid any drastic changes in mirror temperature. This is a rare phenomenon you are not likely to encounter.

L. RA drive preload and master switches

There are just three switches in the office downstairs that every observer is concerned with. The master switch (or "main switch") turns on power to the drive motions, dome paddle, etc., and is the left of two switches on brass plates at eyelevel on the east wall of the office (Fig. 27). This may ordinarily be left on. The RA preload (the other switch on a brass plate next to the master switch) and the RA drive oscillator should be turned on just before actual observing and off at the end of the night. The oscillator is in the electronics rack in the southeast corner of the room (Fig. 27). It is the piece of equipment with the large (~5") black and blue-gray dial in the upper left hand corner. The only switch to activate is a toggle switch in the lower left corner; just flip it up for on, down for off. In 30 seconds or so you will hear the RA drive start up in the south polar axle housing and the meter on the oscillator will register about 110 volts.

On the floor in the northeast corner of the office is a cable with a switch on the end. The switch may be used to turn the drive oscillator on and off from upstairs in order to drift the telescope across objects at sidereal rate.

M. Operating limits

1) Zenith distance: $< 75°$ to avoid tipping mirror as described in Section I above.

2) Relative humidity: close the dome at 95% Rh or earlier if necessary to exclude any and all moisture from the dome. In particular be alert for sudden and unexpected fog formation and do not leave the vicinity of the dome if it's open without being very alert for any sudden change in the weather. If you can see moisture in your flashlight beam, or if wooden surfaces and papers get wet; close!

3) Wind: no explicit limit, but when leaves and twigs start blowing in perhaps you're pressing too hard. Usually before that happens, the tube will shake too much for reliable observations anyway.

N. New Telescope Drive (R. A. and Dec)

NOTE: THIS SECTION SUPERSEDES SOME OF THE INFORMATION IN II. E AND II. L.

The telescope is now driven by stepping motors in both right ascension and declination.* The motors are controlled by the octagonal paddle described in section II. E and by switches on a control box mounted on the head roughly 90° to the right of the eyepiece. In both coordinates there is a choice of track or drift (fast track) rates, three selectable guide rates, and one set rate. The guide rates are controlled by the N-S-E-W buttons on the paddle and by the F-M-S (fast, medium, slow) selector switches on the control box. The set rates are controlled by hitting the N-S-E-W buttons plus the center button on the paddle. The R. A. track rate can be adjusted with the buttons on the side of the paddle. The drift rates and the dec track rate are adjusted with pots on the control panel.

The rates are approximately as follows:

RATES (arc-sec/sec)

	R.A.		Dec	
Drift	4-62		0.2-9	
Track	12-20		0.06-0.8	(fast)
			0.006-0.07	(medium)
			0.0006-0.008	(slow)
Set	45*	174 Hz West 87 Hz East	38 140 Hz	
Guide	8*		8	(fast)
	4*		4	(medium)
	2*		2	(slow)

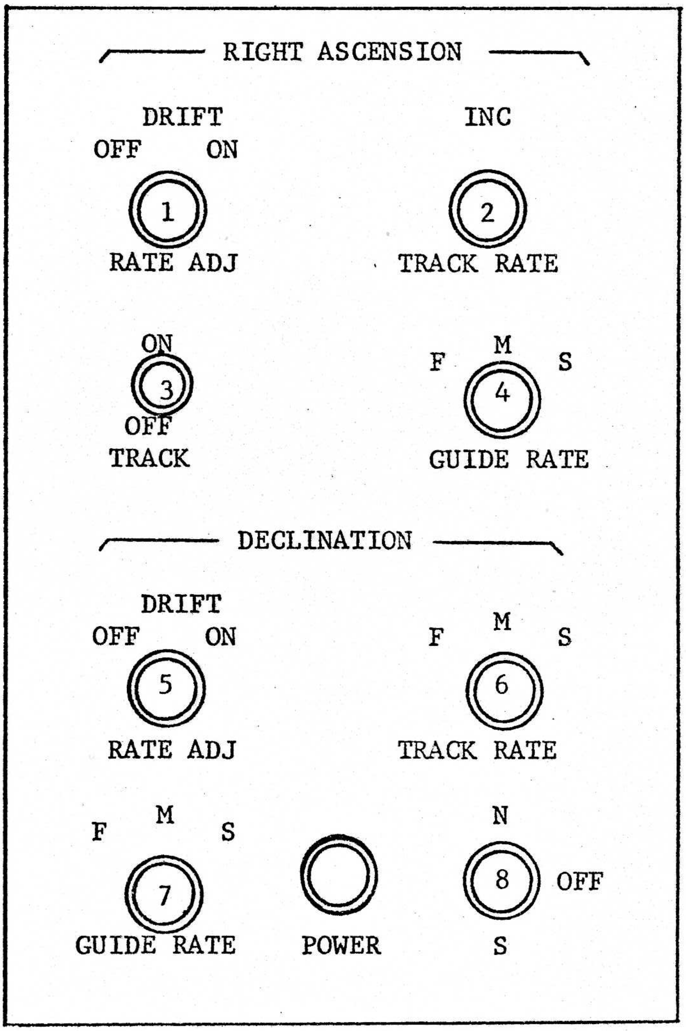
*Relative to sideral rate.

The Master Switch and the R. A. preload switch in the office must be turned on.

* RA: 1 step = .344 arc-sec
Dec: 1 step = .27 arc-sec

45
15
60 "/sec ÷ .344
174 Hz

The control panel switches are used as follows:



Switch
R.A.:

1. Selects Drift (=on) or Track (=off), plus pot to adjust drift rate.
2. Ten-turn pot to adjust track rate.
3. Turns track rate on and off.
4. Selects fast, medium or slow guide rate.

Dec:

5. Selects Drift (=on) or Track (=off), plus pot to adjust drift rate.
6. Selects fast, medium, or slow track rate, plus pot to adjust drift rate.
7. Selects fast, medium or slow guide rate.
8. Enables North or South Drift or Track. Center position is off.

CHAPTER III
THE PRIME FOCUS SCANNER

A. Description

1. General

The Wampler prime focus spectrophotometer (hereinafter called "scanner") was designed primarily for the 120-inch telescope. It consists basically of a collimator which provides a 3.75-inch beam, a 600-groove/mm grating driven by a stepping motor and a 20-inch camera (Fig. 28). The dispersion is 16.3 Å/mm in the second order; filters are used to separate orders. Diaphragms limit the sky entering the instrument for observations of stellar objects, or entrance slits may be used for nebular observations. Bandwidths passed to the photomultiplier are determined by exit slots.

Photomultipliers presently available are FW-130s for the "blue" (3200 Å to ~ 8400 Å) and FW-118s for the IR (~ 6000 - 12000 Å).

From the photomultiplier, the signal goes to an amplifier/discriminator mounted on the cold box and then to the electronics on the movable platform. The electronics automatically cycles through a preselected program of wavelengths, stopping the grating for a predetermined integration time (or "dwell time") at each wavelength. The pulses from the amp/disc are counted for the integration time and then printed on a "grocery tape" and/or punched on IBM cards. An alternate mode allows counting to a predetermined number of counts and recording the time required at each wavelength.

The Crossley installation is essentially the same as the 120-inch one. The auxiliary equipment is duplicated at both places. Thus, the only thing for which spares do not exist is the scanner itself; that is, the equipment supported by the spider exclusive of cold box and amp/disc.

In what follows, "left" and "right" sides of the scanner or telescope are with respect to an observer standing in front of the eyepieces and facing the telescope.

2. Scanner

a) Diagonal mirror and pellicle

The first thing the light encounters as it enters the scanner from the bottom is the diagonal mirror. The mirror has 3 positions, controlled by a flat ended chrome rod protruding low on the right side of the scanner (Fig. 29). If the rod is pulled all the way out, there is no obstruction in the path of the light and it passes on up unimpeded. In the middle (detent) position the light strikes a front surface mirror and is entirely deflected out to the field eyepiece (east to the right, north down). This is the appropriate position to use in order to focus the telescope and identify your object, and it can act as a dark slide. With the rod all the way in, there is a pellicle in the light path which gives you two 4% images at the eyepiece and passes 92% of the light on through. Unless your object is extremely faint and there is nothing else to guide on, the two 4% images are usually the best to use since it allows you to monitor the guiding while observations are being made. Whichever you choose, guiding images or none, it is ordinarily desirable to observe your standards in the identical mode.

b) Filters

The order separating filters are carried in a slide just above the diagonal mirror. Whereas the mirror handle has the smooth, chromed, flat ended handle, the filter slide has a knurled cylindrical handle (Fig. 29). This is important to know so you can identify them easily by touch. There are six positions for the filter slide, five of which are useful and read out on a meter on the electronics rack. All the way out is not a valid filter position, and the light beam is obstructed by the end of the filter slide. In one click is filter #1, two clicks is filter #2, etc. Filter #3 is with the end of the filter slide handle even with the black box just above it, and filter #5 is all the way in. It is best to set the filter carefully by number of clicks and position of handle, then use the meter to verify your setting. The meter occasionally reads incorrectly due to static charge on the faceplate. The useful wavelength ranges for the filters are as follows:

Filter No.	Type	λ	
1	Cu SO_4 + UG2	3000 - 3400	2nd order
2	Cu SO_4	3200 - 5200	2nd order
3	BG 23	3800 - 5400	2nd order
4	GG 14	5200 - 9000	1st order
5	RG 5	6500 -12000	1st order

The manufacturers response curves for these filters are presented in Appendix C. Please do not take the filter slide out. They are well protected from dust in the scanner and are checked periodically. It is felt that the best interests of all observers will be served if everyone avoids tampering with the filters unnecessarily.

c) Entrance apertures

The entrance apertures are carried on long slides (Fig. 30) which fit into a receptacle on the left side of the scanner (Fig. 31). They are held in by a spring loaded clip which pulls out against the spring and rotates in either direction to clear the slide: then the slide may be slid in or out freely. The slides are bevelled so the correct side must be up; namely, the wide side. Do not fail to replace the clip after putting in a new slide to be sure it is driven home and so it won't fall out on the mirror! There are single and two-channel round entrance apertures, usually stored in the black and red anodized boxes, respectively. There is also a wide selection of slits which may be in either box. The boxes are usually on top of the electronics racks or on a shelf nearby.

Here are the aperture sizes now available:

Single Channel	Two Channel	Slits
0.25 mm	0.5 mm	0.275 x 1 mm
0.35	0.7	0.5 x 1
0.53	1.0	0.2 x 2
0.80	1.3	0.5 x 2
1.09	1.5	0.6 x 4.5
1.71	2.25	0.9 x 4.5
2.87		1.8 x 4.5
4.00		0.09 x 5
		0.2 x 5

d) Dark slide

After passing through the innards of the scanner (collimator, grating, camera) the light next encounters the dark slide. It is opened and closed by a knurled knob at the top right rear of the scanner (Fig. 32). To open, pull out (~ 1"); to close, push in. When it is closed, the red light marked "dark slide" on the scanner control console is lit (Fig. 47).

e) Exit slots

The exit slots (Fig. 30) are usually all kept in the black anodized box with the single-channel entrance apertures. With some exceptions they are of two lengths, 3 and 5 mm, as shown here:

0.2	x 2 mm	0.125	x 5 mm
0.101	x 2.5	0.2	x 5
0.4	x 3	0.4	x 5
0.6	x 3	0.6	x 5
1	x 3	0.8	x 5
2	x 3	1	x 5
3	x 3	2	x 5
3.75	x 4.125	2.4	x 5
		3	x 5
		4	x 5

For the two channel system the 5 mm exit lengths <u>must</u> be used to ensure an unocculted beam to both channels. The width of the slot determines the spectral bandpass, at 16 Å/mm in 2nd order and 32 Å/mm in first order. The wheel for the slots is at the top left rear of the scanner under a hinged cover. The cover opens to expose about a 90° segment of the exit slot wheel (Fig. 33). There are four positions on the wheel 90° apart. The exit slot positions are numbered 1 to 4 by serrations in the rim of the wheel (e.g., three serrations for exit 3) and by the meter on the console marked "exit slot" (Fig. 47). As before, set the slot by reference to the serrations and then cross-check the less reliable meter. Notice that the numbers refer to the slot which is in position <u>in the beam, not</u> to the position accessible at the open cover. The accessible slot is 180° from the indicated slot. Thus, if you feel 1 serration and the meter indicates 1, the slot now accessible is slot 3; if you feel 4 serrations, the accessible slot is number 2. Any size slot can go in any slot position. Notice the slides are bevelled; they go in with the wide side down. It is up to you to log the exit slot sizes and positions so six months hence you know what you used. Only the exit slot position number is automatically recorded on the fixed data cards (paragraph A.5.m below). Be sure to use the hinged slot cover to avoid light leaks.

f) <u>Other scanner controls</u>

There are three other controls on the scanner whose function you may wish to know even though it is unlikely you will ever use them. These are two toggle switches and a rotary switch mounted on the top of the black box on the right side of the scanner (Fig. 34). The rotary switch controls the slew rate for the grating. It is normally left at maximum (100 Å/sec) to waste as little time as possible between integrations. To the lower left is a toggle marked "auto/man." The normal mode is auto, when program wavelength extremes ("endpoints") are sensed automatically and grating direction is reversed at those wavelengths. In manual, program endpoints are not sensed and grating reversal, if desired, is accomplished with the other toggle switch to the right of the grating slew speed control. Again, you will probably not have any occasion to use these switches. You may save some grief for the observer following you if you leave these switches in their normal positions (auto, max grating speed).

g) Wavelength calibration: mercury lamp

At the bottom right rear of the scanner is an indented box with a chrome rod and a toggle switch (Fig. 29). This contains Hg and Ar lamps to calibrate the wavelength setting of the grating. Turning the toggle switch to the right turns the lamps on; pull the chrome rod out for Hg, leave in for Ar. The pellicle must be in the middle position so the lamp sees the back of the mirror and is deflected up into the scanner optics. The scanner dark slide must be open. The usual reference lines are Hg I λ4358.3 with filter 3 or λλ5770 and 5791 with filter 4. A small entrance (0.8 mm or smaller) and a small exit (0.125 mm) will make the check more accurate. Using the entrances and exits suggested, one can for example make a program (paragraph A.5.h) to scan every angstrom from λ4349 to λ4370 and back, and the peak should be at λ4358. If it is not, but it falls at λ4355 for example, one programs all of ones planned wavelenths λ_o as λ_o-3 Å to correct for the grating offset. This discrepancy should be noted in the maintenance log so it can be corrected by the maintenance crew. After calibration, be sure to close the scanner and Hg dark slides and turn off the lamp.

Don't try to use the Hg lamp as a source of standard intensity; it varies wildly.

h) Cold box adapters

On the top rear of the scanner you will normally find a 4" round plate flush mounted with a small chrome snap cover in it (Fig. 35). This is the "single-channel adapter". The hole accepts the ring around the Fabry lens of the single channel cold box, and the adapter incorporates a hot collar to prevent moisture from condensing on the lens.

If you desire to use the two-channel system, use a 7/64" Allen wrench (usually to be found in or on the grey table on the upper fixed platform) to remove four Allen screws holding the adapter to the scanner. Lift out the adapter plate, using the two brass screws from the two-channel adapter in the round brass can marked "P.F. Scanner beam splitter" which is stored in the steel grey cabinet in the office. Using the 2 brass screws as handles, very carefully lift the beam splitter out of its can. Be very careful not to touch the glass either above or below. Orienting the lenses from side to side with respect to the scanner and paying attention to the final position of the hot collar contacts lower the beam splitter into position and put in the 4 Allen head screws. Finally remove the two brass screw handles (Fig. 37) and put them in the single-channel adapter in the beam splitter box.

DO NOT leave the beam splitter exposed during the day. Tape an IBM card over the lenses. DO NOT leave the beam splitter in the scanner at the end of your run. Always replace it safely in its gold box and replace the single-channel adapter. Store the beam splitter in the steel grey cabinet in the office.

i) General caution

DO NOT under any circumstances try to get into the interior of the scanner or try to make any adjustments or changes except as described above.

3. Photomultiplier and amplifier discriminator

a) Photomultipliers

The photomultipliers (Fig. 38) are normally stored in the office, but are sometimes left on the upper fixed platform. The single-channel FW-130 and FW-118 are in plain aluminum boxes. There are two pairs of two-channel FW-130s, one pair in a gold anodized box and one pair in a blue anodized box. The two-channel FW-118s are in a black anodized box. You will find two other types of photomultipliers around, not normally used with the scanner; a two-channel FW-129 (S-11) in a green anodized box and a single channel EMI 9658 A (very hot S-20, but high and very irregular $\sim 100 \pm 75$ cts/sec dark current) in a plain aluminum box. All boxes are labelled with tube type and recommended high voltages. The single-channel boxes contain the hottest (most quantum efficient) tubes, but in instances where the sky is anticipated to be a large portion of the signal or must be monitored continuously, the two-channel boxes may be preferred.

b) Amplifier/discriminator

The amp/disc is an aluminum box about 2/3 the size of a shoe box (Fig. 38) usually found on the upper fixed platform or in the office. Its function is to discriminate against the very small pulses which originate as thermal noise in the amplifier, and to amplify and shape the remaining photomultiplier pulses so they may travel down the signal cables to the counting electronics without being attenuated out of existence. Discrimination is accomplished by biasing of a tunnel diode.

c) Mounting

Pour any water and alcohol out of the cold box you choose. The amp/disc is mounted on the cold box of your choice by putting the mounting plates together, and fastening with the captive screws on the cold box mounting plates (Fig. 39). A long-handled Allen wrench (Fig. 38) is on or in the grey table on the fixed platform for this purpose.

Next find a solid silver-colored coax (or two if required for a two-channel box) in the drawer of the grey table on the upper fixed platform, to go from the cold box to the amp/disc. (The solid coax is just highly insulated to protect the tiny signals out of the cold boxes against noise until they are amplified by the amp/disc.) Pick a solid coax that is already the correct length and shape. DO NOT BEND THEM. They eventually break, degrading the shielding and sometimes even introducing spurious counts. If you don't screw up your own data you may screw up someone else's later, so avoid any unnecessary bending. UCSC observers: if you use single channel and plan to use the O'Connell reduction program, be sure to use Ch A for data output (program requirement).

The cold box/amp/disc are mounted on the scanner as a unit (Fig. 40). Be sure the appropriate single or two-channel adapter is in the scanner, and verify the hot collar is working (adapter should be warm to the touch). Then place the cold box on it with the amp/disc facing to the front of the scanner, carefully setting the cold box on the adapter so the raised ring around the lens(es) slip gently into the appropriate hole. The box is held to the scanner by the four captive screws at the base of the box. Firm finger-tight is sufficient.

Locate four cables hanging inside the telescope tube and hook them up as follows. Two signal cables (black coax) marked "A" and "B" go to the respective BNC connectors marked "A" and "B" on either side of the amp/disc. One "blue ribbon" connector which comes from a red anodized finned box on the outside of the telescope (a power supply) goes to the right bottom of the amp/disc. Finally a black coax cable with a 1" x 1" x 2" silver box on the end (a filter) attaches to the high voltage connector on the cold box (Fig. 40).

d) Setting the discriminator level

With all cables connected and power switches on (see paragragh A.5.a below) except high voltages, turn the switch on the front of the amp/disc to the ± 12 volt positions. A meter reading of 70 to 80 should result. If outside of this range, note the discrepancy in the maintenance log and get another amp/disc (usually in the Crossley; if not try the 120-inch and log the removal!). Set the dial on the front of the amp/disc to Ch 1 (≡ Ch A) or Ch 2 (≡ Ch B) and turn the corresponding ten turn pot on the side of the amp/disc until a full-scale deflection results. Then turn the pot counterclockwise until the meter just reads zero. Note the pot reading (for example 810) and back it off 20 units (to 790). Lock the pot. Repeat for the other side (other channel). If you forget to do this before turning on the high voltage and icing you can do it after the tubes are fully cooled and dark current is a minimum.

There is one amp/disc which has red buttons on the side instead of the pots. The discriminator level is preset and no adjustment is necessary. Just check ± 12 volts for equal deflection, press each button to be sure oscillation occurs, and you're all set.

e) High voltage and icing

The icing procedure differs for the blue cells (FW-130s) and the red cells (FW-118s). In general, ice in the late afternoon, top it off just before observing and check it and top it off again if necessary at midnight.

i) FW-130

The high voltage power supply is in the office on top of the rack containing the RA oscillator (Fig. 27). There are two switches and a knob. Before turning on the high voltage (HV) be sure the knob is turned all the way counterclockwise (minimum voltage). Turn on the left toggle switch which allows the filaments to warm up, then in 30-60 seconds turn on the right switch which turns on the HV. Slowly advance the high voltage to the figure indicated on the side of the cold box you're using. Notice the voltage dial is marked 50 v/division. If you should check the voltmeter after some time you may notice it reads ~ 30v higher (due to warmup: it is stable in 30-60 minutes). DO NOT reset the voltage if you have already started observing!

Dry ice is in the icebox on the ground floor to the west of the front door. Carry it in the styrofoam bucket usually left on the upper fixed platform (Fig. 41). There is only one scoop which is usually found upstairs also. After the HV has been on 15 minutes, fill the cold box with dry ice using the brass funnel and wooden dowel (for packing) found on the fixed platform (Fig. 42). If you are using the two-channel boxes, use the adapter on the grey table to fit the funnel to the box (Fig. 41). Some observers like to add alcohol (in a plastic squeeze bottle on the upper platform) to make a slurry, ensuring good thermal contact between the dry ice and the walls of the cold box. It should hardly be necessary to add that the mirror cover must be closed, and be careful not to let ice fall down the tube. Allow two hours for cooling.

ii) FW-118

The icing procedure for the red cells differs from that for the FW-130 in the following way. Turn the HV up only to 1000 volts initially. Then wait, ice, etc., as usual. After icing is complete, observe the dark current until it stops at 1000 volts, then proceed to turn the voltage slowly up to its final value. The reason for this is that the dark current of the FW-118s is inherently very high, and might damage the tube if the HV is turned all the way up before cooling. Except for this caveat, the procedure is the same. The FW-118s take 2 hours to cool down and need the alcohol slurry!

Section iii) Deleted

iv) At the end of the night

It is suggested you remove the cold box from the telescope. If you wish you may keep it iced, but there is always the possibility of a power failure while you're sleeping that you don't hear about, or an unsupervised visitor pulling the darkslide or . . . . . If you just turn the voltage off but leave the box on the telescope, there is a possibility of condensation on the box which may drip down into the telescope. Again, it is suggested you remove the cold box from the telescope.

4. Scanner controls on the telescope tube

a) Reticle illumination

The intensity control for the reticle is on a small grey box attached to the top of the telescope tube just behind the finder scope. The box has a plug, a red light, a knob, and a red and a black button (Fig. 18); the knob is the reticle intensity. The reticle is illustrated in Fig. 43. The diameters of the rings, from inside out, are approximately 20, 30, 40, 60 and 120 seconds of arc. Notice that one of the crosshair ends is enlarged. This is the dimension which is parallel to the blaze of the grating. Thus, although care should always be exercised in guiding, it will be more disastrous to let a star drift perpendicularly to this line than parallel to it, because a change in the effective wavelength of observation results. Offsets for the reticle are not available; it is fixed.

b) Focus

The red and black buttons just below the reticle illumination knob are for scanner focus (Fig. 18). This is accomplished by a small motor on the bottom of the scanner which moves the whole assembly up and down on the spider. It is not possible, in normal use, to perform a Foucault knife edge focus test because one cannot look through the diaphragm. Therefore one simply focuses for the sharpest image of a bright star, seen through the field eyepiece in the field mirror (middle position of pellicle). The result should be very nearly the same from either method. You are asked not to refocus the field eyepiece; it has been taped to prevent this. You will find the focus motion is slow, and a good firm push is required to activate the buttons.

c) Hot collar

The hot collar rheostat is a military surplus unit located just below the box with the focus buttons. Its knob is barely visible behind the diagonal mirror of the finder in Fig. 18. It is usually left on and with the knob pointing to about a 9 o'clock position. The small red light on the box with the focus buttons indicates the hot collar is drawing current. It should be lit, at least dimly. It is good practice to check the adapter plate for warmth with your hand before mounting the cold box to be certain the hot collar is doing its job.

5. Electronics racks and keypunch

a) General

There are two racks of electronics on the movable platform each of which is turned on with a "rack power" toggle switch on a 1-1/2" rack panel about a foot above floor level (Fig. 44). All the other power switches on both racks (except the paper tape printer) are left on, so everything turns on and off with the rack power. These should be turned on at least a couple of hours before observing, and in cold weather you may wish to leave them on throughout your run. The keypunch on the upper fixed platform also requires a couple of hours of warm-up. It turns on and off with a switch on the front of the right sidewall of the keypunch below the counter (at knee level).

In what follows, we discuss first the left rack equipment top to bottom, then the right rack top to bottom, and finally the keypunch.

b) Card reader

The card reader (Fig. 45) must have a "master card" in it if you use the keypunch. The master card must have 3 data fields, for star name, RA and dec respectively, occupying columns 1-30. The format is 10 columns, space, 10 columns, space, 8 columns. Characters used may be numbers, + or -; no letters or blanks are allowed in the data fields. All 3 fields are punched on the fixed data cards at the beginning of each scan, and the star name (1st field) is punched as the first field of every data card. A sample of a master card for η Hydrae (HD 74280) is shown in Fig. 46.

The card is inserted in the card reader with the handle pulled out, face up, 9 row (bottom) first. Be sure the top of the card is down below the lip of the chrome plate at the front so the card is flat against the reading sensors, then push the handle all the way in. If the card is being read properly, the red light next to the handle will come on. To get the card out, pull the handle out sharply.

c) Punch interface logic chassis

The chances are you will never have to do anything on this chassis (Fig. 45). The "equipment selector" switch in the lower left corner should always be on 1 for scanner - no other equipment uses this rack. The "card fixed data" toggle switch should always be on, and the square black pinboard should always have 8 pins in it. There is no reason any of these should ever be in any other condition. The pinboard determines the order in which information is punched on the fixed data cards. Since the extant reduction programs anticipate the format as now programmed on the pin board it should not be changed. The red lights in the upper left will light up in sequence as the appropriate information is punched on a fixed data card.

d) Paper tape printer and tape format

The controls for the printer are well marked and largely self-explanatory (Fig. 45). The printer should always be on when the punch is working. If you don't wish to have the tape, leave the printer on but press the "inhibit" button. The green "on" light is very bright, so it is best to leave it pulled out far enough so it doesn't work. When the printer is first turned on, press "print once" once to reset the logic; otherwise it may fail to print. The silver block next to the paper dispenser is a clutch. If it is pressed down, the paper is released from the drive mechanism so you can pull it out freely by hand. Usually it is just as convenient to use the "paper advance" button.

Spare paper tape is usually to be found in a cardboard box in the bottom of the steel grey cabinet in the office. If there is none there (better check before the night begins!) there is more in the southwest corner of the shop building just east of the diner. To put in a new tape, turn off the printer and unlock the two black locking knobs in the lower corners of the printing section and slide the whole section out. Place the new paper tape in the bin and slide the top end of the tape forward under a thin horizontal shiny metal plate and then under the back end of a vertical triangle which hides the drive wheel. When the paper is contacting the drive wheel, turn the printer back on and use the "paper advance" button to drive it on out. Close and lock the printer. After the first time or two, the whole procedure will take less than 60 seconds.

The paper tape printer prints three lines per integration; the first (as it feeds out of the printer, i.e., bottom to top) has the wavelength and dwell time, the second shows counts in channel A, and the third line shows counts in channel B like this:

00075143	(star in Ch B)
00000057	(sky in Ch A)
04358003	(λ4358, 3 secs)

e) <u>Program connectors</u>

These fill up the bottom of the left rack under the desk, and there will probably never be any reason to be concerned with them. There is only one switch (except for the rack power) and it should be left in the "Fixed Data Panel Program Connector" position.

f) <u>Scalar</u>

The scalar (Fig. 47) consists of two independent units, channels A and B, which can count 9,999,999 without ambiguity. The power is normally left <u>on</u> so it goes on and off with the rack power. Normal input sensitivity for the scalar is 500 mv. The "start-stop" toggle switch opens/closes the gate manually if desired for monitoring dark current, locating the diaphragm center or whatever. The gate may be closed (reset) as well with either of the two red buttons below the gate lights. The gate lights are on whenever the scalar is counting. The toggle marked "A, A and B, B" is used to enable either or both channels of the scalar. Finally, the "function" switch is used to select "count" (i.e., normal operation) or "test". To use the test function, disconnect both inputs, set the discriminator levels to 100 mv and open the gate (start-stop toggle to "start"). Both channels should count the internally generated pulses equally. If they do not, one or both channels of the scalar may be faulty.

g) Wavelength, filter and exit readout (Fig. 47)

The wavelength readout is always in second order angstroms. The filter slide and exit slot meters read the numbers of the filters and exits directly. Occasionally they get a static charge on the glass which causes them to read incorrectly.

h) Wavelength program board; programming

There are two program boards which slide out for programming (Figs. 47, 48). A program is a group of wavelengths which you intend to scan together and for which the filter, exit slot and integration time are the same. Each program must have its highest and lowest wavelengths designated by pins in the appropriate far left hand columns (marked "high" and "low"). These pins cause the direction of grating rotation to reverse so the scanner stays within the current program. Each program must have a unique program number designated with the red pins in the five right hand columns. The programs are later selected with toggle switches (see paragraph i below) corresponding to these program numbers.

The program itself may occupy any lines anywhere on either board. There is no requirement to stay on one board or to use consecutive lines. Normal programming is done with the thin ("straight") pins. For example, λ4358 (Hg calibration line) would require a thin pin in the 4 column of the thousands section, one in the 3 column of the hundreds section, etc. The thick pins ("diodes"; that's what's in them) allow doubling up. That is, more than one wavelength can be put on the same line. If you want to program, say λ3500 and 3600, use thin pins for the 3 and the two zeros as before, but use diodes in both the 5 and 6 column of the hundreds section. The scanner will then stop at both wavelengths and you have used only one line. There is no restriction on how many wavelengths may be placed on a single line, but doubling up is not permitted on lines which designate endpoints.

The program illustrated in Fig. 48 will scan every wavelength from λ4349 (designated low endpoint) to λ4370 (designated high endpoint), to scan across Hg λ4358 and calibrate the wavelength setting of the grating readout. The pins at the right show this is program number 5.

All programming is done in second order angstroms, so first order wavelengths must be divided by 2. The limits of grating travel in second order angstroms are 2514 and 6499, so your program should be within these bounds.

The pins are kept in two wooden boxes on or near the electronics racks. Please keep them segregated; e.g., thin, thick white and red each in their respective bins.

It is possible to select subsets of programs. For example, suppose you wish to do program 1 consisting of 30 wavelengths on a program star, but you need do only 5 of those 30 wavelengths on your standard stars. You might designate those 5 wavelengths as program 21. Then when program 1 was selected any wavelength for which a 1 was programmed in the program columns would be scanned, but if you selected program 21 only the subset of 5 wavelengths would be scanned. The scanner does <u>not</u> distinguish, e.g., programs 12 and 21.

You will save yourself grief later if you <u>check your program</u>. This is done by selecting printer only (see paragraph j below) and inhibiting the printer (so as not to waste paper). Select a short integration time (paragraph i) of one or two seconds, select each program in turn and scan through it, checking the wavelength readout against your wavelength list to ensure you programmed everything correctly (including proper designation of endpoints).

Please remove all pins from the program board at the end of your observing run; don't make the next observer clean up after you.

i) <u>Digiswitch panel</u> (Fig. 47)

The four sets of digiswitches (or thumbwheels) are for information which will be recorded on the fixed data card at the beginning of each scan. The four sets are for star name, dec, hour angle and dwell (integration time). Of these, only the dwell time actually is a control function, and it must not be changed during a scan. The others may be changed at any time. The star name switches are often used instead to record a two digit scan number in the first two columns and a star-sky code (1 = star, 0 = sky for single-channel; 1 = star in A, 0 = star in b for two-channel) in the last column. Use of these switches will depend on what's required by the particular data reduction program you plan to use.

Below the digiswitches on the left are four buttons. The "start/stop" button controls the scanner grating motion and so starts and stops the scan. The "increase/decrease" button determines the direction (in wavelength) the grating will travel initially. If the current wavelength readout is 3000 and your program runs from λ4500-λ5000, you will of course want to be on "increase" before pressing "start". (Occasionally the grating will start then "stick" before it reaches the program. Press stop, then start again.) The third button is "enter fixed data". Pressing this will cause a fixed data card to be punched from the master card, the digiswitches and the filter and exit slot readouts. A sample is presented in Fig. 52 and discussed in section m below. The fourth button is "general reset" and should be pressed whenever you change the dwell time or if "something doesn't look right". If you fail to press it after changing dwell time, it may use the old one or the new one or an infinite one. If you press it when a card is <u>partway</u> through the punch, the electronics will not know where the card is but it will know it is not in the usual starting position. It will be necessary either to go up to the keypunch and position a new card by pressing the "release" button, or to press the "enter fixed data" and "general reset" buttons alternately (a few zeros will punch each time) until a new card feeds in.

Next to these four switches are the five toggle switches for program selection. To select program 51, for example, switches 5 and 1 should be <u>up</u>.

Finally, the red light marked "dark slide" is lighted if the dark slide is closed, and the "card fault" light is lighted if there is not a card in position to be punched (due to a jam or the input hopper being empty) or if the output hopper is full.

j) <u>Punch control panel</u> (Fig. 49)

The toggle switch at the left of this panel is very important. It is marked "photometer/polarimeter" in one position and "scanner" in the other position. If this switch is set to the wrong position you will be unable to enter fixed data. The next switch is the printer/punch selector. In "printer" position only the printer will operate, but in "punch" position both operate unless the printer is on "inhibit." Anytime you change this switch, press the small black "general reset" button next to it. On the right hand side of this panel are two toggle switches which are down for normal operation. If both switches are up, the grating will step in increments of 0.2 Å between integrations. If the right hand switch is up, the grating will not step at all, and repeated integrations will take place at the wavelength you are set to. This is useful for monitoring the sky. The toggle switch and BNC connectors in the middle of the panel are used for the "time to counts" mode of operation described in Section a.6 below.

k) Power supplies (Fig. 49)

The remaining equipment under the desk in the right rack are five power supplies which are always left on so they go on and off with rack power.

l) Keypunch

The power switch for the punch (on the upper fixed platform) is on the front of the right sidewall of the punch, below the desk. All four switches on the top of the keyboard should be up, and the auto feed switch at the top of the output hopper should be down (on). Load cards, and use the feed and release buttons to feed 3 cards. Then it is only necessary to keep the in hopper full and the out hopper empty. One idiosyncrasy of this punch is that if you let the pressure plate for the in hopper come forward too fast, the plate with the machine number on it may pop forward enough to open an interlock behind it. Just bang it down smartly to close the interlock and cards should then feed.

If the out hopper gets full it turns off the auto feed switch at the top of the hopper. Remove the punched cards and turn the auto feed back on to resume normal operation.

Cards are stored in the grey card hopper under weights to keep them from warping. Do NOT leave them in the machine or in a half full card tray so they warp. In winter the card hopper is kept on top of the HV power supply in the office. In summer the hopper will be upstairs on the fixed platform. The cards are unreasonably expensive, so do not let them warp. Spare cards may be found in the office downstairs or stored with the spare grocery tape for the printer in the shop building.

m) Card output format

The data deck generated by the punch consists of two kinds of cards, "fixed data cards" and "data cards".

Fixed data cards (Fig. 50) are punched whenever the fixed data button on the digiswitch panel is pressed (paragraph i above). The information contained on the card is as follows:

Column	Content	
1 - 10	star name	from master card
12 - 21	RA	
23 - 30	dec	
34 - 43	star name	from digiswitches
45 - 49	dec	
51 - 54	HA	
56 - 57	dwell	
59 - 64	always zero	
66 - 71	always zero	
73	filter	
75	exit	

The data cards (Fig. 51) are punched at the end of each observation at each wavelength. The format is:

Column	Content	
1 - 10	star name (from master card)	
14 - 17	wavelength	1st observation
19 - 25	counts in Ch A	
27 - 33	counts in Ch B	
37 - 40	wavelength	2nd observation
42 - 48	counts in Ch A	
50 - 56	counts in Ch B	
60 - 63	wavelength	3rd observation
65 - 71	counts in Ch A	
73 - 79	counts in Ch B	

You will notice that use of the proper master card will help if you should drop your data deck!

6. Time to counts mode

The normal mode of operation is to count at each wavelength for a predetermined dwell time. Alternatively, one may determine the number of total counts in advance and find the time required to count them.

In the middle of the punch control panel in the lower right portion of the scanner electronics rack (Fig. 49) are a toggle switch marked "normal" in one position and "time to counts" in the other, and two BNC connectors, one marked "from disc" and one "to scalar". The easiest way to connect the system is to disconnect the short input cable to the scalar. One end of that short cable was from the discriminator and the other end was (obviously) to the scalar. Using two BNC cables, connect the "to scalar" BNC output on the punch control panel to the scalar, and connect the "from disc" BNC input to the discriminator output the scalar was formerly connected to.

To operate in the time to counts mode, turn the toggle switch up. This routes the signal from the object to a countdown circuit which accumulates until the total is equal to the number which has been preselected. The total number of counts is chosen with the "dwell time" thumbwheel switches, but in this mode the number selected times 4096 equals total counts. Thus, if you dial in 03 on the thumbwheels 3 x 4096 = 12288 counts will be accumulated and then the accumulation time will be printed out, for each wavelength. The time is determined by routing pulses from a 4096 Hz tuning fork oscillator to the scalar. When the preselected total of counts from the object is reached, the time from the scalar is punched on cards and printed on the grocery tape in units of 1/4096 second. Since the "dwell time"is also on the cards and tape, you have all you need - so long as you remember which mode you were observing in!

The advantage of this system is that you can predetermine the number of counts according to the desired accuracy, and observe each wavelength just long enough to obtain that accuracy. This results in a time saving over the normal mode, where achieving the same minimum accuracy at all wavelengths usually means the brighter wavelengths get more observation time than is really required.

A disadvantage of the system is that it can only be used in a single channel mode.

B. Scanner checklist

1. Before you come to the mountain

a) Prepare your observing list with precessed coordinates for the current epoch.

b) Prepare finding charts, recommended for anything fainter than 6th magnitude. Know the scale and orientation (N at the top and E left is traditional).

c) Bring whatever standard star lists you will require.

d) Prepare master cards (Chapter III, Section A.5.b).

e) Bring warm clothes.

f) You may wish to bring your own flashlight, although you can usually check one out from the diner.

g) Know when the end of twilight, dawn and moonrise occur for your observing nights.

2. Set up (in afternoon)

a) Turn on main switch in office.

b) Turn on both racks and punch.

c) Check "Photometer/Polarimeter//scanner" switch on "scanner"; 5 power supplies "on."

d) Put in appropriate single/two-channel adapter plate.

e) Verify hot collar on.

f) Mount amp/disc on cold box and connect solid coax signal cable(s).

g) Mount cold box on scanner, connect four cables: HV, amp/disc power, two signal cables.

h) Set discriminator level.

i) Turn on HV and wait 15 minutes; verify some dark current to be sure all cables are hooked up correctly.

j) Ice.

k) Verify sufficient IBM cards in dome and load punch, advancing three cards: card fault light out.

l) Check sufficient paper tape in printer; spare tapes in dome.

m) Are master cards on hand for all objects?

n) Program wavelengths on the pin boards and check.

o) Insert desired exits and entrance slide.

3. Preparing to observe (early evening)

a) Open shutter, weather permitting.

b) Open rain shield.

c) Close four ropes for safety.

d) In office, turn on RA oscillator and RA preload switches.

e) Open mirror cover.

f) Find focus star in Ephemeris (mag 2-4) and set telescope to it.

g) Focus for best image (diagonal mirror in middle position).

h) Note coordinate offsets, position of star in finder with star centered in field eyepiece.

i) Change entrance aperture as appropriate for the seeing.

j) Open dark slide.

k) Use the bright focus star to "fish" for diaphragm edges (see Chapter III, Section C below). Use same diagonal mirror position you plan to use for observations.

4. Observing routine

a) Set telescope to program star (diagonal mirror in middle position for temporary dark slide).

b) Insert master card.

c) Fill out log, note scan number on paper tape.

d) Use log to set thumbwheels: scan no., star/sky code, dec and integration time (set HA just before starting; see below).

e) Set correct filter, exit slot, program number, grating increase/decrease correct for upcoming program.

f) Check: star centered, pellicle in guiding position and guiding satisfactory, telescope not occulted by dome, windscreen clear.

g) Enter HA on digiswitches, press "enter fixed data" and "start".

h) Fill out log: HA, PST start.

i) Check counting rate: is it reasonable? Check centering.

j) Make scans symmetric in "ups and downs" through the program; in star scans and sky scans; and in Ch A and Ch B.

k) Periodically check: guiding, dome and windscreen clearance, punch fed and hopper not overfull.

l) At end of scan log PST end.

m) Space paper tape for next scan.

5. Shutdown procedure

a) Dark slide closed.

b) Lights on.

c) Mirror cover closed.

d) RA drive, RA preload, HV off (in office).

e) Telescope on zenith, unclamped in RA and dec.

f) Dome stowed, floor up.

g) Wind screen up.

h) Rain shield up.

i) Plastic cover over top of tube, tube centered under rain shield.

j) Punch, 2 racks off.

k) Dial lights, reticle turned off.

l) Finder cover on.

m) Cold box removed and lens covers on cold box; store in case in office if end of your run.

n) Beam splitter removed if end of run, otherwise covered.

o) Note any discrepancies in log book.

p) Clean up any mess.

q) Windows closed and locked.

r) Lights off.

s) Lock front door when you leave.

C. Miscellaneous observing hints

The comments of Chapter IV, Section C apply, as well as the following additional points.

An A0 star of mag ~ 1.8 should result in about 10^6 counts/sec at between 4000 and 4500 Å with a 3 x 5 exit slot and the single-channel FW-130. The two-channel systems have lower quantum efficiency.

To locate the edges of the diaphragm with respect to the reticle ("fishing for the diaphragm"), put the pellicle in the observing position and open the gate of the scalar. With an appropriate grating setting and filter selected for a bright star, move the star around until you get a high counting rate so you know the star is somewhere in the diaphragm. Then move the star straight east, say, until the counting rate drops off sharply. Note the position of the star. Move it west until the rate drops off by a like amount and note the position of the star. Now put the star halfway between those two positions and do the same thing north and south. Then split the two north-south positions for the center. It is advisable to do this for each aperture used on each run (but once determined, this is unlikely to change during a series of nights). It is suggested you sketch the reticle and the center positions you find on the back of your log sheet for later reference if necessary.

Log sheets (Fig. 52) are in the second drawer of the desk in the office, as are Program Planning Sheets (Fig. 53).

Try to keep the individual scans on star or sky symmetrical. Hit each wavelength the same number of times in the first half of the scan as in the second half. If the grating is precisely at a program endpoint when you start, it will not integrate there but will scan to the next wavelength first. Therefore start and stop at a wavelength other than the endpoint, but such that the endpoint is the first program wavelength the grating will encounter. Also, notice the scanner integrates each endpoint wavelength twice.

A typical scan might be as follows. Suppose we are to observe λλ 4500, 4600, 4700 and 4800. Start anywhere below 4500 with the grating on increase, or between 4500 and 4600 with the grating on decrease, or anywhere above 4800 with the grating on decrease, or between 4700 and 4800 with the grating on increase. That is, don't start on an endpoint but hit it first. Suppose we press "start" with the grating at 3900 and increasing. The grating will scan up to the endpoint λ 4500 and two integrations will be performed, then it will do one integration each at 4600 and 4700, then two at 4800 where the grating will automatically reverse (if you have designated the endpoints correctly on the programming boards!). Then it will go back down; one integration each at 4700 and 4600 and then two at 4500 where the grating will again reverse. The program will continue on indefinitely if you let it, but if one scan (once up and back in wavelength) is sufficient, let it start up from 4500 on its way to 4600 before stopping it, and at the same time reverse the grating direction with the increase/decrease switch. The scan has been symmetric:

4800 - 4800

4700 4700

4600 4600

4500 - 4500 4500 - 4500

and if you move off onto sky you have merely to press "start" to start another symmetrical scan.

D. Troubleshooting

SYMPTOM

POSSIBLE CAUSE	NO STARS	STARS WILL NOT STAY CENTERED	NO COUNTS	DARK COUNTS ONLY	COUNTING RATE TOO LOW	COUNTING RATE TOO HIGH	POOR REPEATABILITY OF RESULTS	INCORRECT WAVELENGTHS	WILL NOT STAY IN PROGRAM	
DOME CLOSED	X									
TELESCOPE NOT POINTING OUT SLIT	X				X		X			
WINDSCREEN OR RAINSCREEN OCCULTING					X		X			
CLOUDS	X				X	X	X			
MIRROR COVER CLOSED	X			X						
DIAGONAL MIRROR IN WRONG POSITION	X			X						
WRONG STAR					X	X				
BLANK FIELD	X									
RACK POWER OR POWER SUPPLIES NOT ON			X							
HIGH VOLTAGE OFF OR INCORRECTLY SET			X		X	X				
POWER FAILURE NOW		X	X							
CABLES NOT HOOKED UP CORRECTLY			X							
UNNOTICED POWER FAILURE OR BAD ICING PROCEDURE					X	X	X			
OBJECT NOT CENTERED IN DIAPHRAGM					X		X			
FILTER SLIDE NOT DETENTED CORRECTLY				X	X		X			
WRONG FILTER SELECTED					X	X				
ENTRANCE APERTURE INCORRECTLY SEATED				X	X		X			
EXIT SLOT WHEEL NOT DETENTED CORRECTLY				X	X		X			
WRONG EXIT SLOT					X	X				
DARK SLIDE CLOSED				X	X					
WRONG PROGRAM SELECTED					X	X		X		
INCORRECTLY PROGRAMMED								X		
NO ENDPOINT WAVELENGTHS DESIGNATED									X	
AUTO/MAN SWITCH ON SCANNER ON MAN.									X	
OSCILLATOR NOT ON		X								
OSCILLATOR RATE NOT WELL SET		X					X			
A CABLE IS HOOKED ON SOMETHING		X					X			

CHAPTER IV

PHOTOMETER/POLARIMETER

A. Description

1. General

The prime focus photometer/polarimeter (Fig. 54) at the Crossley essentially consists of a programmable filter wheel, a diaphragm wheel to limit the sky seen by the photomultiplier, an adapter to hold a programmable analyzer for polarimetric observations and means to mount the photomultiplier tube.

From the photomultiplier, the signal goes to an amplifier/discriminator mounted on the cold box, and then to the electronics on the movable platform. The electronics automatically cycles through a preselected filter sequence (and analyzer position angle sequence if the polarimeter is used), stopping the filter wheel for a predetermined integration time (or "dwell time") at each selected filter. The pulses from the amp/disc are counted for the integration time and then printed on a "grocery tape" and/or punched on IBM cards. Alternatively, in the "time to counts" mode (Section A.7) a predetermined number of counts is specified and the time to achieve that total is recorded.

Photomultipliers presently available are single and dual channel FW-130s for the "blue" (~ 3200 Å to ~ 8500 Å), single and dual channel FW-118s for the "red" (~ 6000 Å to 12000 Å), a dual channel FW-129 for those who wish a response more easily transformed to the UBV system, and an EMI 9658A which has an S-20 spectral response and very high quantum efficiency but high and sporadic dark current (~ 50-200 cts/sec).

In what follows, "left" and "right" sides of the photometer or telescope are with respect to an observer standing in front of the eyepieces and facing the telescope.

2. Photometer head

a) Polarimeter

The polarimeter, its adapter ring and the analyzer plate boats (Fig. 55) are stored in the steel grey cabinet in the office.

Do not be deceived by the fact that you will use the two-channel cold box into using the two-channel diaphragms. Remember that the beam is not split until it goes through the Wollaston prism incorporated in the polarimeter head, after the filter, diaphragm and analyzer. Therefore a single channel diaphragm wheel should be used.

A filter wheel containing nine interference filters for use with the polarimeter is available. These filters are described in Appendix C.

Before mounting the polarimeter, select the appropriate plate boat ($\lambda/4$ or $\lambda/2$) and insert it in its rotating holder on the bottom of the polarimeter (Fig. 56). The analyzers are described briefly in Appendix C.

The adapter ring for the polarimeter mounts in the space normally occupied by the cold box adapter on the photometer (Fig. 57). Then the polarimeter is bolted to the photometer head using the four bright metal captive screws on the polarimeter. The proper orientation is with the plate boats fitted down inside the adapter ring and the lenses on top of the polarimeter toward the front of the telescope (Fig. 58).

On the right side of the polarimeter base is a socket for a connector about 2" long and 1/4" wide. This connector will be found plugged into the photometer base just below. Simply unplug it from the photometer and plug it into the polarimeter (Figs. 58 and 59). This provides power for a built-in hot collar in the polarimeter, in addition to powering the analyzer rotator and reading out the analyzer position.

The photomultiplier is mounted and iced in the usual manner (Section 3 below). Notice that the photomultiplier and amp/disc unit mount so that the amp/disc is pointing toward the back of the telescope (Fig. 59).

b) Changing analyzers

Analyzer plate boats may be changed from position 1 to position 2 or vice versa at analyzer orientation of 0° or 180° (programmed positions 0 or 50; see paragraph 6.h below). They are changed with the chrome rod which sticks out of the front of the photometer base (Fig. 59). With the analyzer position angle at 0° or 180°, rotate the rod an eighth of a turn clockwise to unlock it, then press it all the way in and release it. Check the polarimeter plate position lights on the control box (paragraph 5.a below) to verify that the boat is positioned correctly. If not, rotate the analyzer 180° and repeat. The normal convention is, position angle 0°, rod in gives analyzer #1; position angle 180°, rod in gives analyzer #2. Notice this convention is reversed for the $\lambda/4$ plate boat.

c) Photomultiplier adapters and hot collar

(See Chapter III, paragraph A.2.h). The procedures are the same as for the scanner, except the two-channel adapter for the photometer is kept in a black anodized box. The scanner and photometer beam splitters are not interchangeable.

d) Diagonal mirror

The diagonal mirror is the first thing which might be in the light path as the light enters the photometer. It is moved with a chrome rod with round black ends which is accessible from either the left or right side of the photometer (Fig. 54). It has three positions. In the middle (detent) position all of the light is deflected to the eyepieces for field identification and centering. If the mirror is pushed all the way to the left, a relatively small hole is in the light path which leaves the maximum area on the mirror surrounding the hole for selection of an offset guiding star, if required. If a diaphragm larger than ~ 1.5 mm is used, push the diagonal mirror all the way to the right to put the larger hole in the light path, to ensure the hole in the mirror is large enough to pass the entire beam.

e) Dark slide

The dark slide is the left hand small lever sticking out of the front of the photometer base (Fig. 60). All the way to the left is closed, to the right is open. The dark slide is interlocked with the movable portion of the photometer head (see following paragraph) so the head may only be slid back if the dark slide is closed.

f) Moving or raising the photometer head

The top portion of the photometer slides back and forth. In the normal (forward) position (Fig. 61) the photomultiplier is in position in the beam, and the prism mounted just in front of the cold box is in position to read the diaphragm size presently in the beam (see paragraph g below). If the head is slid back to the full rear position, the prism is in position over the selected diaphragm so you may center and focus through the diaphragm.

In order to slide the head back, the dark slide must be closed (due to a protective interlock) and a catch at the right rear of the photometer head must be depressed (Fig. 61); then the top layer of the photometer should slide back smoothly until a catch at the right front engages to hold it back. To slide it forward, depress the catch at the front and bring the movable portion forward until the rear catch engages.

There is a third position of importance for the sliding portion of the head. This is back about 1-1/2", so the first screwhole from the front on the top left side of the photometer is opposite the roundish handle on the left side of the head (Fig. 62). Then pull the handle out (away) from the photometer head and simultaneously rotate the head to the right to expose the diaphragm wheel and filters (Fig. 63). The head may lay back so the cold box rests on the teflon-tipped rod on the right-hand spider. It should move smoothly and easily; if it seems to bind, something is wrong.

g) Diaphragm wheels

There are three diaphragm wheels, two for single-channel and one for two-channel observations (Fig. 64). The single-channel wheel with the diaphragms mounted at the top is for use with filters in the light path; the one with the apertures mounted on the bottom is to compensate for the change in focal plane if no filters are used. The diaphragm sizes available are as follows:

WHEEL	SIZES (MM)
Single Ch. No Filter	0.13, 0.26, 0.37, 0.51, 0.74, 4.00
Single Ch. w/Filters	0.26, 0.36, 0.50, 0.72, 1.00, 1.44, 2.00, 2.82, 4.00
Two Channel	0.26, 0.36, 0.50, 0.72, 1.00, 1.42, 2.00, 2.82, 4.00

In the two-channel filter wheel, the standard channel separation is 2/10 inch. For diaphragm sizes of less than 1.00 mm, apertures are available with separation of 1/10 inch.

The diaphragm wheel is locked and unlocked with the flat lever which sticks out of the front of the photometer next to the dark slide (Fig. 60). Pushed to the right is unlocked, to the left is locked. Notice that if when you are ready to observe you pinch the dark slide and diaphragm locking lever together between thunb and forefinger, it will both open the dark slide and ensure the diaphragm wheel is locked and properly detented.

The wheel is turned manually. The right front edge of the wheel can be reached even with the movable portion of the head in the forward position.

Notice that the diaphragm sizes are marked on the wheel 180° from the diaphragms to which they apply. This is so when the movable head is in the forward position, the prism sees the size of diaphragm which is actually in the beam (as described in paragraph f).

In order to change the diaphragm wheels, the mirror cover is closed and the movable portion of the photometer head is opened and layed back as described in paragraph f above. The wheel is retained with a small screw and a retaining disc in its center (Fig. 64). The screw should be only fingernail-tight. The screw is very small and not captive, so don't let it drop down the telescope tube. Unlock the diaphragm wheel locking lever before lifting out the wheel, and don't drop the chrome disc out of the center of the wheel. Place the new wheel in position, diaphragm size markings up, with a slight outward motion against the detent spring and be sure it slips down flat over the 1" center locating disc. Place the chrome disc in its recess in the center of the wheel with the countersink for the retaining screw up, and put in the screw just fingernail tight.

The diaphragm wheels are stored in the steel grey cabinet in the office downstairs.

h) Filters

Either 1" round or 1" square filters may be used. If you wish to bring your own filters, spare filter wheels are available. Snap rings are used to retain the filters. The wheels for round filters hold 10 filters each; the ones for square filters hold 7 (Fig. 65). There are four filter wheels of each type and each type is stored in its own anodized aluminum box in the steel grey cabinet in the office. If a wheel seems to be missing, it may have been left in the photometer.

If it is necessary to clean the filters, please use lens tissue only.

To change filter wheels, the photometer head must be raised as described in paragraph f and the diaphragm wheel must be removed (paragraph g) (Fig. 63). A filter wheel in the photometer is removed by unscrewing the knurled brass captive screw in the middle of the filter wheel and lifting it out. To put in a new filter wheel, notice the small chrome pin about 1" out from the center of the filter wheel receptacle and orient the wheel so the pin will slip into the small hole in the bottom of the wheel. Gently twist the wheel until it seats on the pin and then tighten the screw finger tight. Be sure to place the wheel you removed in its storage box.

If you wish to work on very bright stars, cover any empty filter positions with black cardboard inserts to avoid tube fatigue.

i) Reticle and offsets

The reticle is movable over the entire field of the telescope for offset guiding. The reticle is moved by twisting the two metal rods which terminate near the eyepieces. The position is read from the two 2-inch diameter micrometer dials (north-south and east-west) mounted on the photometer (Fig. 54), which read in thousandths of an inch, where 1/1000 inch is very nearly 1 second of arc. The dials read in four digits, the first two from the red inside scale and the last two from the black outside scale.

The reticle is shown in Fig. 66. The arms are roughly 1-1/2 arc minutes long and the small hash marks on the horizontal arms are 5 seconds of arc apart.

Reticle coordinates for the centers of various diaphragms are noted in the front of the maintenance log book. (They are not noted here because they may change if the instrument is cleaned or repaired.) If the coordinates don't seem to work, you may find your own new center coordinates by accurately setting to a very bright star with the largest available diaphragm selected. If the object is not in the diaphragm it should be close enough to locate easily (if not, recheck the telescope coordinates!). Center the star in the large diaphragm, and then select progressively smaller ones until you get to the size you want to use. The center coordinates will change due to flexure if you move the telescope through any extreme range in hour angle or zenith distance. To be sure, set to a bright star near the object and find new center coordinates.

> It is well to remember that the only <u>certain</u> way to center an object is to center an <u>in-focus</u> image by looking <u>through</u> the diaphragm with an eyepiece which has been carefully focused <u>on the diaphragm</u> (focal plane).

Once the star is carefully centered in the diaphragm, the reticle may be quickly moved to any star on the portion of the diagonal mirror surrounding the hole through which the light passes (section d above), for offset guiding.

3. <u>Photomultipliers and amplifier/discriminator</u>

a) <u>Photomultipliers</u>

See Chapter III paragraph A.3.a,

b) <u>Amplifier/discriminator</u>

See Chapter III paragraph A.3.b.

c) <u>Mounting</u>

See Chapter III paragraph A.3.c.

d) Setting the discriminator level

See Chapter III paragraph A.3.d.

e) High voltage and icing

See Chapter III paragraph A.3.e. If you use the FW-129, follow the icing procedure as described in Chapter III for the FW-130s but use alcohol and allow at least 2 hours for the tube to cool down; the longer the better. The FW-129 you may wish to keep cold all day since the dark current will eventually reach a very low value.

For the procedure to follow in case of power failure and at the end of the night, please see Chapter III paragraph A.3.e.

4. Eyepieces and relay lens

a) Eyepieces

There are three eyepieces on the eyepiece plate attached to the front of the telescope (Fig. 67). The top eyepiece is fixed in position and always looks through the prism on top of the photometer, so it sees the diaphragm size if the head is forward and looks through the diaphragm if the head is back. It focuses by slipping back and forth in its collar (as do the other two).

The bottom two eyepieces are for viewing the field and are mounted on a movable plate. The field of view of the low power (25 mm) eyepiece is very nearly the entire field of the telescope (~ 20 arc minutes). The field of the high power (16 mm) eyepiece is about 3 arc minutes. East is right and north is down.

In order to move the plate holding the lower eyepieces, loosen the two knurled bright metal knobs (Fig. 67) and push the plate wherever you desire. Retighten the knobs.

Notice that contained on the movable plate is yet another plate in which the eyepieces are actually mounted. The latter plate slides back and forth so that if one eyepiece is centered on an object the other may be centered on the same object just by sliding the inner plate.

b) Relay lens

The relay lens is about 3" in diameter and is mounted on the front spider arm (Fig. 54). It has two positions, one near the eyepieces for use with the low power eyepiece, and one near the photometer to use with the high power eyepiece. To change positions, a black plastic tab just below the lens is lifted to release it, then the lens is swung through a semi-circular arc on the left hand side of the spider arm until the arm holding the lens lies along the top of the spider in the other direction. Then reclamp the lens in the new position.

Remember then, that to change from one power to the other it is necessary to change the eyepieces and the relay lens position. Also, if things look screwed up through the eyepiece, check to be sure the eyepiece in use matches the relay lens positon selected.

5. Other controls mounted on the telescope

a) Control box

The black control box hangs on the right hand side of the telescope (Fig. 68). In the lower right hand corner is an on-off switch. If it doesn't seem to work, reverse the 110 volt plug where the control box plugs into the telescope.

Features of the control box, starting in the upper left corner, are as follows: the polarimeter plate lights indicate whether plate 1 or plate 2 of the polarimeter plate boat is presently in the beam. The diaphragm illumination rheostat controls the brightness of a light mounted just below the diaphragm viewing prism which illuminates the diaphragm size markings or the diaphragm (for centering) depending upon whether the movable head is forward or back. The reticle illumination rheostat controls the brightness of the reticle. The dark slide light is on if the dark slide is closed. The diaphragm position light is on if the diaphragm is not locked. Referring now to the upper right portion of the control box, the focus buttons marked U (for up) and D (for down) drive the focus motor. Below them are two function toggle switches which are interdependent. Their positions for various functions are shown here:

FUNCTION	LEFT SW.	RIGHT SW.
NORMAL PHOTOMETRIC OPERATION	FILTER ONLY	NORMAL
POLARIMETER ONLY	FILTER & POLARIMETER	HOLD FILTER & RECYCLE POLARIMETER
CYCLE FILTERS AND POLARIMETER	FILTER & POLARIMETER	NORMAL

Below the toggle switches are the start button which may be used to start an observational sequence, and a reset button which may be used to stop observations.

The start-stop functions may also be performed from the scanner digiswitch panel (see paragraph 6.i below). To transfer control from the scanner to the control box, press "start" then "general reset" on the scanner control panel; "start" button will remain lighted. To transfer control back to the scanner electronics, press "stop" on the scanner control panel.

b) Remote paddle

Connected to the control box and hanging somewhere near the top of the telescope you will find the remote paddle (Fig. 68). It has four buttons and three knobs. The top two buttons are for the same "start" and "reset" functions as the buttons on the control box. The next two knobs are for reticle illumination and diaphragm illumination, respectively. (Notice that the functions are inverted from the control box arrangement.) These rheostats are in series with the ones on the control box, so you may have to adjust both, initially, to get the desired light level. Next come buttons for focus down and up, and finally at the bottom is a knob which controls the brightness of all the lights in the control box and on the remote paddle.

c) Hot collar

See Chapter III paragraph A.4.c. The hot collar for the polarimeter adapter receives its voltage through the long thin blue ribbon connector at the right rear of the adapter.

6. Electronics racks and keypunch

a) General

See Chapter III, paragraph A.5.a.

b) Card reader

See Chapter III, paragraph A.5.b.

c) Punch interface logic chassis

See Chapter III, paragraph A.5.c.

d) Paper tape printer and tape format

See Chapter III, paragraph A.5.d. Note that the "wavelength" printed on the tape output is really a filter and/or analyzer position angle code as described in paragraph g below.

e) Program connectors

See Chapter III, paragraph A.5.e.

f) Scalars

See Chapter III, paragraph A.5.f.

g) Filter and polarimeter position angle readout

Below the scalars is a panel with wavelength, filter and exit readouts for the scanner (Fig. 47). In the photometer mode, the two meters are disabled and the wavelength readout is used to display a code for filter and polarimeter position angle. The number displayed will be 2XYY where X is the current filter position and YY is a two digit representation of the current one of 100 possible analyzer position angles.

h) Programming boards; programming

Programming is done on the two slide-out drawers just below the wavelength readout, by inserting pins to determine filter sequence and/or analyzer position angle. Either drawer and any lines may be used.

In order to determine which filter numbers correspond to which positions on the filter wheel, it may be necessary to program, say filters one and two according to the rules given below, then lay the photometer head back so you can see the wheel, run the program and observe which filters the photometer stops at. Then you can count to determine the filters you really want and reprogram accordingly.

Filter numbers are designated by inserting pins into the programming pinboards as described below. For the ten-position (round filter) filter wheels the filter positions one through ten are designated by putting pins into the corresponding positions one through ten of the hundreds columns of the pinboard. However, for the seven-position (square filter) filter wheels the coding usually works as follows:

Filter Number	100's Columns Number
1	2
2	0
3	5
4	6
5	0
6	9
7	0

Notice that it is the <u>100's columns number</u> which is printed out on the grocery tape and punched on cards as the filter identifier, so be sure the sequence of filter positions chosen includes at least one which is uniquely identified so you can tell which filter was which in the sequence later.

There is one further option in filter control. You may conveniently choose to repeat integrations at each filter until you feel you have enough counts then advance to the next filter manually. This may be accomplished by the two toggle switches and BNC connector on the right hand spider (see Fig. 60, just above and behind the reticle offset micrometer dials). The two switches are "toward each other" (left switch to right and right switch to left) for normal operation. For manual control, switch these switches away from each other (left switch to left and right switch to right). Connect the BNC cable with a 1 inch square by 5 inch long aluminum block labelled "manual photometer advance" (kept in grey table on fixed platform) to the BNC connector. Then each integration is started with the start button on the remote paddle, and filters are advanced with the button on the manual photometer advance. With this arrangement it is possible to advance the filter while still integrating and vice versa, so be careful. When used in this way there is no filter readout so you may wish to write the filter used on the grocery tape if it will not be obvious from the relative count rates.

i. Photometer only

To program a filter sequence, use only one line per sequence and designate each line with a different program number (red pins). Put a thin white pin in each of the 2 columns of the thousands, tens and units sections. In the hundreds section, use the thick white diode pins to designate the filer numbers you wish to observe with. The top program in Fig. 69 shows filters 3, 4 and 5 selected for program 1.

ii. Polarimeter only

There are 100 possible position angles for the analyzer, 3.6° apart. The 100 positions are programmed in the tens and units sections of the program board. Only single lines are used for those programs. Only one program should be on the boards since the polarimeter does not allow for distinguishing between programs. As before, a thin white pin should be in the 2 column of the thousands section. In the hundreds section place a thin white pin in the number of the filter you plan to use and be certain that filter is in the beam when you start or else the electronic logic won't work properly. If necessary, first program as described in the photometer only section just above to get the correct filter in position. In the tens and units sections, use the thick white diode pins to program the positions desired. For example, to program the analyzer to stop every 36°, put pins in <u>all</u> of the tens columns, and one pin in the 0 column of the units section. The analyzer will then stop at positions 00, 10, 20, ----, 80, 90, 00, etc. To observe every 18°, program as before but add a pin in column 5 of the units section. In Fig. 69, the middle program illustrates the pin arrangement to use filter 3 and stop the analyzer every 18° (20 position angles out of the 100 possible).

iii. <u>Polarimeter and filters</u>

These programs require two lines. The first line requires a 2 in the thousands section, and pins in the hundreds section to designate filters desired and in the tens and units section to designate analyzer position angles desired as described just above. The second line tells the electronics at what analyzer position angle you wish the filters to change. The thousands and hundreds sections should duplicate the first line. In the tens and units, show only what specific position angle to change filters at (it must be one of the position angles in the first line). Designate the second line with a thin white pin in the "low" column at the left edge of the drawer. Again refer to Fig. 69. The bottom program shows how to select five analyzer position angles at intervals of 72° with filters 4, 5 and 7, the filter to change at position angle 0°.

i) <u>Digiswitch panel</u>

See Chapter III, paragraph A.5.i. Note that the "increase/decrease" button serves no function with the photometer, and the digiswitch panel "dark slide" light does not work (the photometer dark slide light is on the control box (paragraph 5.a above)). To transfer control of the start/stop functions from the scanner digiswitch panel to the photometer control box, press the digiswitch panel start button and then quickly press general reset (paragraph 5.a).

j) <u>Punch control panel</u>

See Chapter III, paragraph A.5.j.

k) <u>Power supplies</u>

See Chapter III, paragraph A.5.k.

l) Keypunch

See Chapter III, paragraph A.5.1.

m) Card output format

See Chapter III, paragraph A.5.m. Notice that the "wavelength" punched on the data cards will in this case be a filter and/or analyzer position angle code as discussed in paragraph g above.

7. Time to counts mode

See Chapter III, section A.6.

B. Photometer Checklist

1. Before you come to the mountain

a) Prepare your observing list with precessed coordinates for the current epoch.

b) Prepare finding charts, recommended for anything fainter than 6th magnitude. Know the scale and orientation (N at the top and E left is traditional).

c) Bring whatever standard star lists you will require.

d) Prepare master cards (Chapter III, A.5.b).

e) Bring warm clothes.

f) You may wish to bring your own flashlight, although you can usually check one out from the diner.

g) Know when the end of twilight, dawn and moonrise occur for your observing nights.

2. Set up (in afternoon)

a) Turn on main switch in office.

b) Turn on both racks and punch.

c) Check "Photometer/Polarimeter//Scanner" switch on "Photometer/Polarimeter"; 5 power supplies on.

d) Mount desired filter wheel and diaphragm wheel.

e) Mount Polarimeter if required.

1) Remove cold box adapter from photometer.

2) Insert adapter ring in photometer head.

3) Insert plate boat in polarimeter.

4) Mount polarimeter on photometer head.

5) Remove long thin connector from photometer and connect to polarimeter.

f) (Photometer only) Put in appropriate single or two-channel adapter plate.

g) Verify hot collar on.

h) Mount amp/disc on cold box and connect solid coax signal cable(s).

i) Mount cold box on photometer/polarimeter, connect four cables: HV, amp/disc power, two signal cables.

j) Set discriminator level.

k) Turn on HV and wait 15 minutes; verify some dark current to be sure all cables are hooked up correctly.

l) Ice.

m) Verify sufficient IBM cards in dome and load punch, advancing three cards: card fault light out.

n) Check sufficient paper tape in printer; spare tapes in dome.

o) Are master cards prepared for all objects?

p) Program the pinboards for filter sequences and/or analyzer position angle as required: check programs.

3. Preparing to observe (early evening)

a) General procedure

1) Open shutter, weather permitting.

2) Open rain shield.

3) Close four ropes for safety.

4) In office, turn on RA oscillator and RA preload switches.

5) Open mirror cover.

6) Find focus star in ephemeris and set telescope to it.

7) Focus (detailed directions below).

8) Note coordinate offsets, position of star in finder with star centered in field eyepiece.

9) Change diaphragm size as appropriate for seeing conditions.

b) Focus procedure

1) Using reticle coordinates (from front of maintenance log) appropriate to diaphragm in use, set reticle to nominal diaphragm center position.

2) With diagonal mirror in center position and using low power field eyepiece, put star on reticle (if sky is not yet dark, reticle will be faint even with both reticle controls all the way up).

3) Check dark slide closed and slide photometer head to full rear position.

4) Move diagonal mirror all the way left or right so beam can pass through hole.

5) Select a filter position corresponding either to clear (e.g., quartz or glass) or to a filter which will pass enough visible light for you to see the star. Do not use an empty position or the optical path length will be different when a filter is in position and the focus will be incorrect.

6) Look through the top eyepiece and thus through the diaphragm. The

star should be visible. If not, follow the procedure described in this chapter, paragraph A.2.i, for locating the star.

7) When the star is visible through the diaphragm, remove the eyepiece so you see the unfocused image of the star apparently fill the diaphragm.

8) Use the edge of the diaphragm to cut the image as you watch it. Move either the telescope or the diaphragm wheel, whichever is more convenient.

9) A perfectly focused image will appear uniformly mottled as it is cut, so you cannot say with certainty from which side the shadow came.

10) Chances are you will clearly see the shadow come in from one side or the other. If so, put the edge of the shadow halfway across the image and press a focus button (either one). If the shadow's edge becomes <u>more clearly defined</u>, you're moving the focus the <u>wrong</u> way. If the shadow's edge becomes less clearly defined, keep changing the focus in the same sense until the image becomes uniformly mottled.

11) Cut the image once or twice more to be sure.

12) Replace and accurately focus the eyepiece on the diaphragm.

4. <u>Observing routine</u>

a) Set telescope to program star (diagonal mirror in middle position to act as a temporary dark slide).

b) Insert master card if punch is to be used.

c) Set integration time (general reset if changed) and other digiswitches as desired, except HA (set below).

d) Check filter/analyzer program as desired.

e) Center star in diaphragm (diagonal mirror out of the way, a filter you can see through selected, cold box pushed back; or use center reticle coordinates).

f) Set to offset guide star if required.

g) Check: cold box forward, dark slide open, diagonal mirror out of the way.

h) Check: guiding satisfactory, windscreen clear, dome centered.

i) Enter HA on digiswitches.

j) Space paper tape, write star name, HA, PST.

k) Press "enter fixed data" (if punching cards).

l) Press "start".

m) Check counting rate; is it reasonable?

n) Periodically check guiding, dome and windscreen clearance, card supply in punch adequate and hopper not overfull.

5. Shutdown procedure

a) Dark slide closed.

b) Lights on.

c) Mirror cover closed.

d) RA drive, RA preload, HV off (in office).

e) Telescope on zenith, unclamped in RA and dec.

f) Dome stowed, floor up.

g) Wind screen up.

h) Plastic cover over top of tube, tube centered under rain shield.

i) Rain shield over telescope.

j) Punch, 2 racks off.

k) Dial lights, reticle turned off.

l) Finder cover on.

m) Cold box removed and lens cover on cold box; store in case in office if end of your run.

n) Beam splitter removed if end of run, otherwise covered.

o) Note any discrepancies in log book.

p) Clean up any mess.

q) Windows closed and locked.

r) Lights off.

s) Lock front door when you leave.

C. Miscellaneous observing hints

For the best results, try to observe your program stars as near the meridian as possible. Avoid large airmasses. There is an airmass nomagram attached to the electronics racks on the platform to help you with this. Do UV and blue observations at smaller airmasses where possible; extinction is one magnitude per airmass at λ3500.

For the very best results, start your observations no earlier than 15 minutes before the end of twilight and end by 15 minutes after dawn.

Try to avoid counting rates in excess of 1 or 2 x 10^6 counts per second. The paired pulse correction is 10% at 5 MHz, and a rate of 1 or 2 million per second allows a large safety margin for fatigue of the tube. A very rough rule of thumb for expected counting rate is 100 counts/sec/Å for a 7.5 magnitude A0 stars at λ4000 with the FW-130.

A total of 10^4 counts above the sky with a given filter results in ~ 1% error (error $\propto \sqrt{1/N}$).

When moving off onto sky with the single channel system, it is faster to use the RA set motion than to use dec. Go at least one diaphragm diameter from the centered position. Be sure no faint star is then in the diaphragm; check with the center mirror position or through the diaphragm the first time. Observe the sky at ~~least~~ most every 15 minutes, every 10 is better.

The dwell time digiswitches allow selection of any integration time from 1 to 99 seconds. For a bright star, be sure the total counts during the total dwell at the brightest observed wavelengths do not exceed the seven digit capacity of the scalar. If you are punching cards, the cyle time for the punching process is just over 3 seconds, so (except for the scalar limit mentioned) you may as well integrate at least that long since an internal buffer allows the counting to continue during the punching.

Since the sky is continually changing, in general it is best to avoid long integration times. A maximum of 10 to 15 seconds is usually best; some observers prefer a 7 second maximum. To achieve the required accuracy just cycle through the program more times than you would with longer integration times. This will at least average the sky variations more uniformly over the observed wavelengths.

Make your star and sky observations symmetrical. That is, do star, sky, star; or 2 star, 2 sky, 4 star, 2 sky, 4 star, 2 sky, 2 star; or some similar scheme (the numbers refer to the number of times through the program). This procedure will more successfully average sky changes.

If there's ever any doubt in your mind about the orientation of the sky in the finder or the main telescope, the only way to be certain is to move the telescope a known direction and see which way that is in the eyepiece. You'd be surprised how many people have wasted long periods unable to match a finding chart to what they saw because they were certain the orientation was other than it is in the telescope. It only takes seconds to check.

The other side of that coin is, if you've set the telescope very carefully, double checked coordinates, precession and telescope field orientation and still can't identify the field, suspect the chart orientation might be wrong even if it's marked. It may have been marked incorrectly or the published source may have been oriented incorrectly. It's really surprising how often such problems arise.

D. Trouble shooting

POSSIBLE CAUSE \ SYMPTOM	NO STARS	STARS WILL NOT STAY CENTERED	NO COUNTS	DARK COUNTS ONLY	LOW COUNTING RATE	HIGH COUNTING RATE	POOR REPEATABILITY	INCORRECT FILTERS
DOME CLOSED	X							
TELESCOPE NOT POINTING OUT SLIT	X				X		X	
WINDSCREEN OR RAINSCREEN OCCULTING					X		X	
CLOUDS	X				X	X	X	
MIRROR COVER CLOSED	X			X	X			
DIAGONAL MIRROR IN WRONG POSITION	X			X	X			
WRONG STAR					X	X		
BLANK FIELD	X							
RACK POWER OR POWER SUPPLIES NOT ON			X					
HIGH VOLTAGE OFF OR INCORRECTLY SET			X		X	X		
POWER FAILURE NOW		X	X					
UNNOTICED POWER FAILURE OR BAD ICING PROCEDURE					X	X	X	
CABLES NOT HOOKED UP CORRECTLY			X					
OBJECT NOT CENTERED IN DIAPHRAGM					X		X	
WRONG FILTER SELECTED					X	X		
DARK SLIDE CLOSED				X	X			
WRONG PROGRAM SELECTED								X
INCORRECTLY PROGRAMMED								X
OSCILLATOR NOT ON		X						
OSCILLATOR RATE NOT WELL SET		X					X	
A CABLE IS HOOKED ON SOMETHING		X					X	
PHOTOMULTIPLIER IS IN REAR POSITION				X	X			

CHAPTER VI

IN CASE OF EMERGENCY

First try to be certain there is a real problem with the equipment rather than a procedural error, and assess the symptoms as completely as you can. Next make a reasonable judgment, as best you can, about whether the problem can be fixed before the night is over. If it cannot be fixed in time to continue observing and poses no immediate hazard to the building or equipment, just shut down and log the discrepancy so it can be fixed in the daytime. If you think it can be fixed in time to continue observing, call

> Ron Laub, ext. 61, for mechanical problems; or Ken Dietsch, 274-2095 for electronic problems; or Rem Stone, ext. 40, if you just can't figure out what's wrong!

APPENDIX A

The following references may be of particular interest to users of the Crossley telescope.

History of the instrument:

The Crossley Reflector of the Lick Observatory; Keeler, J. E. 1900, Ap.J., 11, 325.

Scanner:

Direct Recording of Stellar Spectra; Code, A. D. and Liller, W. C. 1962, Stars and Stellar Systems, Vol. II, pp. 281-301.

Scanner Observations of λ4430; Wampler, E. J. 1966, Ap.J., 144, 921.

Polarimeter:

Polarimetric Observations of Late-Type Dwarfs; Zappala, R. R. 1969, Pub. A.S.P., 81, 433.

Spectrophotometric standards:

An Absolute Spectrophotometric Calibration of the Energy Distribution of Twelve Standard Stars; Hayes, D. S. 1970, Ap.J., 159, 165.

A Rediscussion of the Atmospheric Extinction and the Absolute Spectral-Energy Distribution of Vega; Hayes, D. S. and Latham, D. W. 1974, Center for Astrophysics Preprint Series No. 172.

Photoelectric Spectrophotometry of Stars Suitable for Standards; Oke, J.B. 1964, Ap.J., 140, 689.

APPENDIX B

Below are the spectral response curves for the photomultipliers available for use at the Crossley:

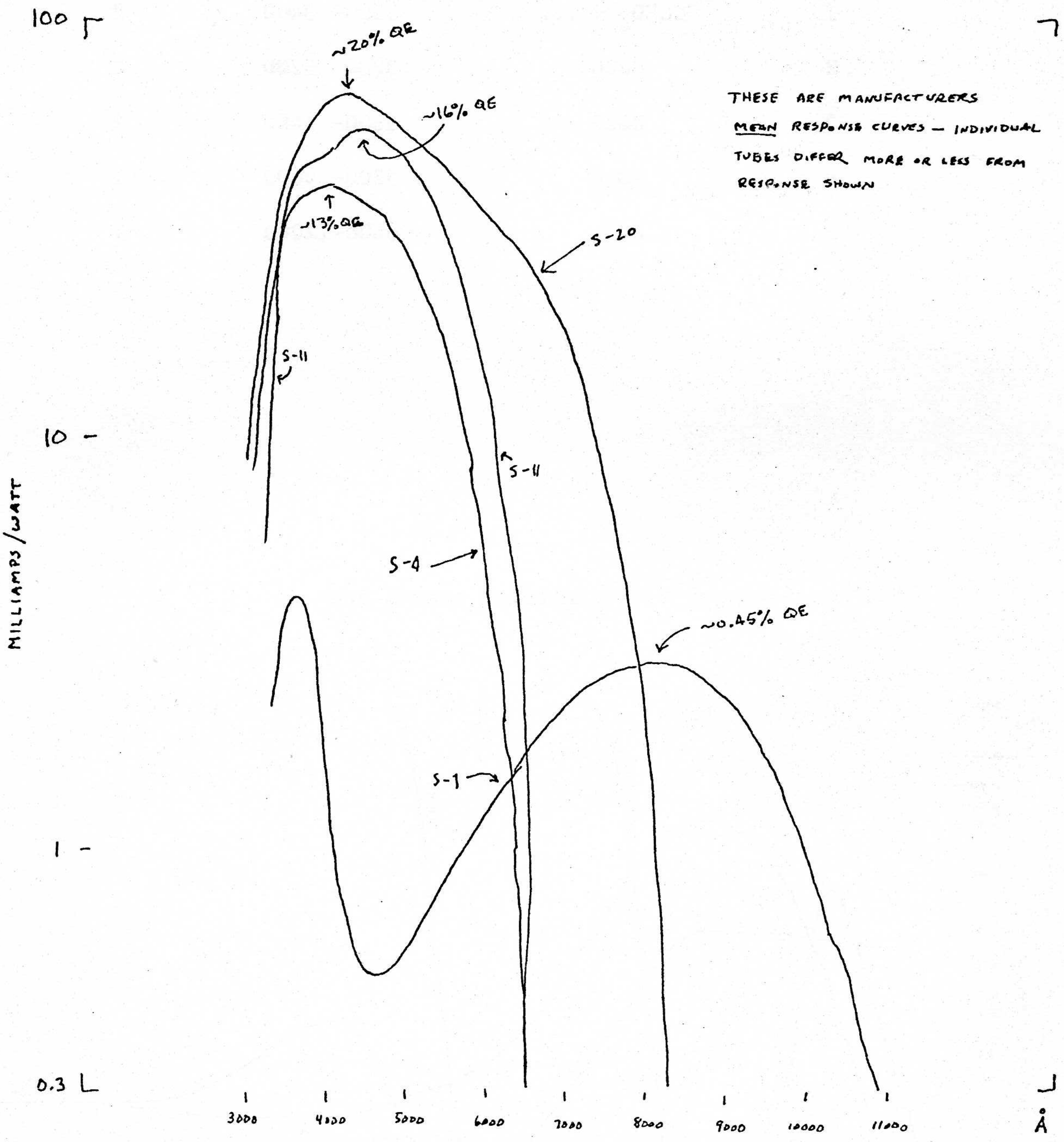
FW-118 (S-1)

FW-129 (S-11)

FW-130 (S-20)

EM1 9658A (S-20)

Also you will find the response curve for the 1P21 (S-4) for comparison purposes. We do not have a 1P21 available at the Crossley.



Note: (1) In fact we find the S-20 to be superior to the S-1 to <u>8400 Å</u>.
(2) S-4 is shown for comparison only ~ a 1P21 is <u>not</u> available at the Crossley.

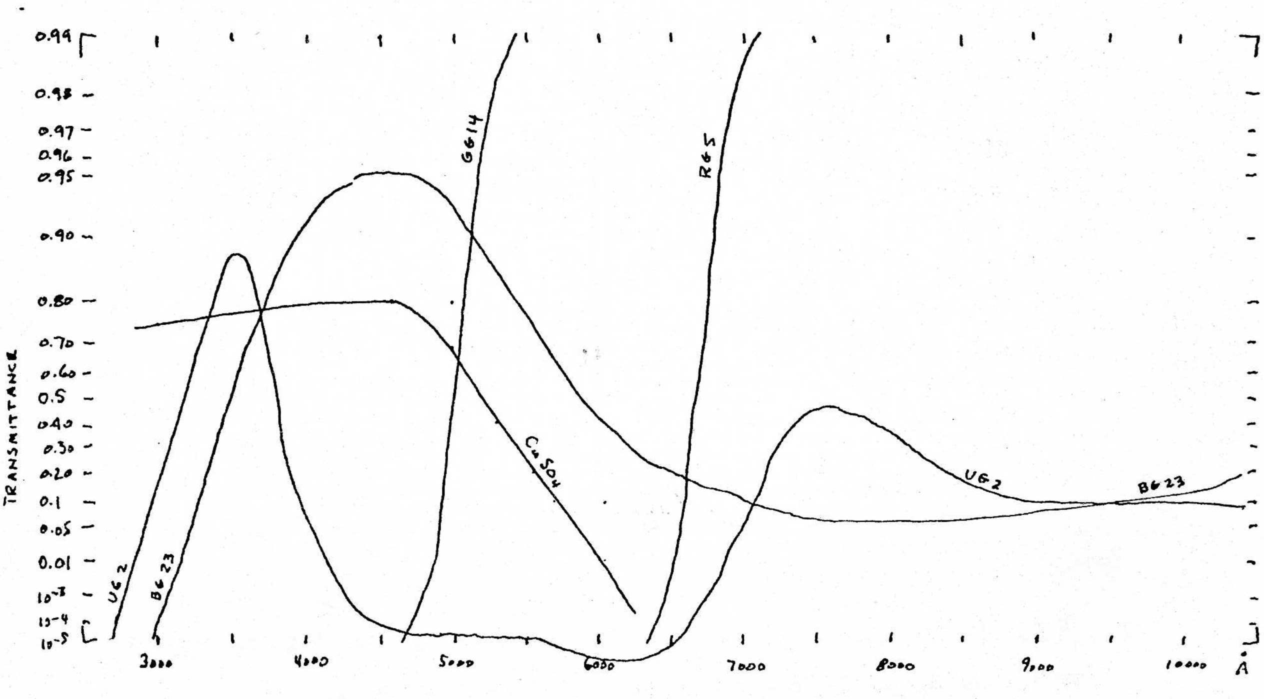
APPENDIX C

1. Scanner

The order separating filters in the scanner are as follows:

Filter No.	Type	λ	Order
1	$CuSO_4$ + UG2	3000- 3400	2
2	CuSO	3200- 5200	2
3	BG23	3800- 5400	2
4	GG14	5200- 9000	1
5	RG5	6500-12000	1

The manufacturer's transmission curves are:



2. Photometer/Polarimeter Filters

Filter sets available for use with the photometer/polarimeter are the following (all thicknesses are in mm):

Ten position filter wheels, 1 inch round filters:

Filter wheel A: UBV with FW-129

U = 1.0 UG1 + 6.5 $CuSO_4$*

B = 2.0 GG13 + 1.0 BG12 + 4.5 quartz

V = 2.0 GG13 + 2.0 glass + 2.0 GG14

Clear = 6.0 glass

*The liquid $CuSO_4$ filter may develop bubbles of air. If so, there is a kit with which to refill it in the steel grey cabinet in the office. Hopefully we will get it replaced soon with a crystal $CuSO_4$ filter.

Filter wheel B: Polarimetric interference filters

λ_o*		λ_{max}	$\Delta\lambda$ (FWHM)
3720 Å		3775 Å	195 Å
4035	(4020)	4005	200
4225		4230	260
4525		4525	240
5225		5170	200
5700	(5740)	5775	240
6300	(6325)	6260	285
7200	(7225)	7070	420
8000	(8020)	7840	465

*λ_o is manufacturer's wavelength, apparently of the centroid. When λ_o estimated by eye differs from the given λ_o, the estimate is in parenthesis.

Filter wheel C: V, R (Johnson) with FW-130

V = 2.0 GG14 + 2.0 BG18

R = 2.0 RG2 + 2.0 GG13

Clear = 3.0 glass

Filter wheel D: miscellaneous!

WR87C gelatin

plus unidentified others

Seven position filter wheels, 1 inch square filters:

At the time of writing we have no permanent filters in these wheels.

3. Analyzer plate boats

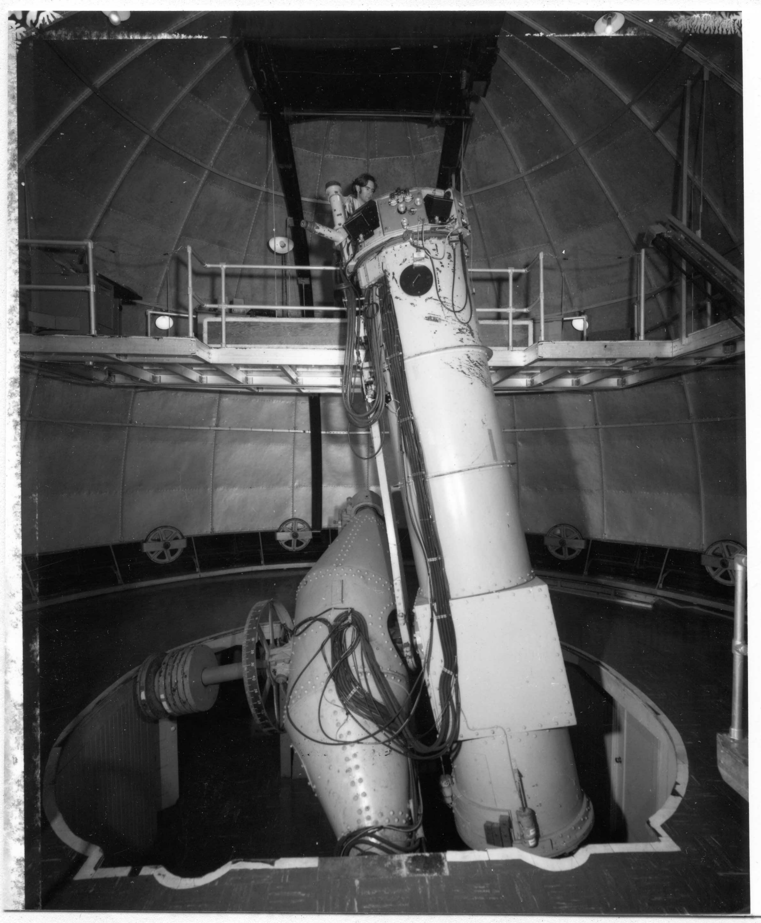
Plate boat A: cell 1: λ4950 half wave

cell 2: λ7500 half wave

Plate boat B: cell 1: λ5893 (NaD) quarter wave (mica)

cell 2: λ4600 quarter wave (quartz)

Note that the cell numbering convention is backwards for the quarter wave plate boat; i.e., when analyzer #1 is in the beam, the readout on the Photometer Control Box will say #2 and vice-versa.



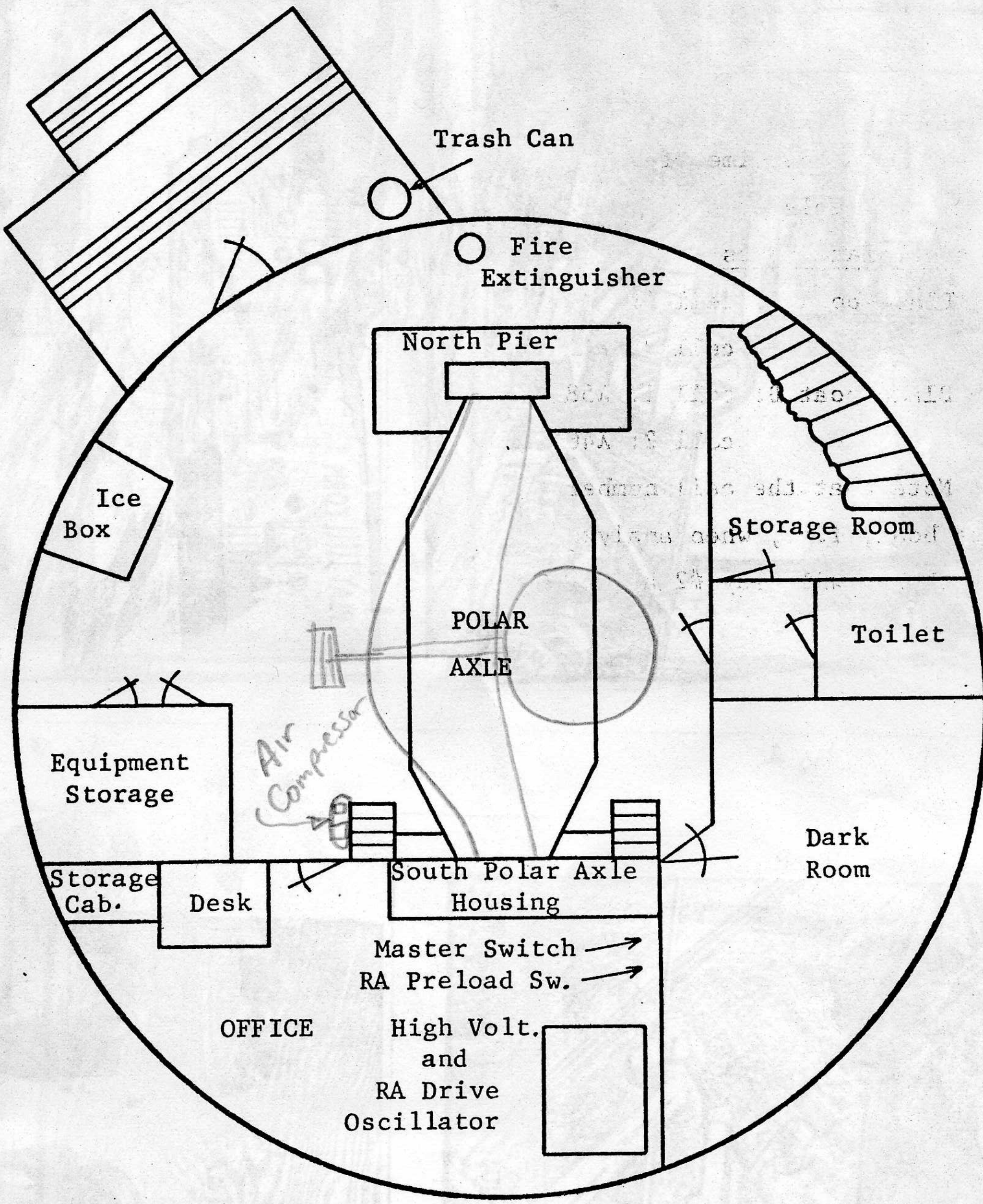


Figure 1: CROSSLEY DOME - GROUND LEVEL LAYOUT

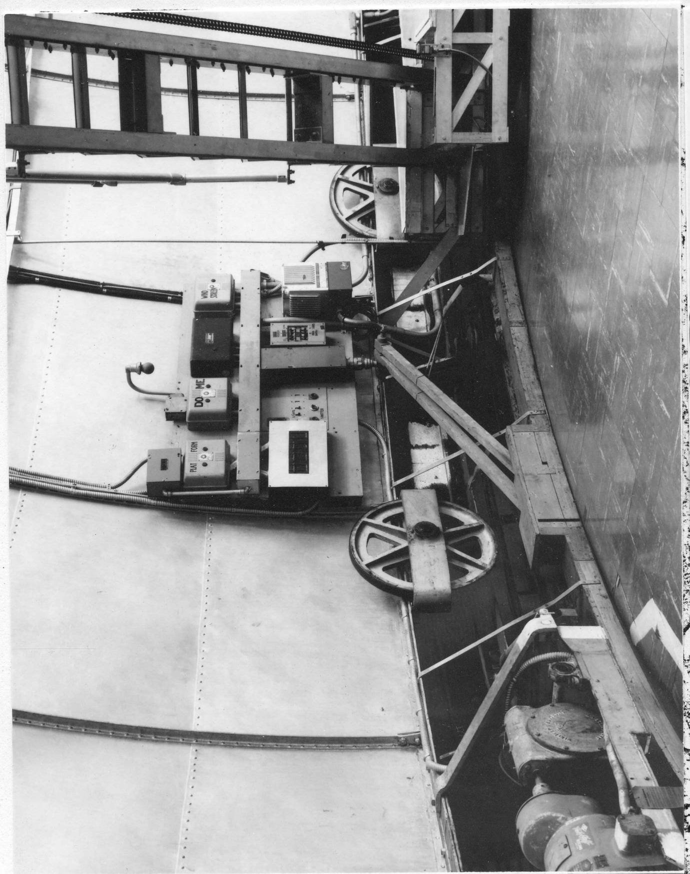


fig 2

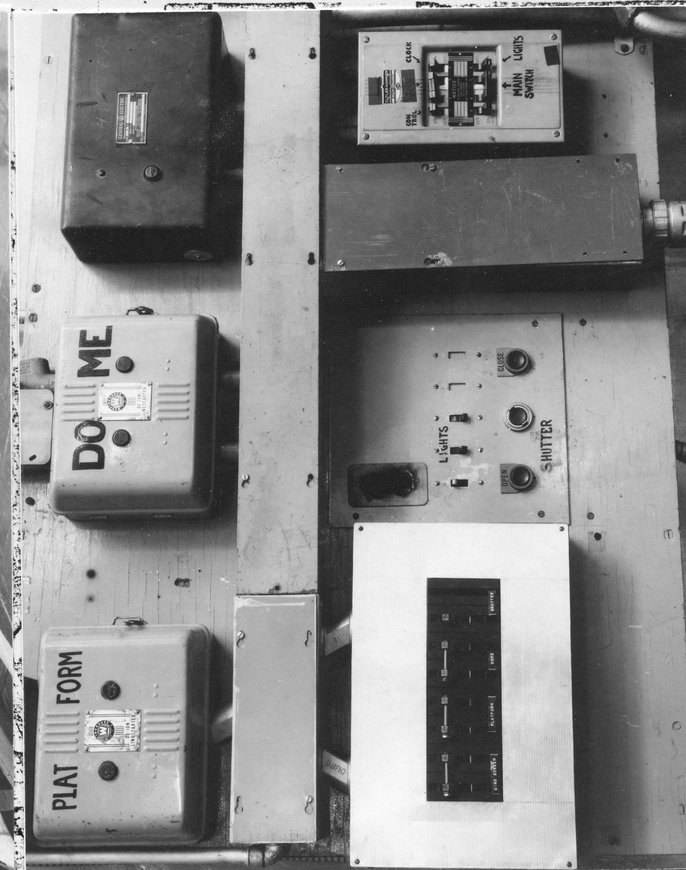


fig 3

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fig 4

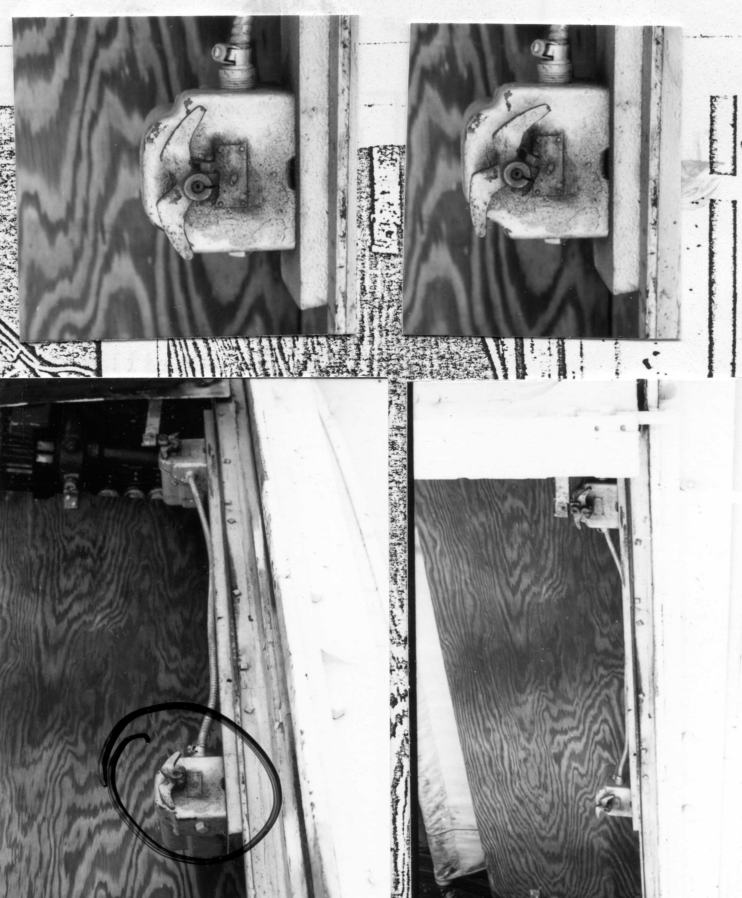

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fig 6.

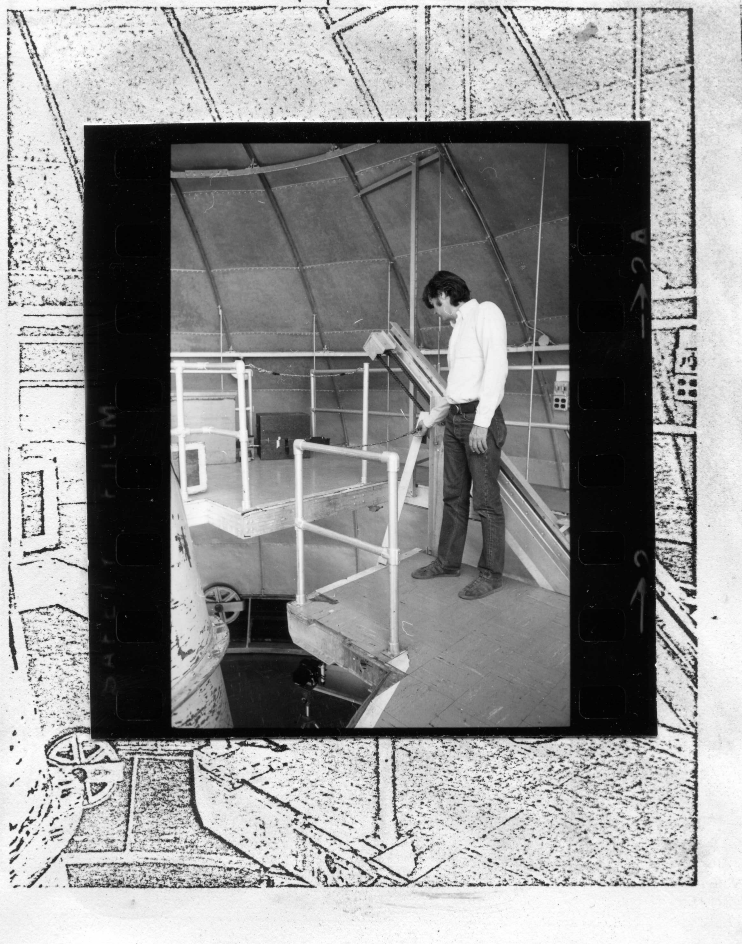

fig 7

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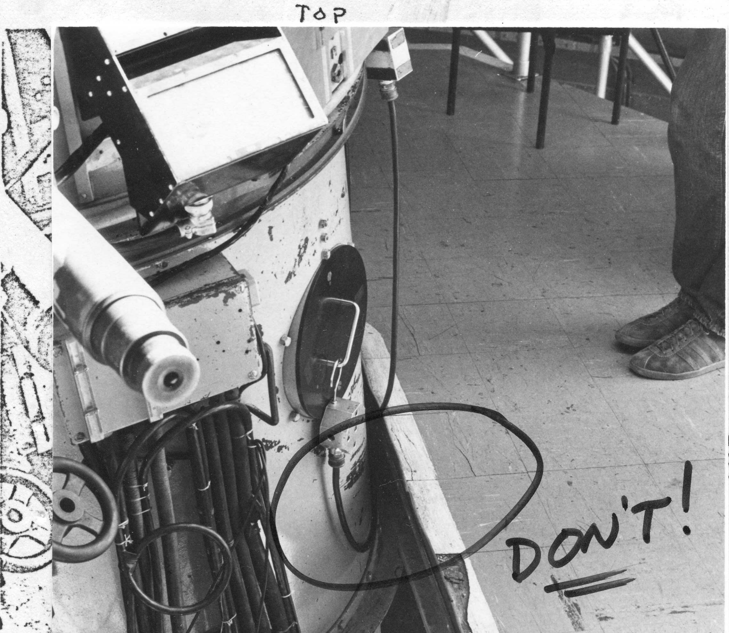

fig 8

fig 9

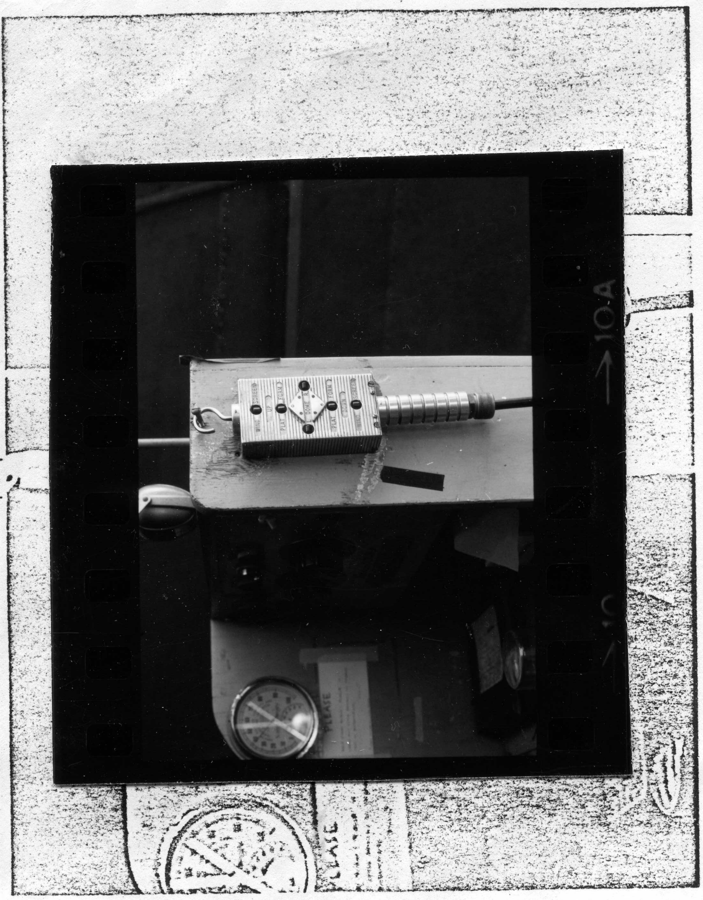

fig 10

fig 11

fig 12

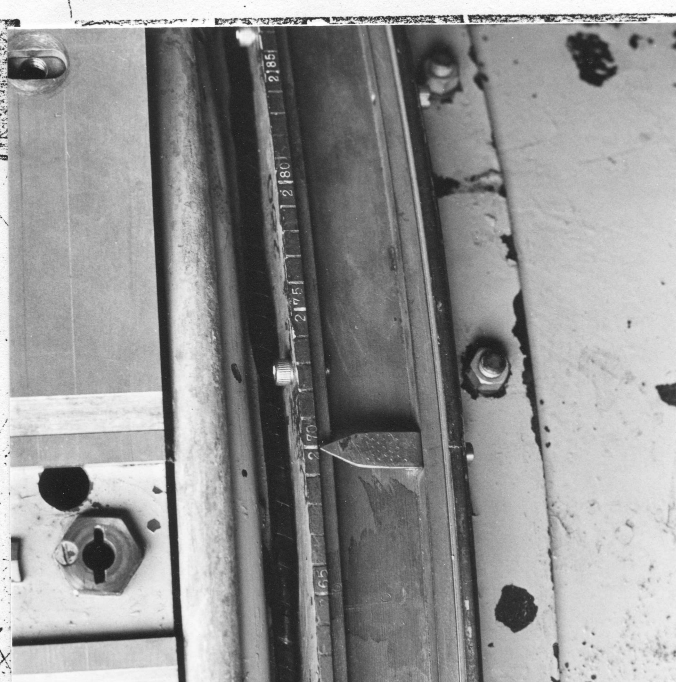

fig 13

fig 14

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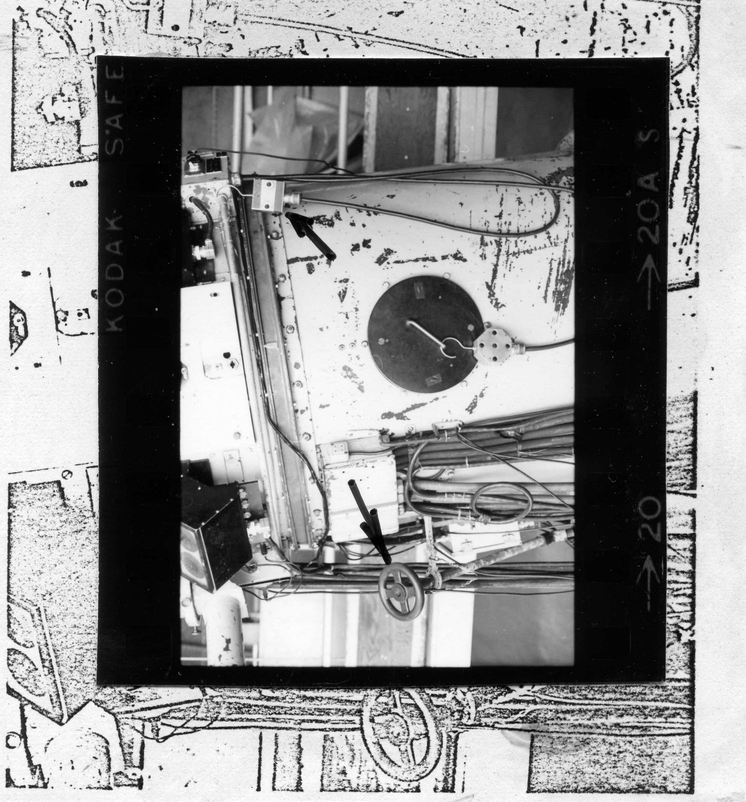

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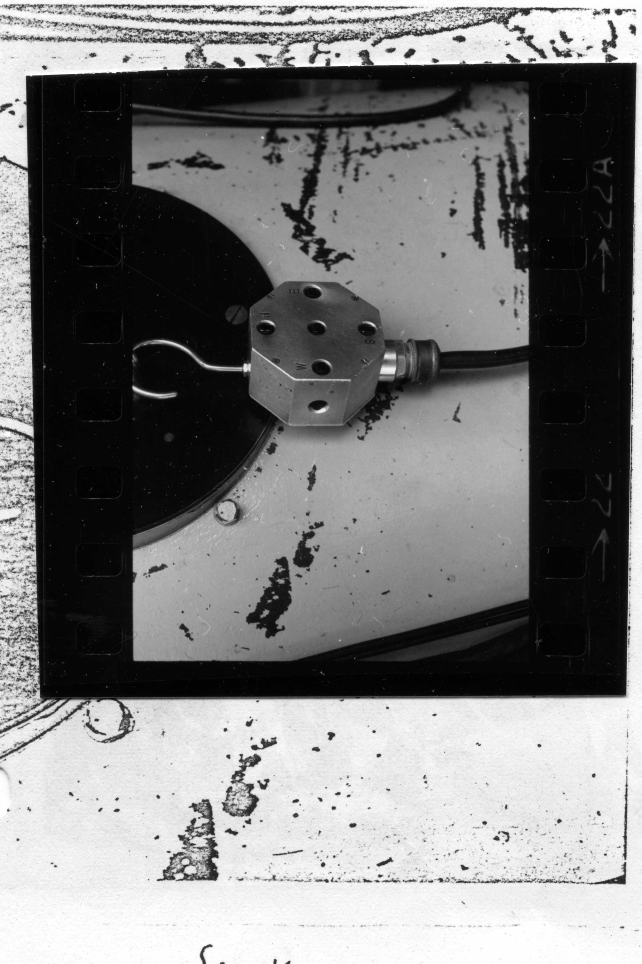

fig 16

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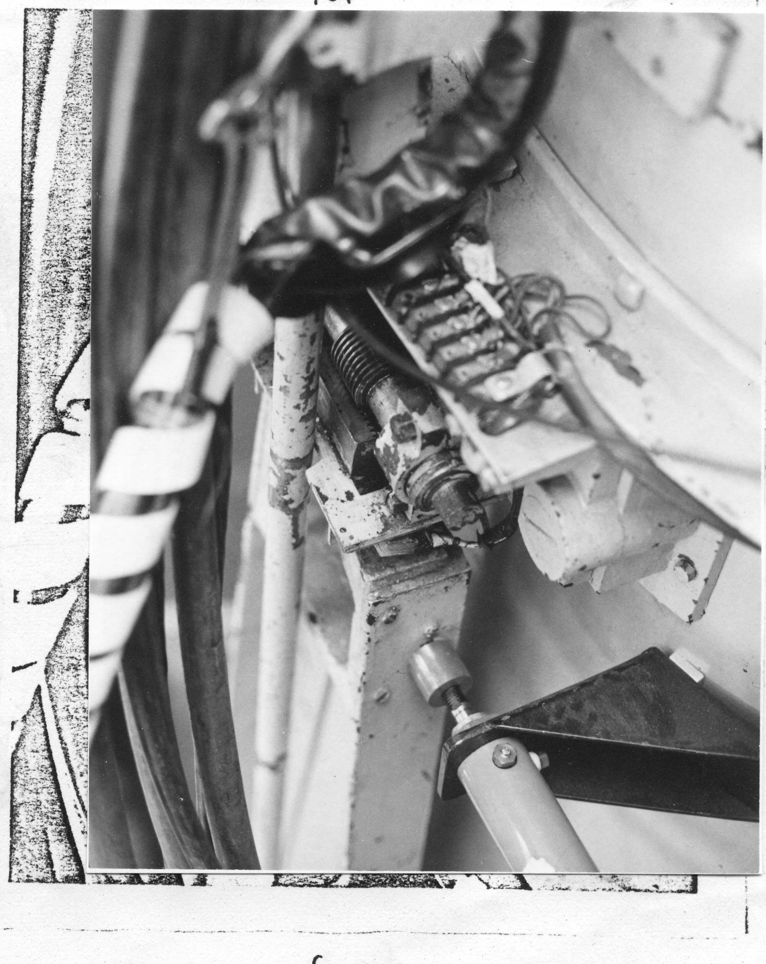

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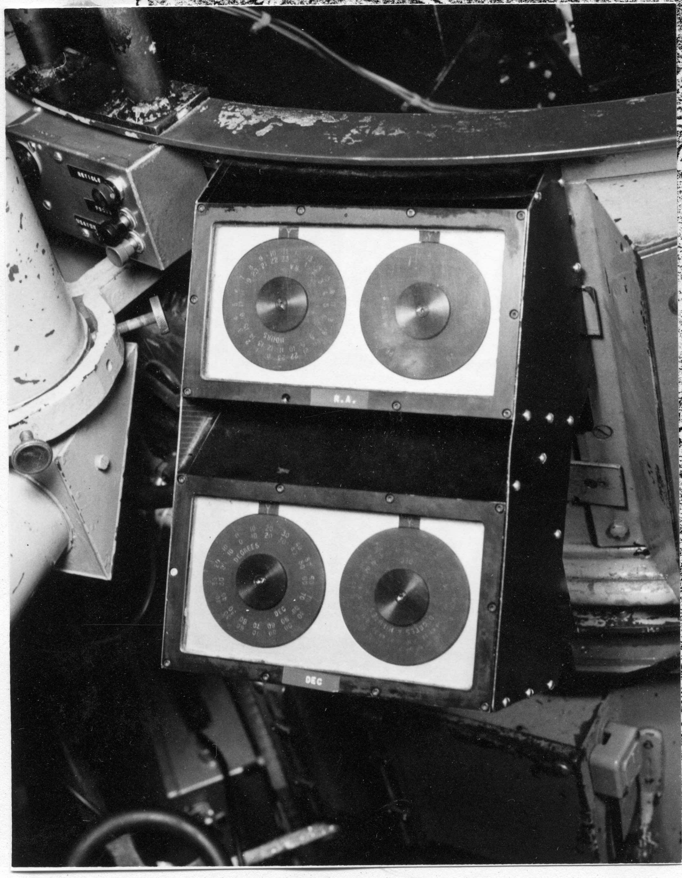

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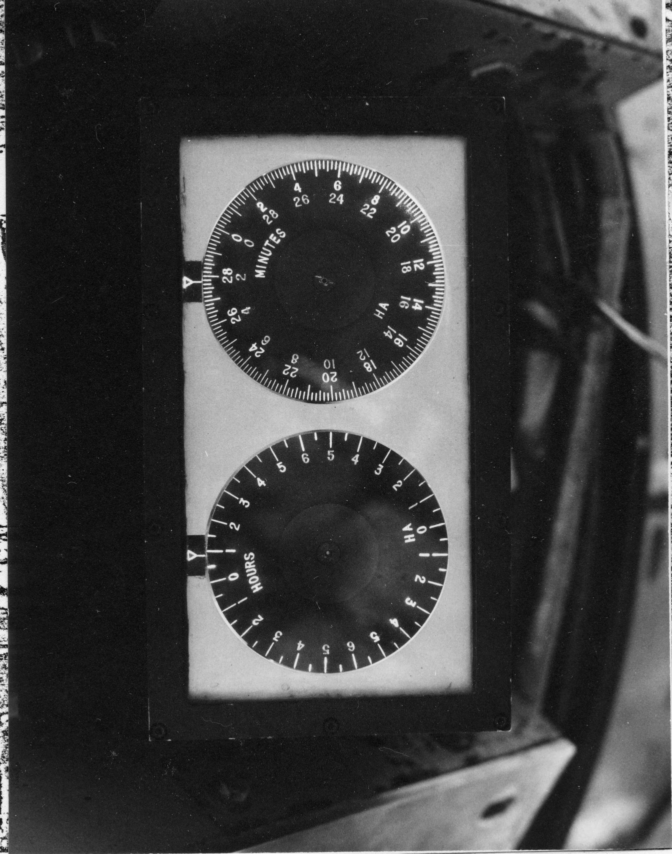

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fig 20

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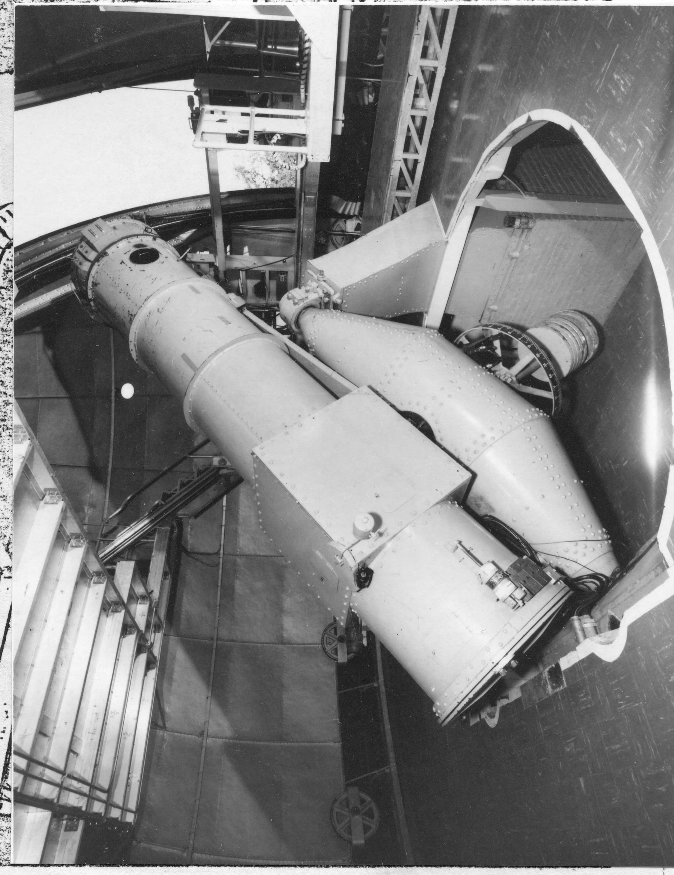
fig 22



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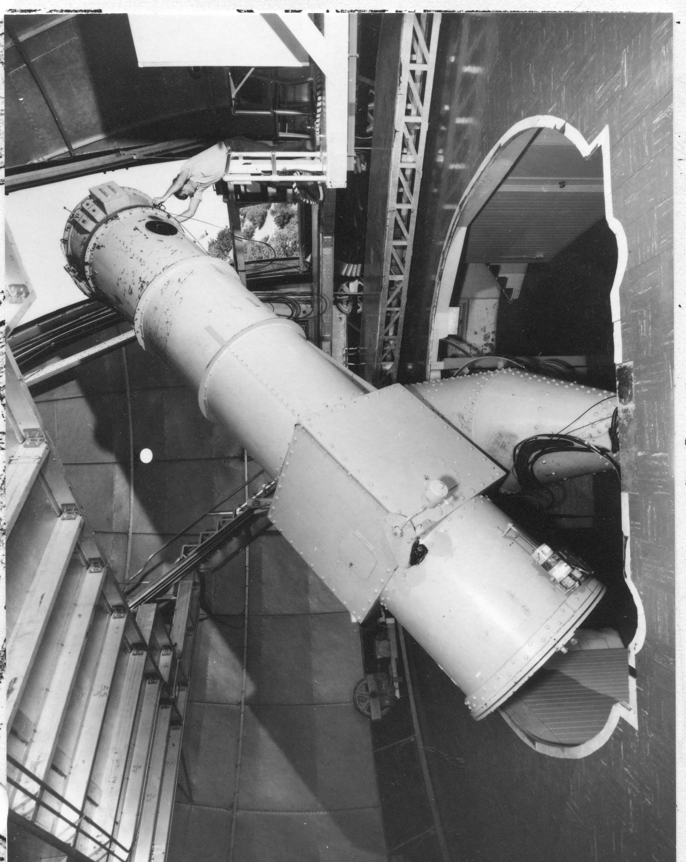

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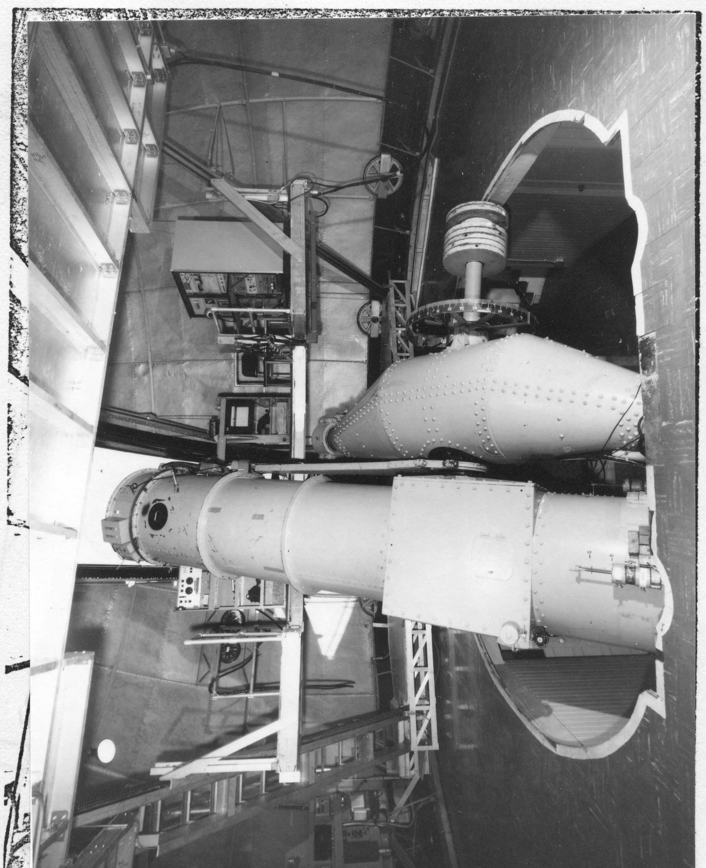

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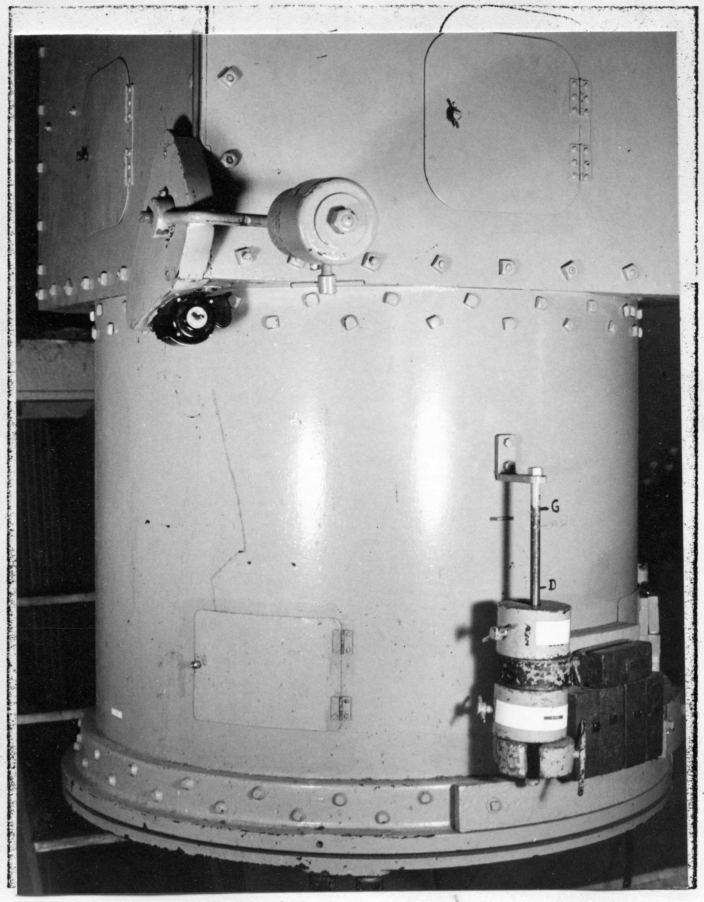

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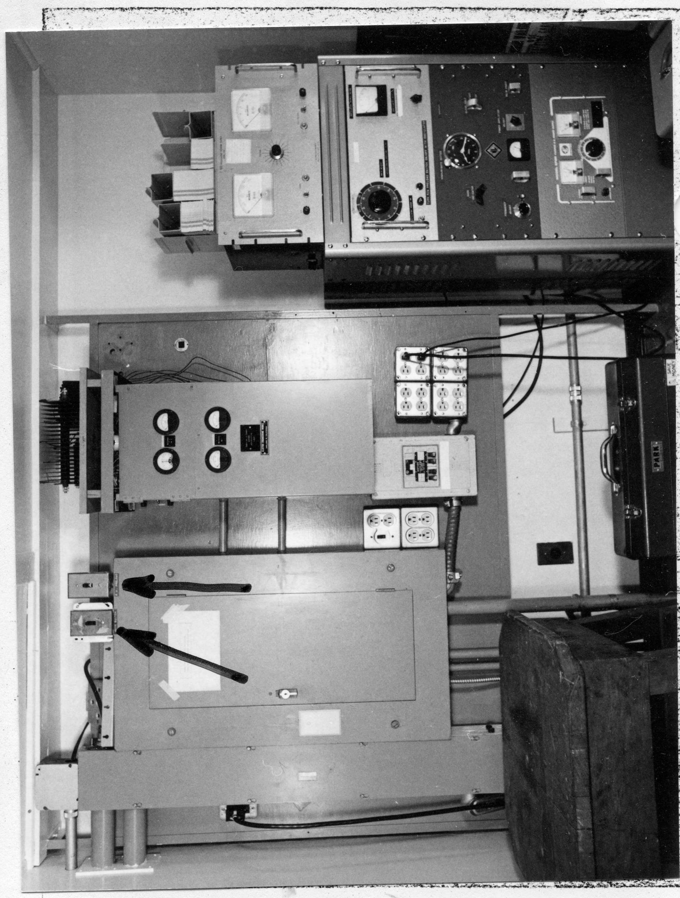
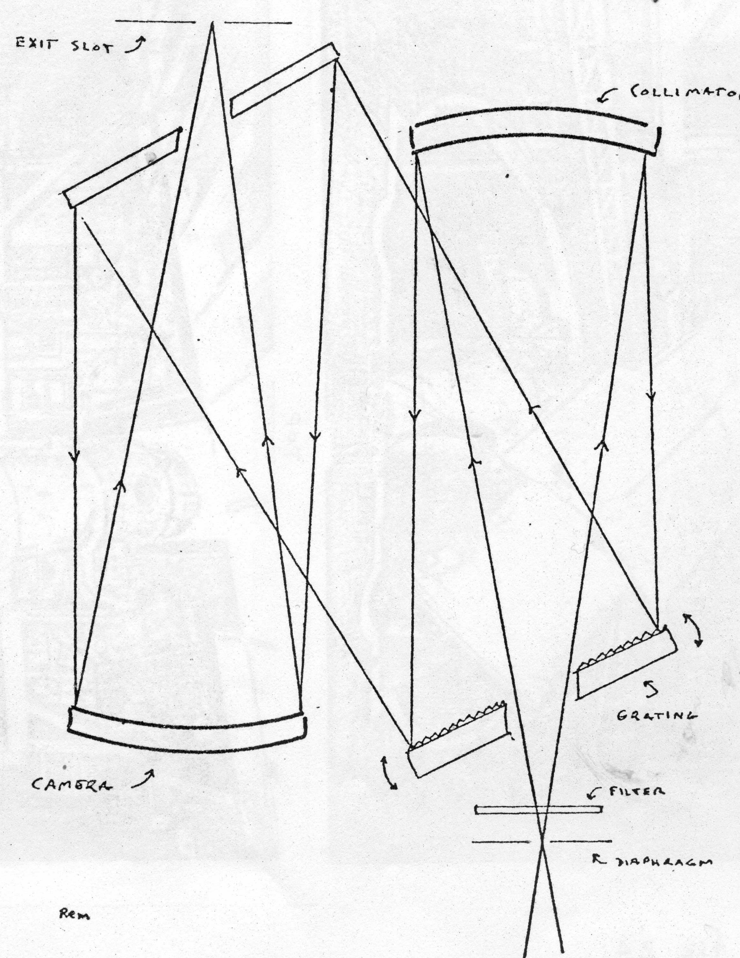


fig 27



Rem

fig 28

fig 29

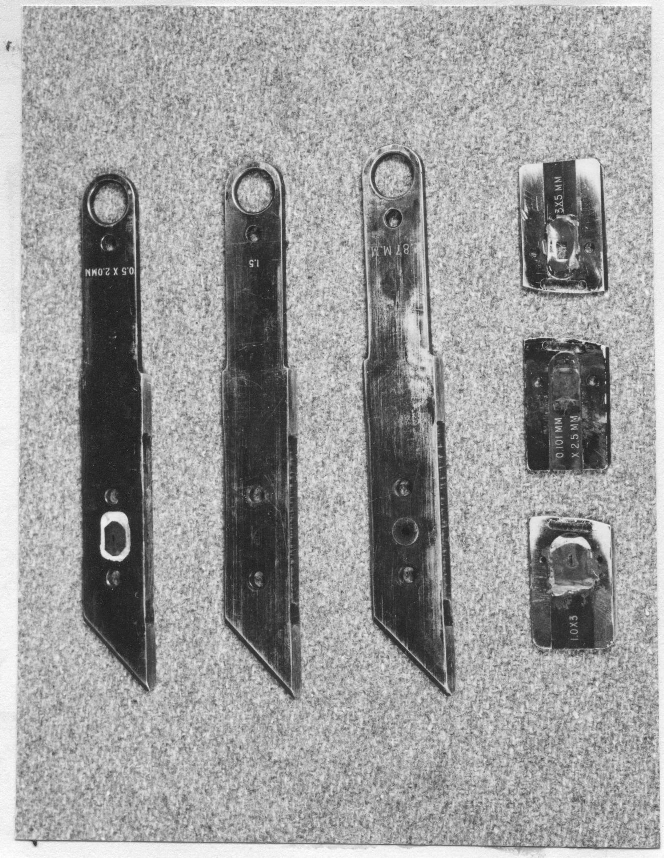


fig 30

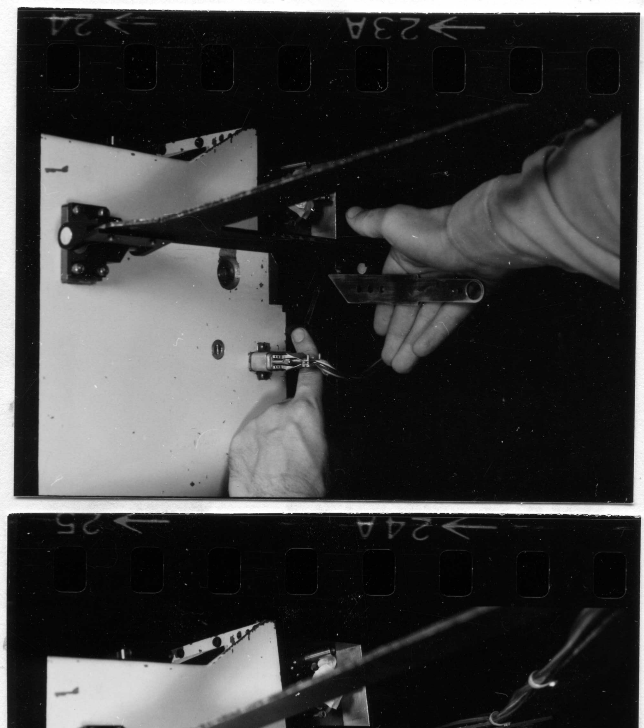
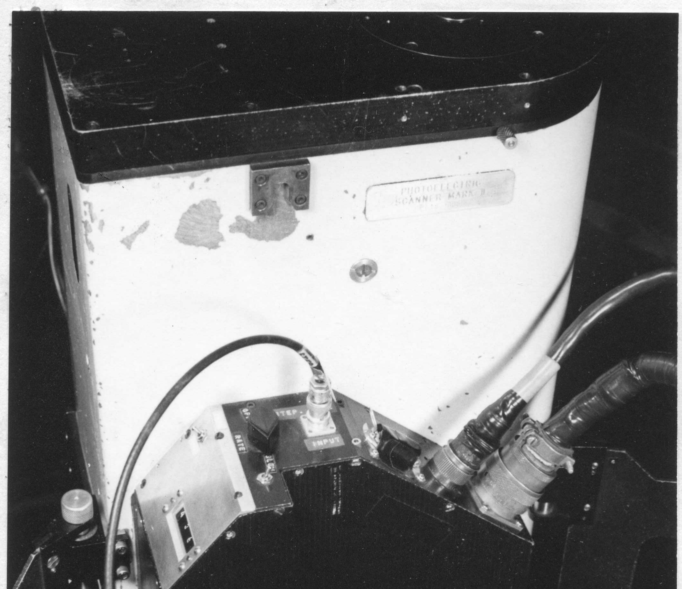


fig 31



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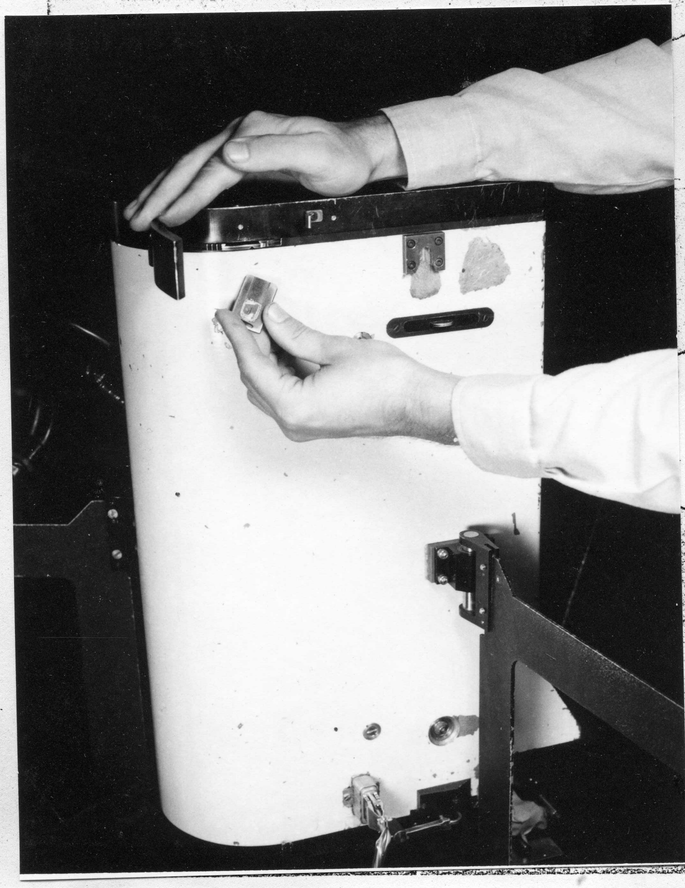

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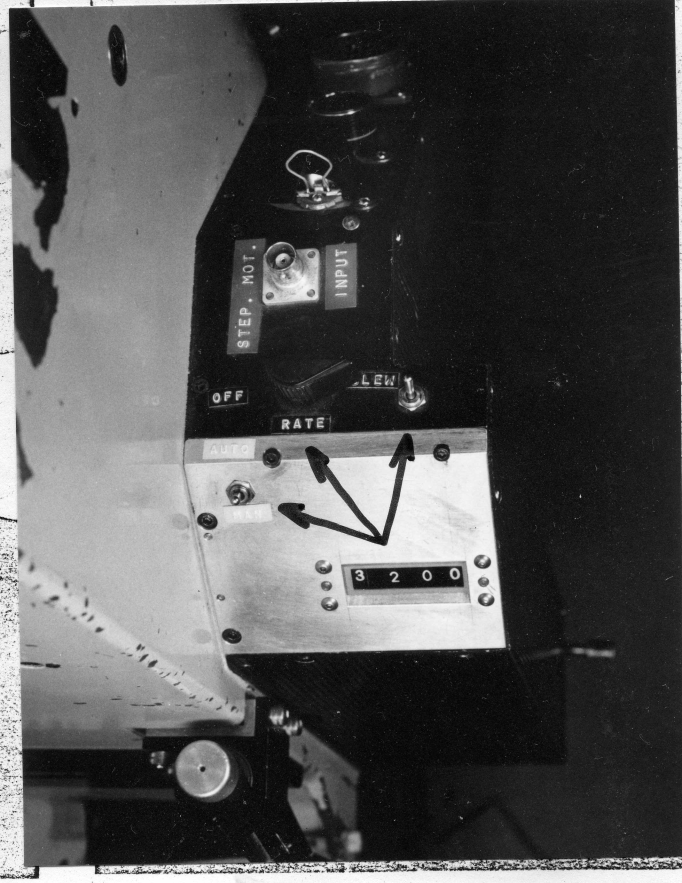
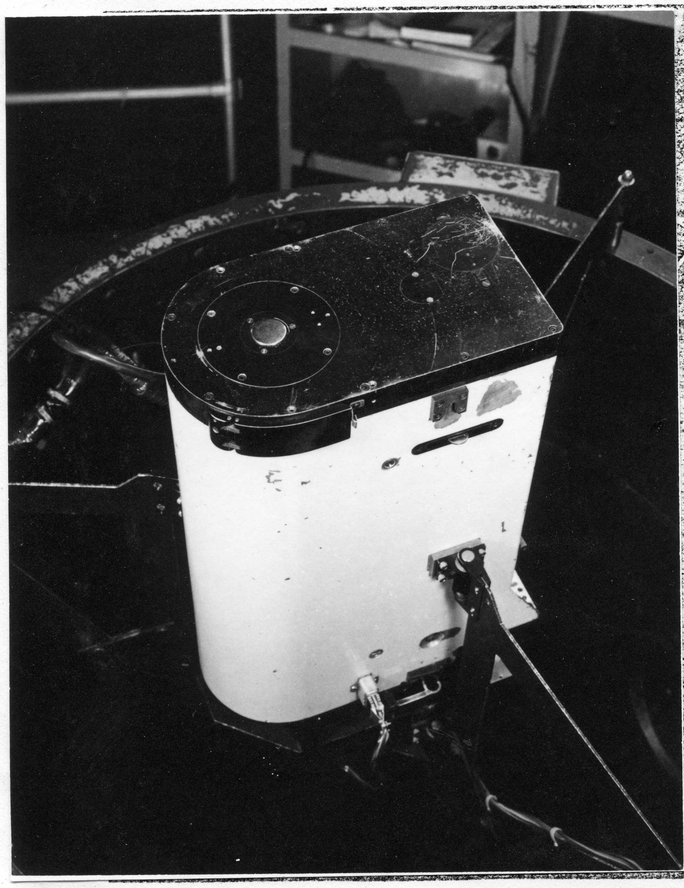


fig 34



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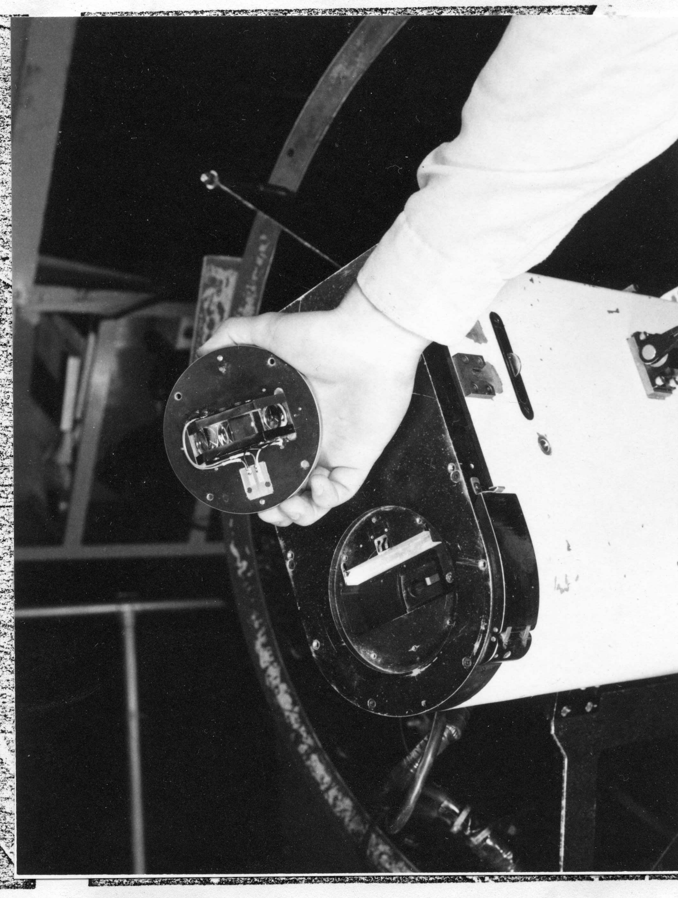

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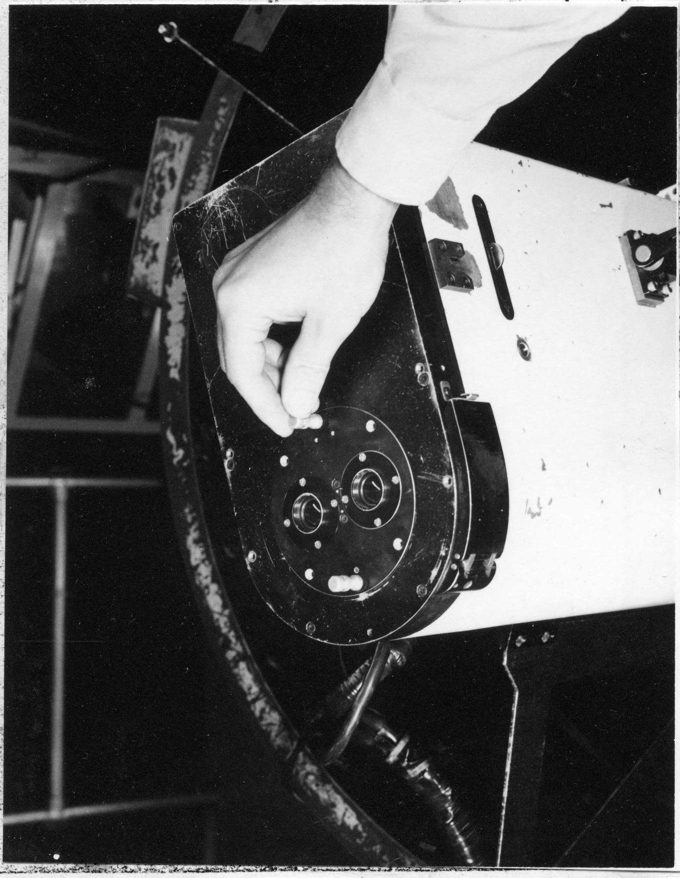

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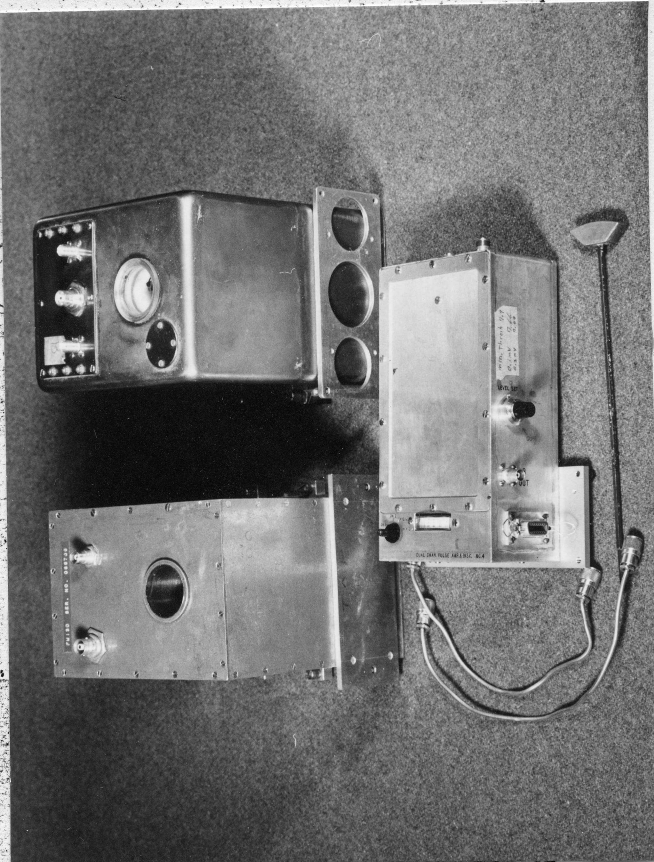

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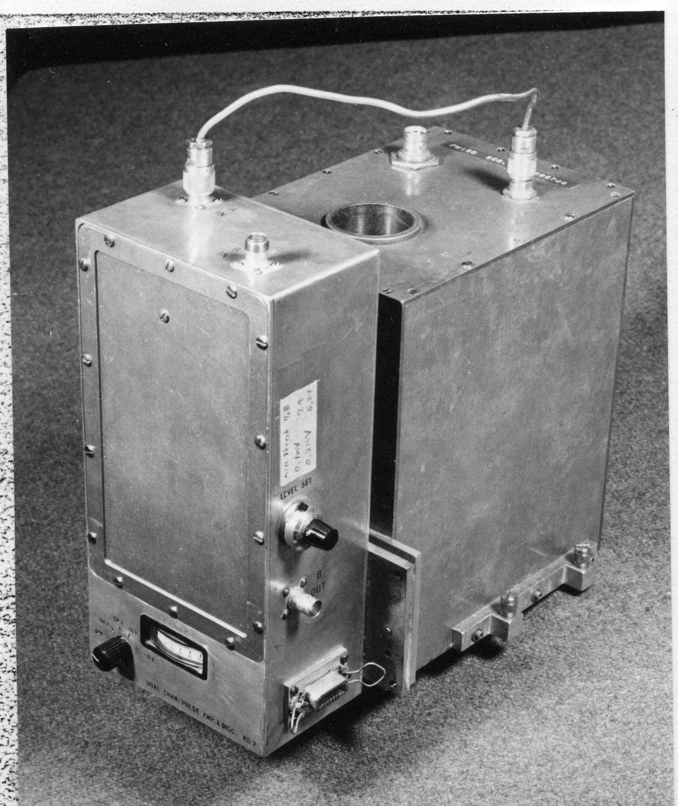

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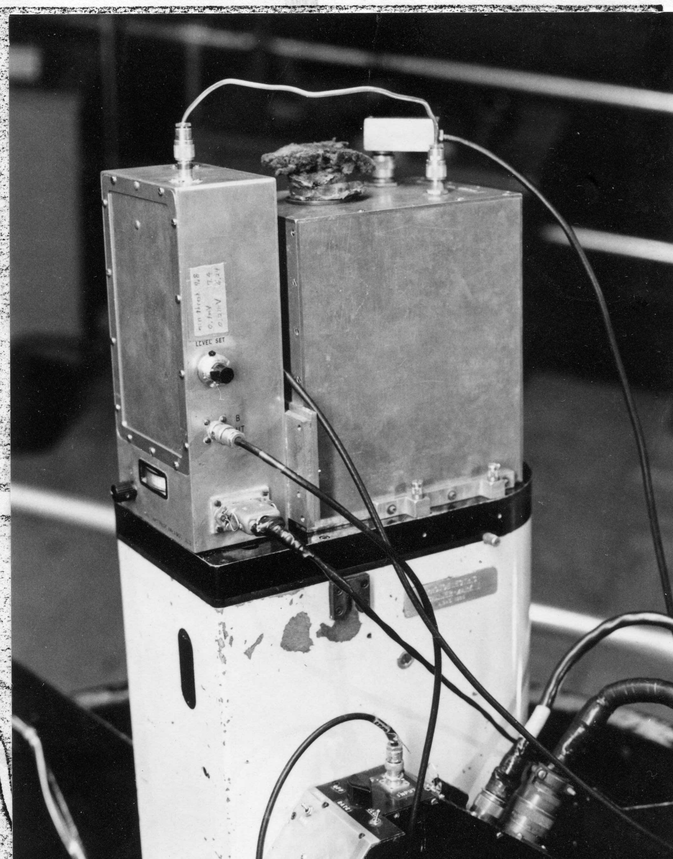

fig 40

fig 41

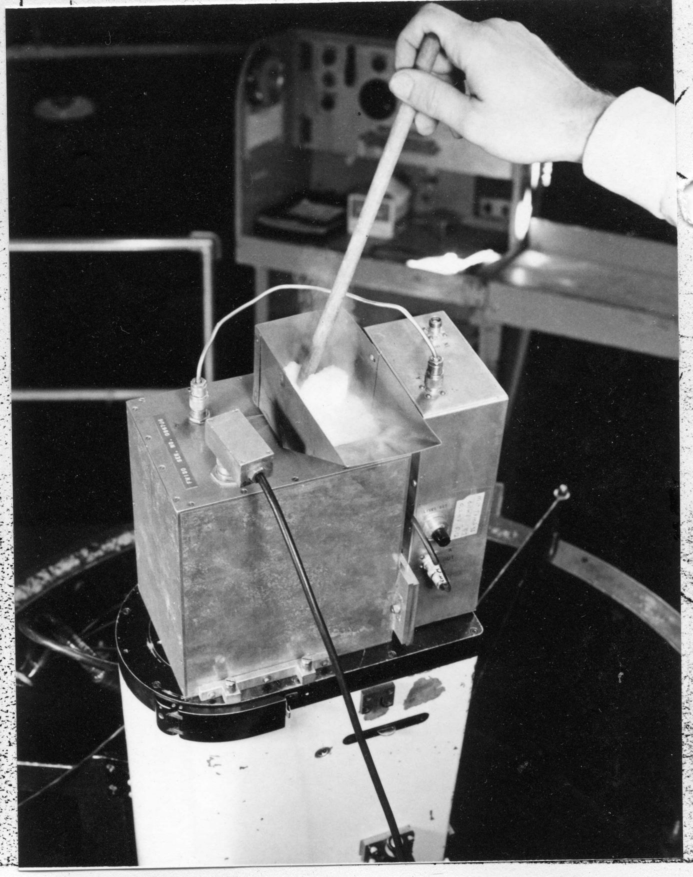

fig 42

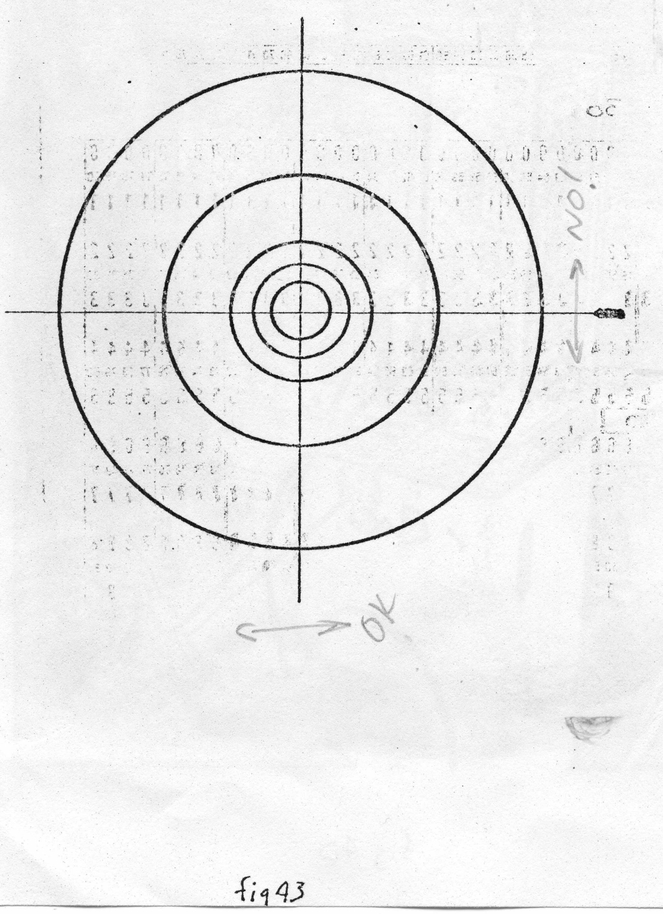

fig 43

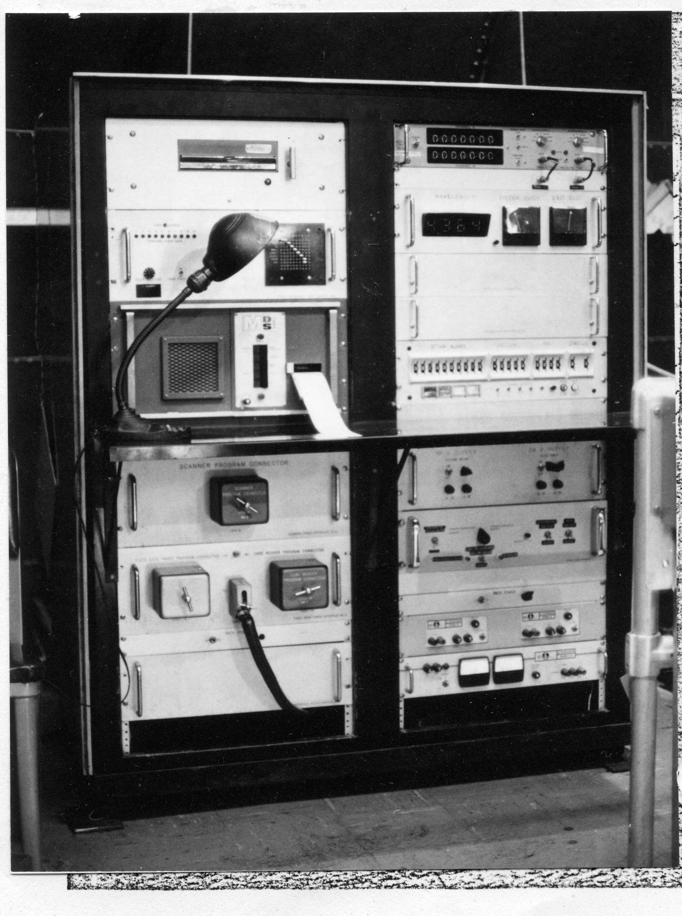

fig 44

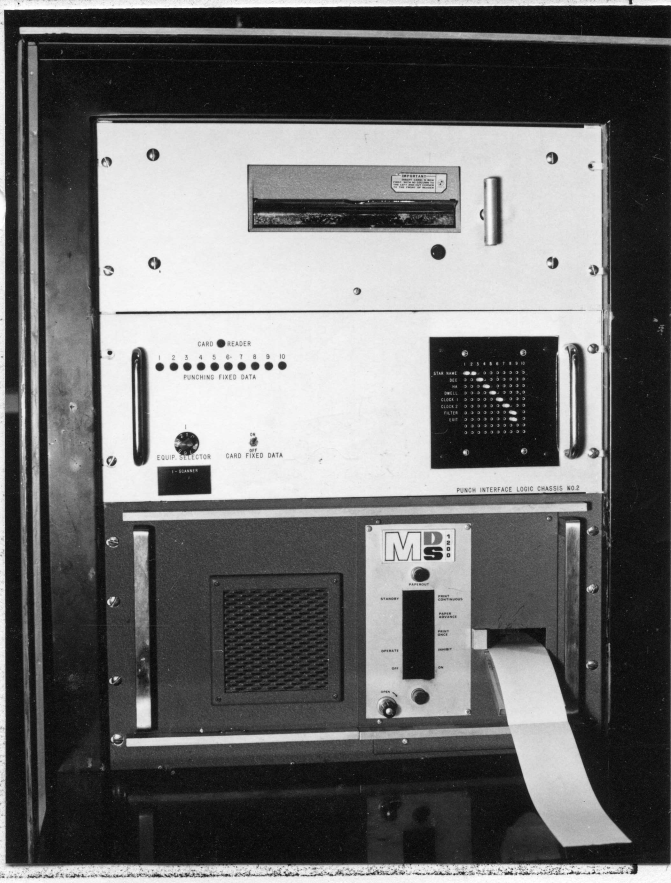

fig 45

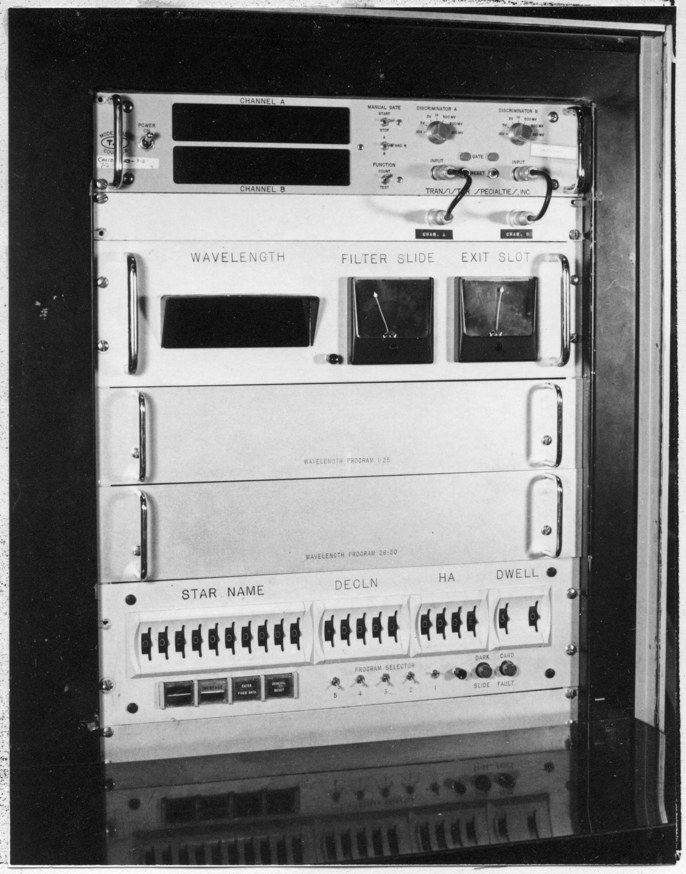

fig 47

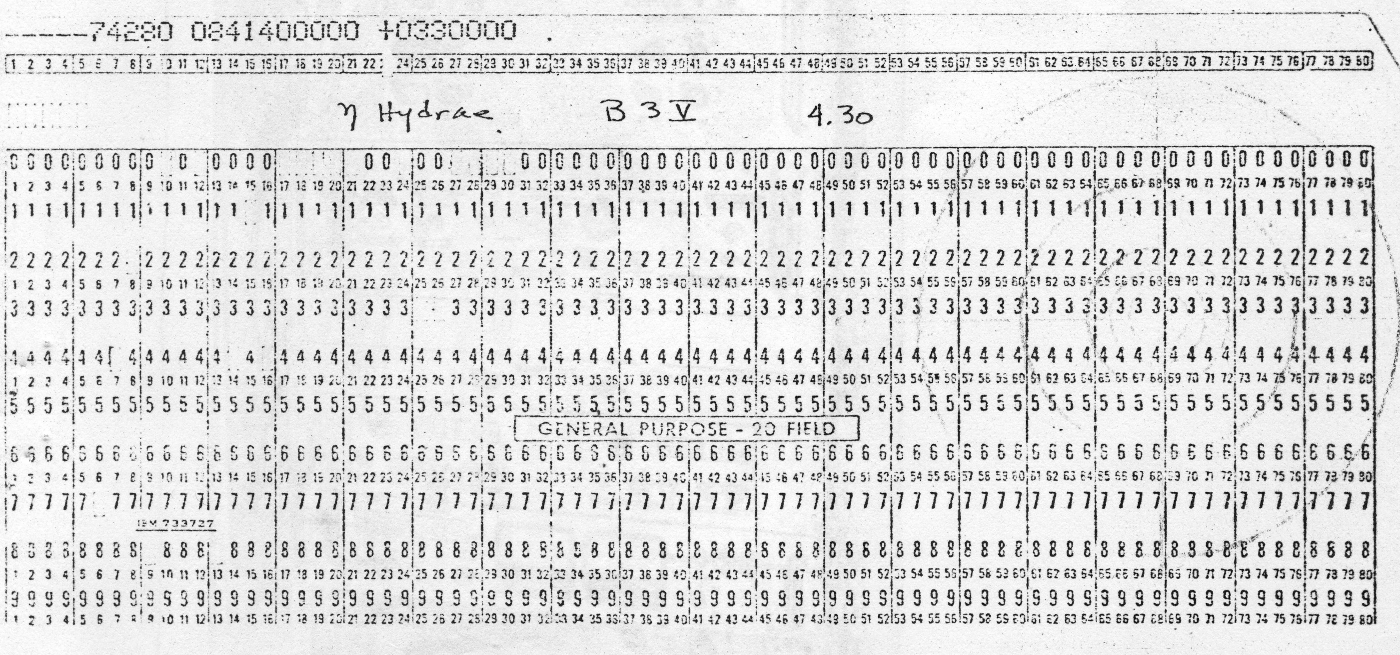

fig 46

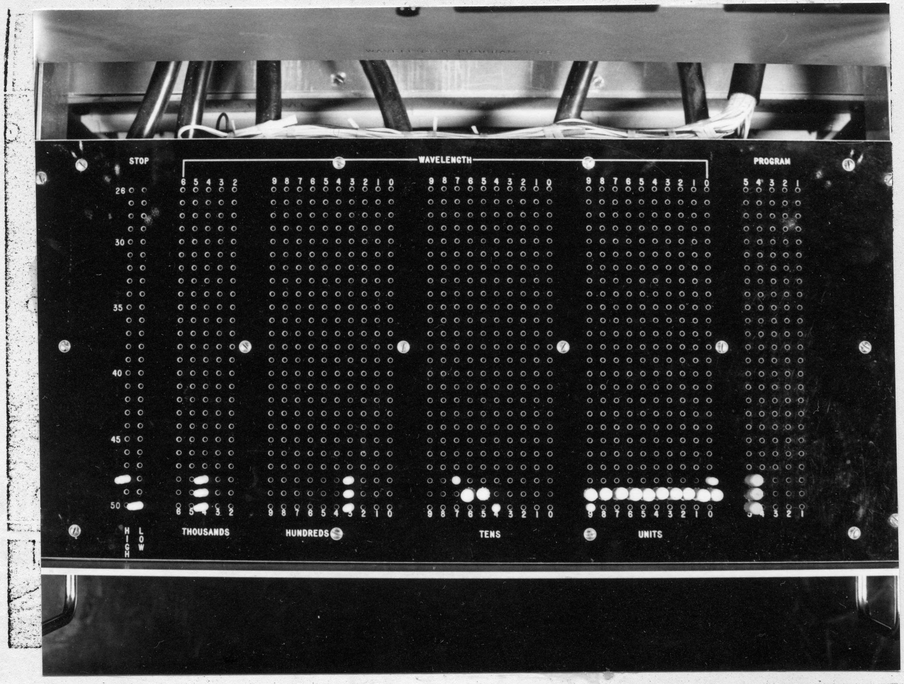
STOP
WAVELENGTH
PROGRAM
26
30
35
40
45
50
HIGH
LOW
THOUSANDS
HUNDREDS
TENS
UNITS

fig 48

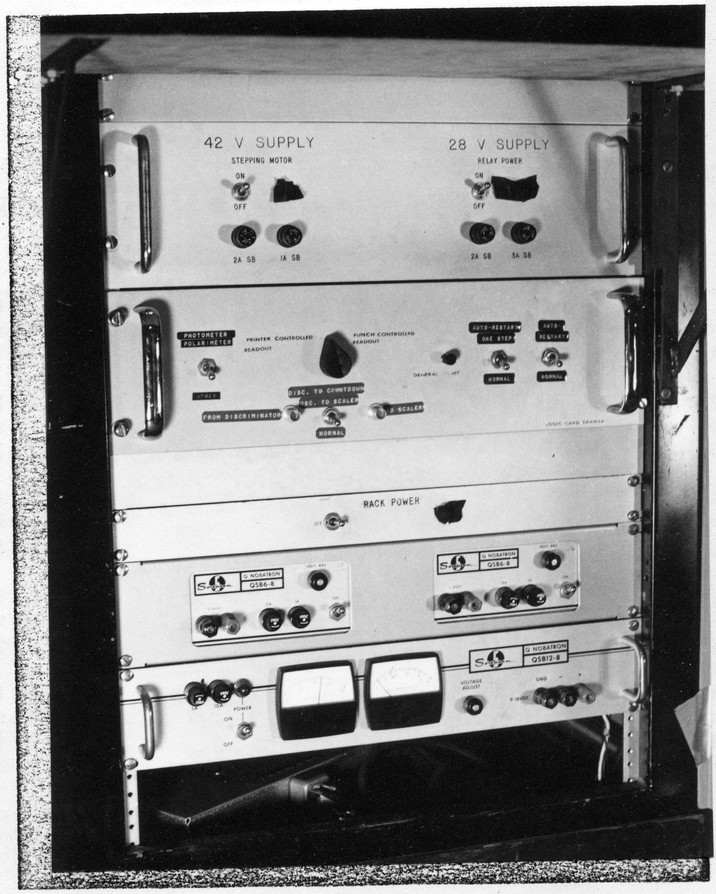
42 V SUPPLY
STEPPING MOTOR
ON
OFF
2A SB
1A SB
28 V SUPPLY
RELAY POWER
ON
OFF
2A SB
3A SB
PHOTOMETER
POLARIMETER
PRINTER CONTROLLED READOUT
PUNCH CONTROLLED READOUT
AUTO-RESTART
ONE STEP
NORMAL
FROM DISCRIMINATOR
DISC. TO COUNTDOWN
DISC. TO SCALER
NORMAL
RACK POWER
Q NOBATRON
QSB6-8
Q NOBATRON
QSB6-8
Q NOBATRON
QSB12-8
POWER
ON
OFF
VOLTAGE ADJUST
GND

fig 49

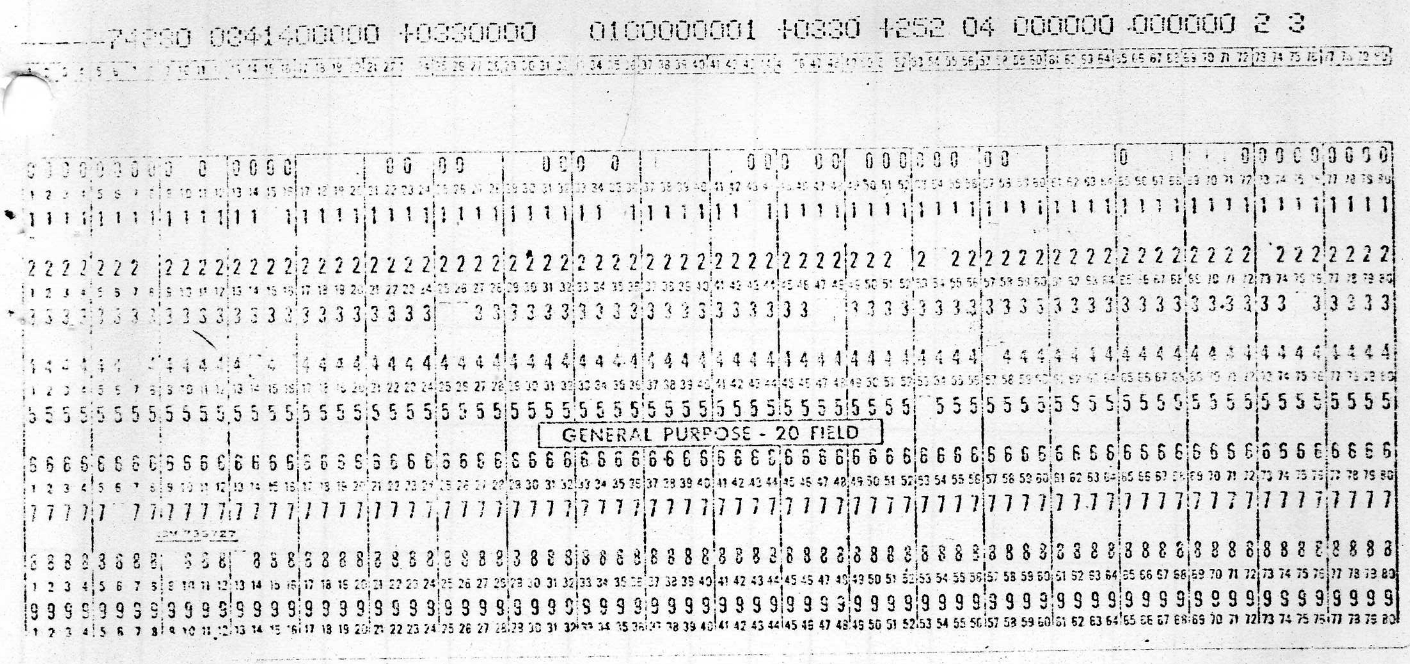
------74280 0341400000 +0330000 0100000001 +0330 +252 04 000000 000000 2 3
GENERAL PURPOSE - 20 FIELD
IBM 733727

fig 50

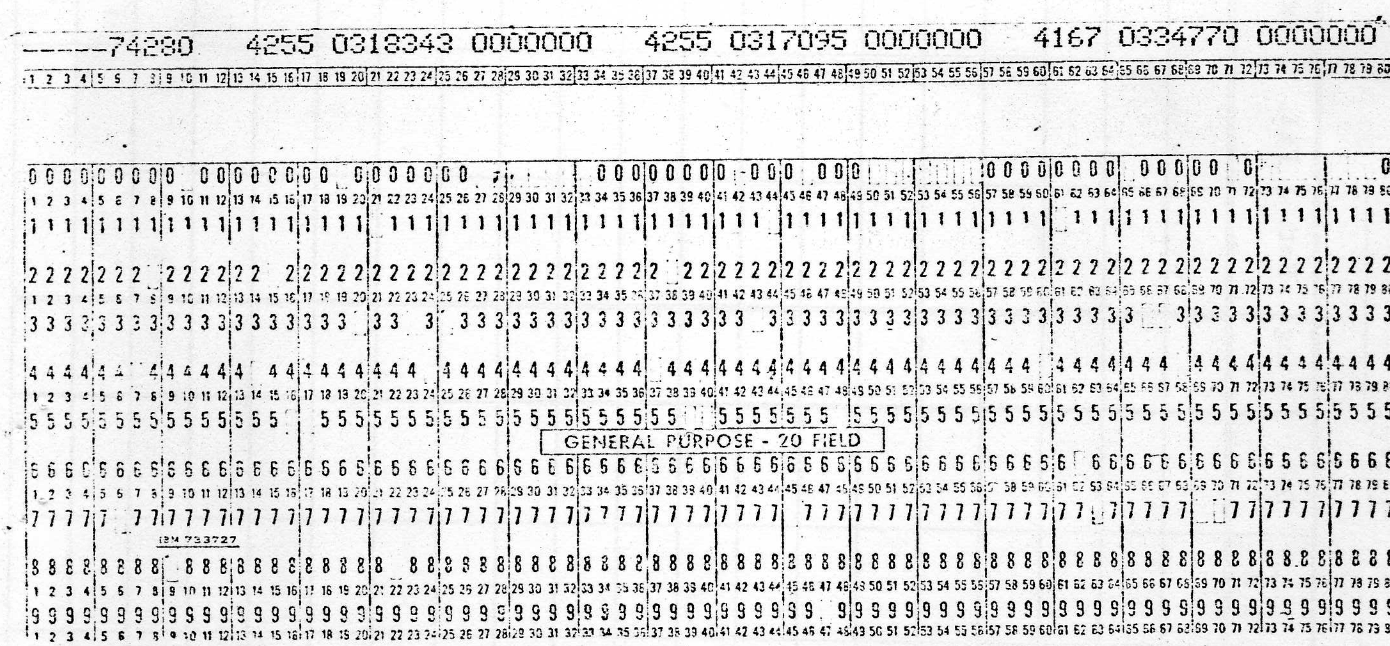
------74280 4255 0318343 0000000 4255 0317095 0000000 4167 0334770 0000000
GENERAL PURPOSE - 20 FIELD
IBM 733727

fig 51

PHOTOELECTRIC OBSERVATIONS

SCANNER

Telescope: ____________

Observer: ____________ Ass't: ____________ Cell: ________ Opr. V: ____________ Date: ________ 19 ______

Scan #	Object	R.A. h m	Decl ° '	Prog #	Ent.	Fil.	Exit	Dwell time	H/A Start	PST Start	PST End	See-ing	Remarks

fig 52

OBSERVERS PROGRAM SCHEDULE

TELESCOPE ____________________

DATE: ______________ 19___

FILTER: Far UV - 1
UV-BLUE - 2
Blue - 3
Yellow - 4
Red - 5

EXIT: 1 - ______ mm
2 - ______
3 - ______
4 - ______

OBSERVER ____________________ ASS'T. ____________________ CELL ____________________

Object - (s)	Prog	λ Limits	Ent.	Filt.	Exit	Dwell	Comment
		:					
		:					
		:					
		:					
		:					
		:					
		:					
		:					
		:					
		:					
		:					
		:					
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		:					
		:					
		:					
		:					

REMARKS:

fig 53

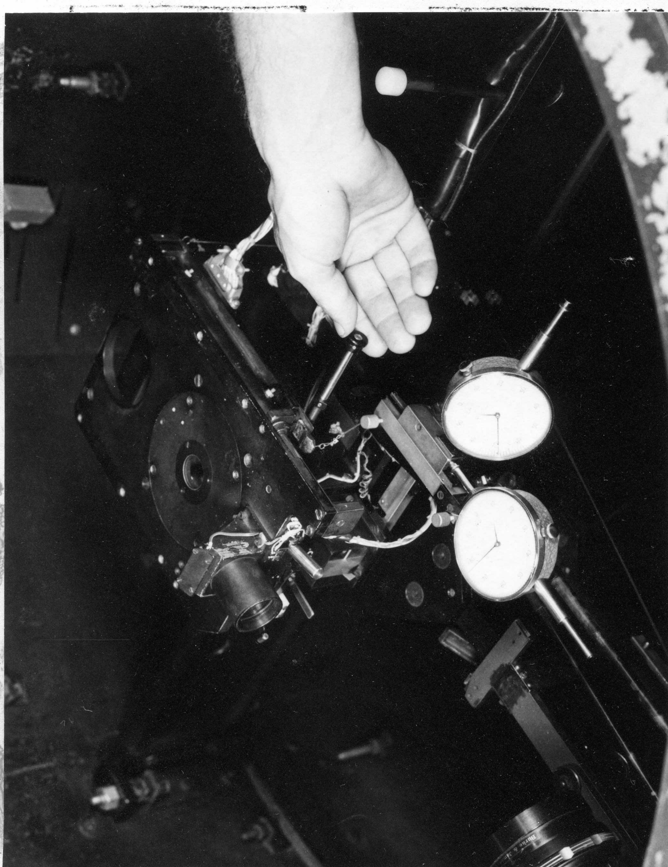


fig 54

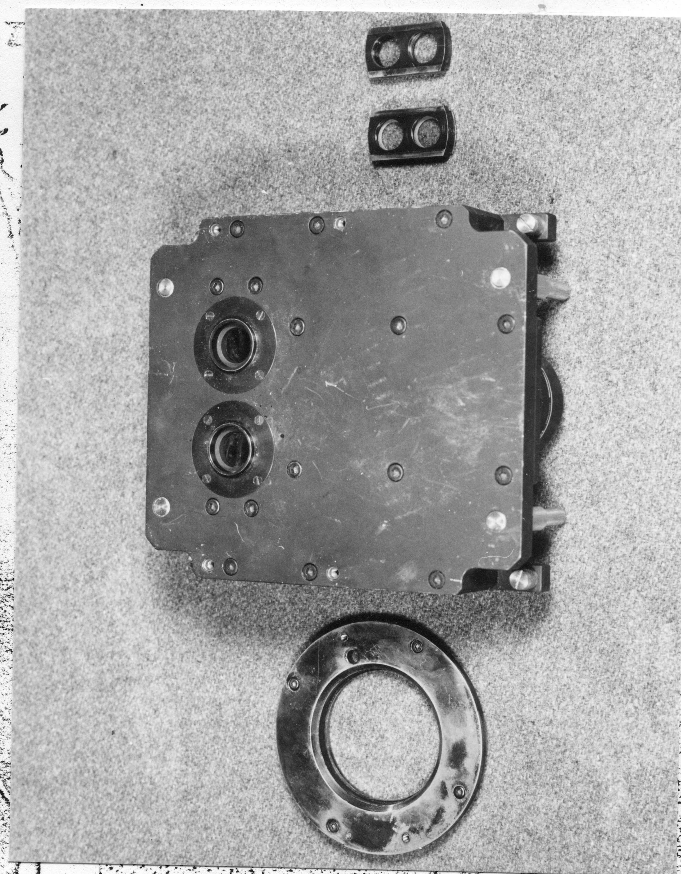


fig 55

fig 56

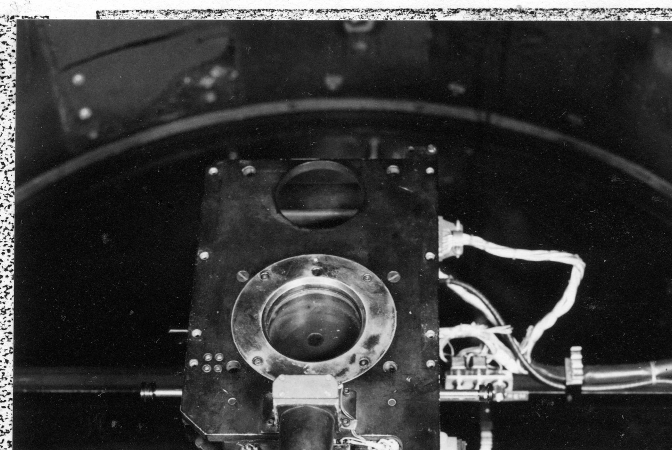
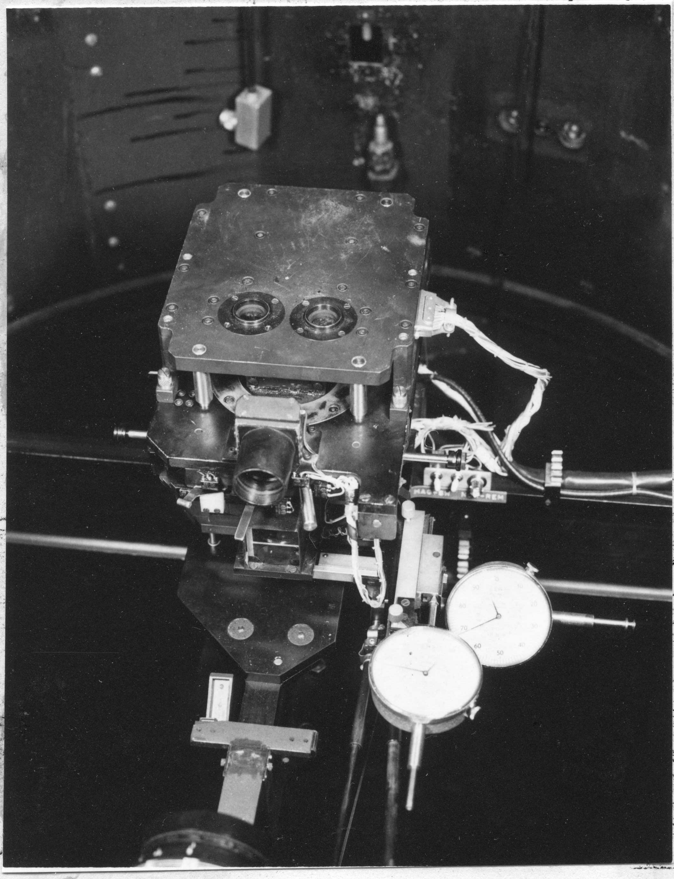


fig 57



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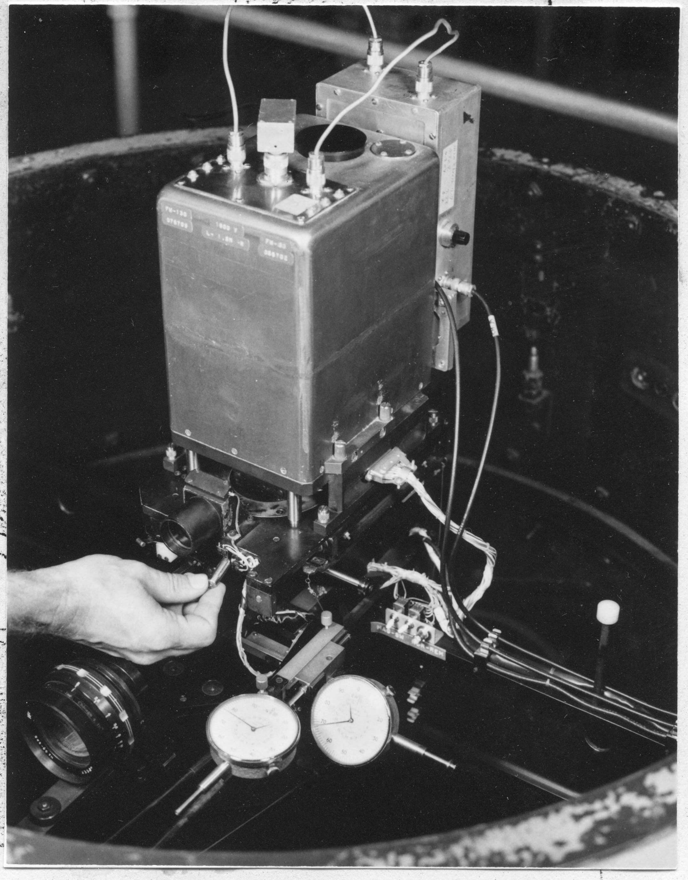

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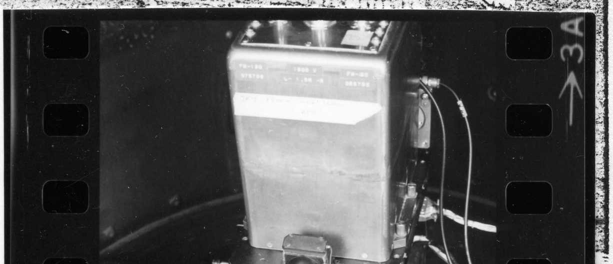


fig 60

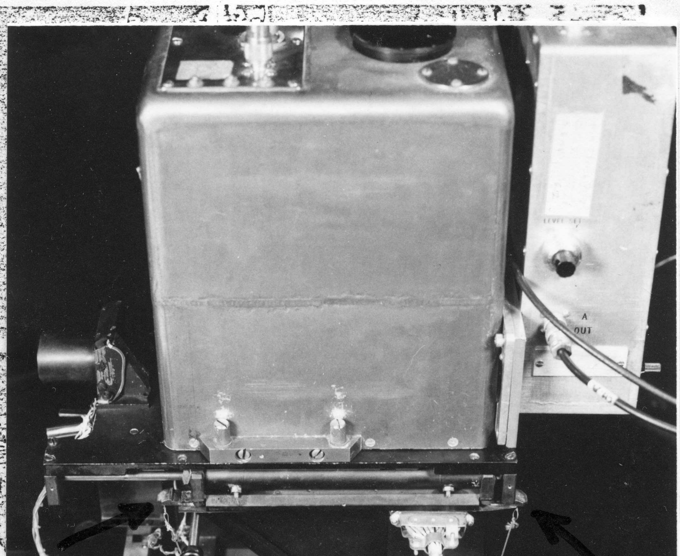


fig 61

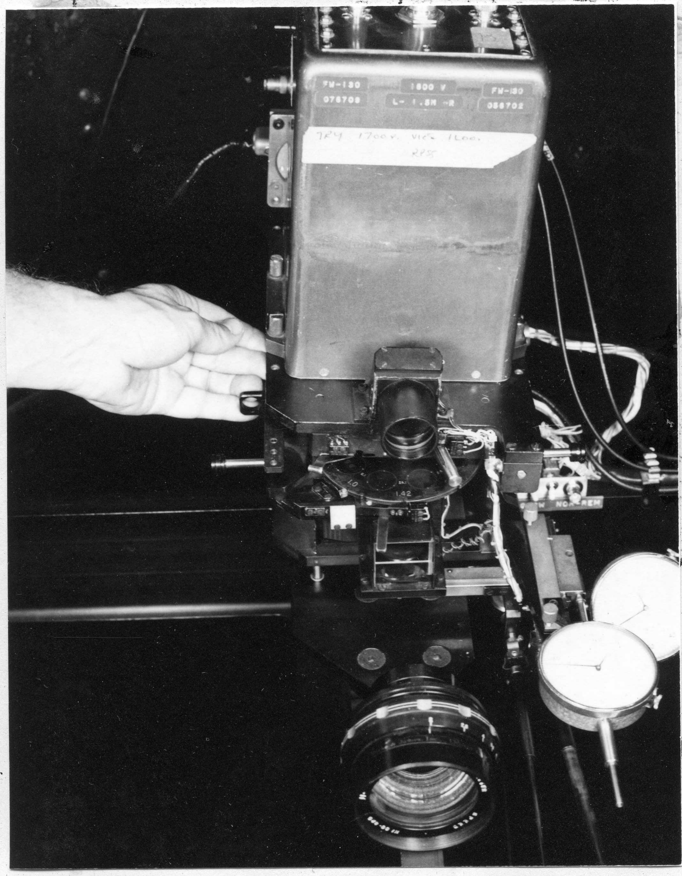


fig 62

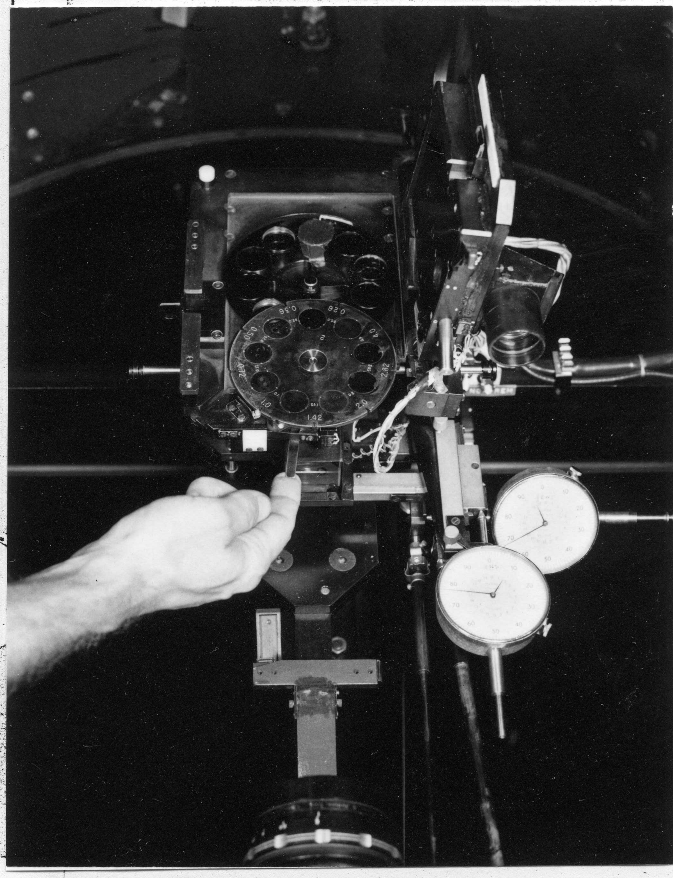


fig 63

TOP

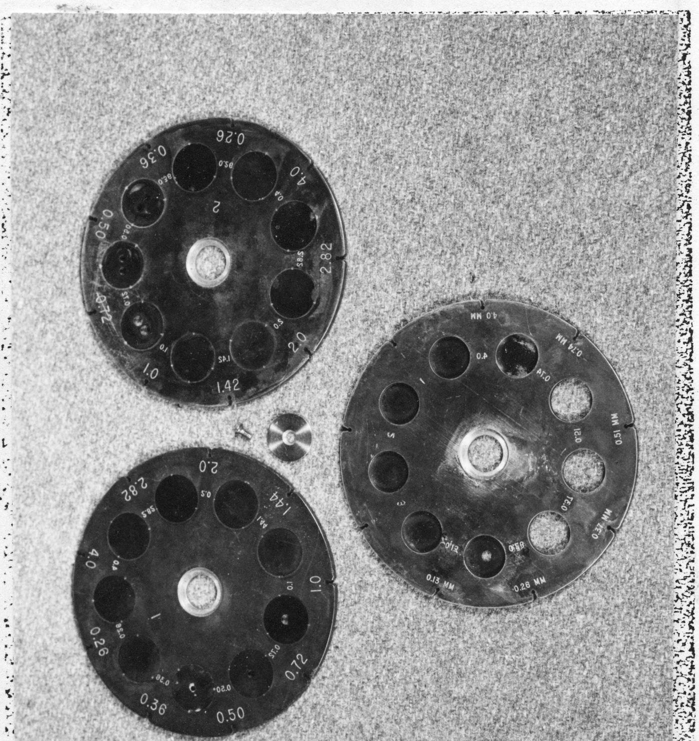
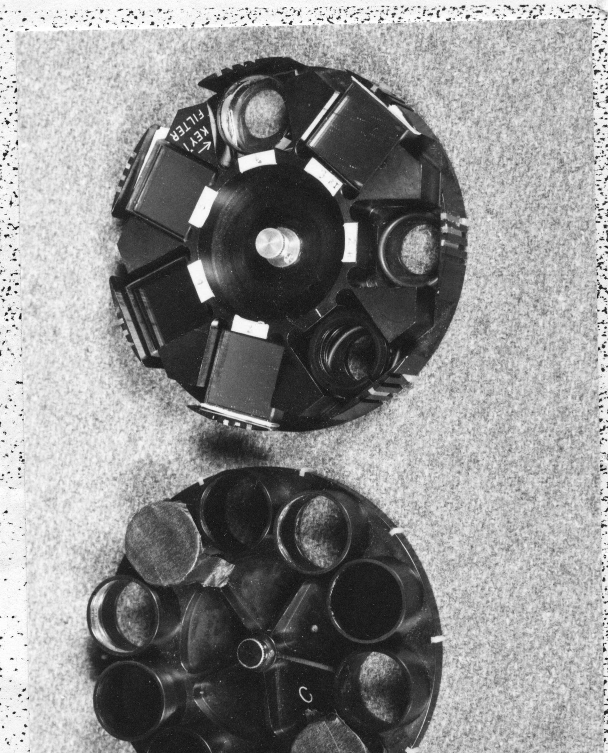


fig 64

TOP



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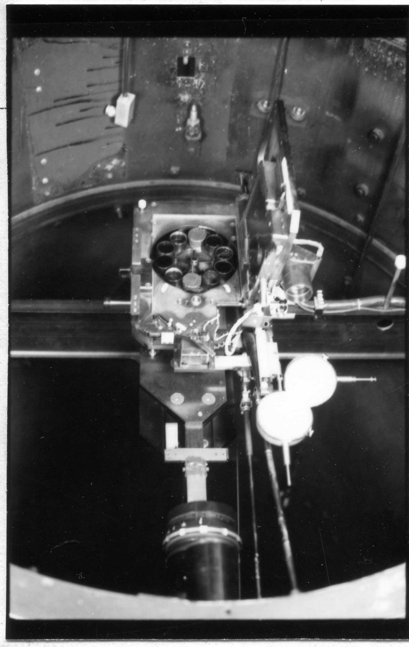

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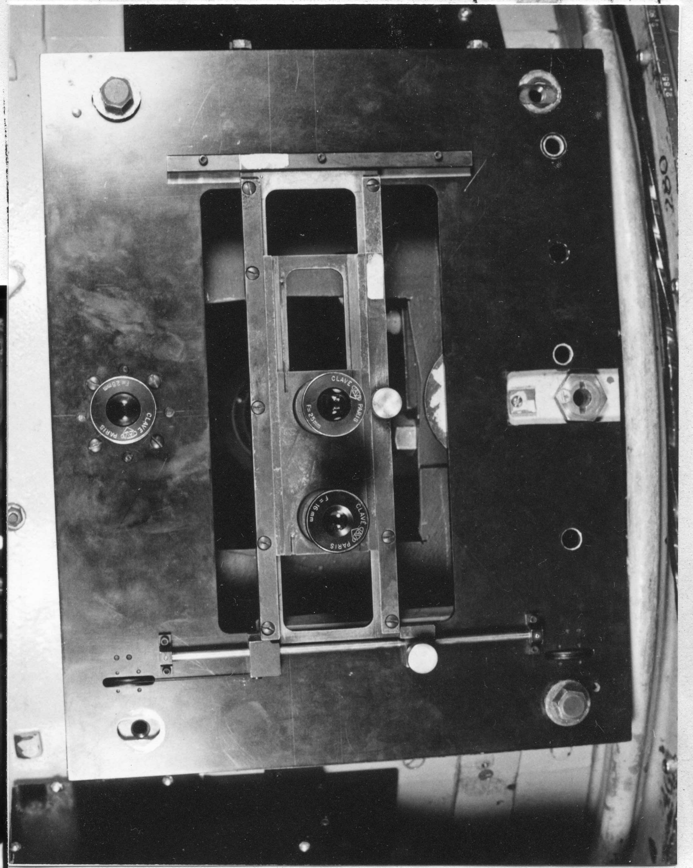


fig 67

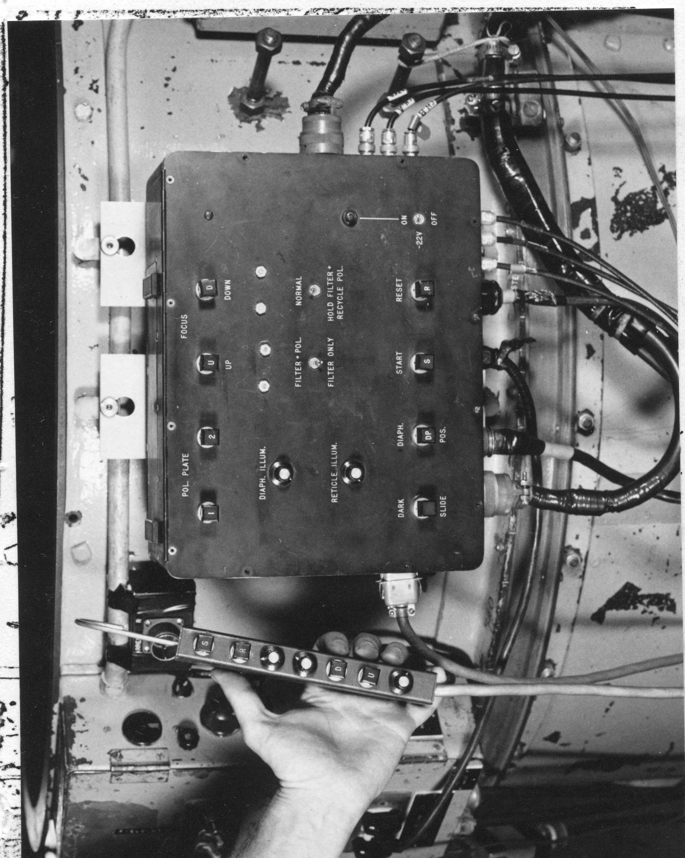


fig 68

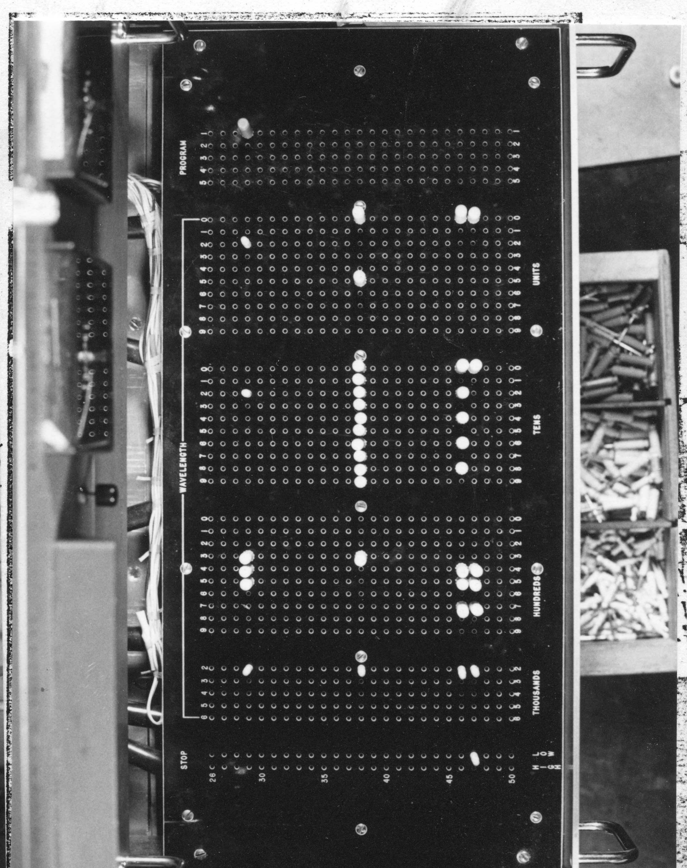
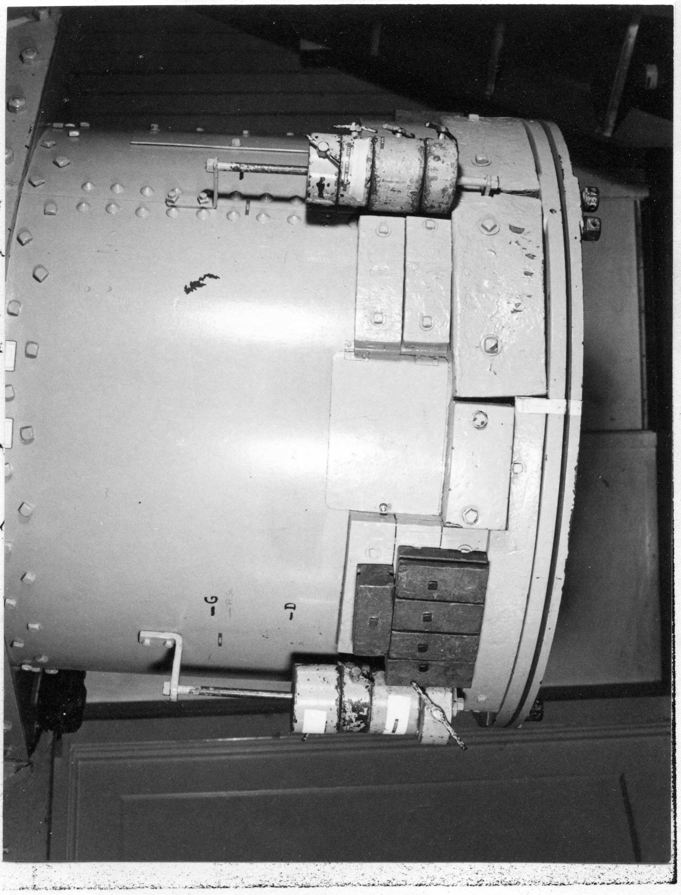
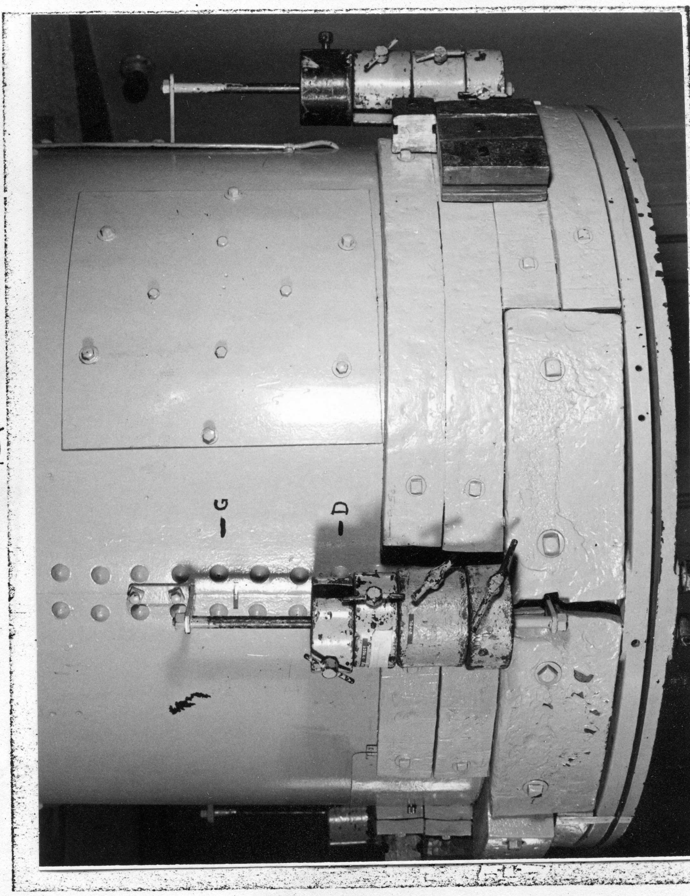


fig 69





TOP

fig 72

fig 73

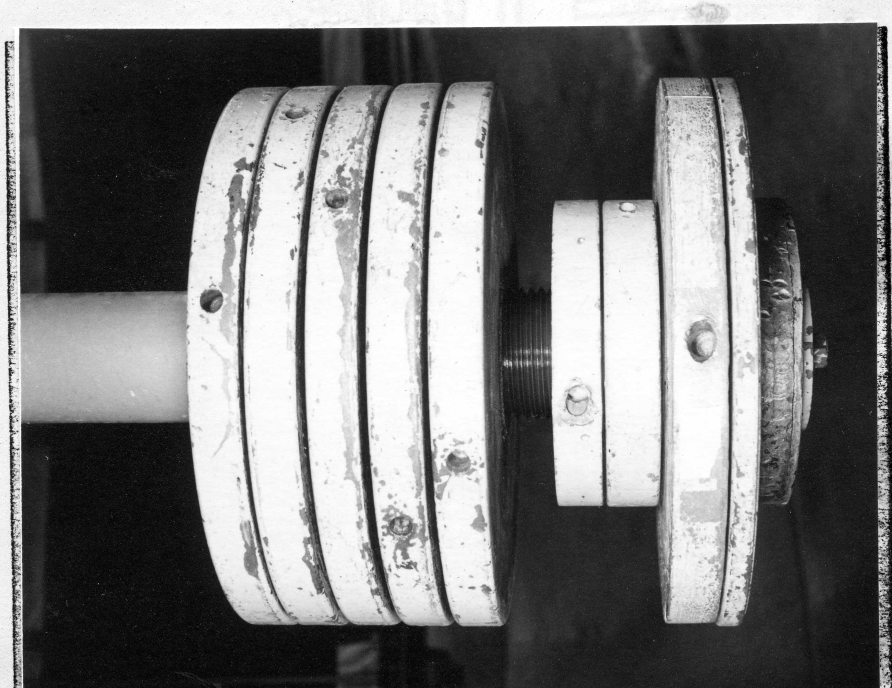


fig 74

Recommended weight distributions for Scanner

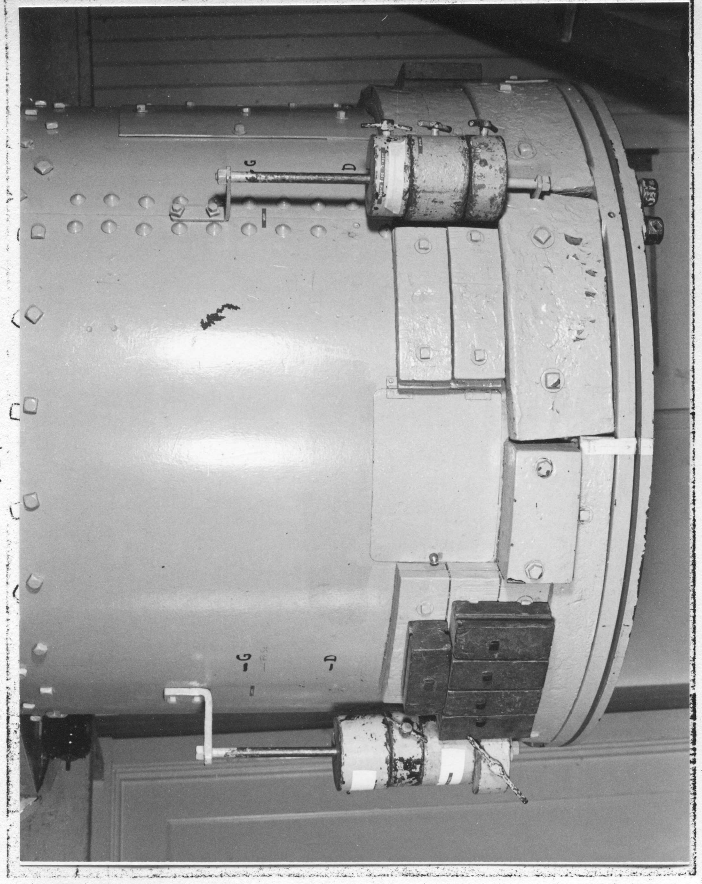


fig 75

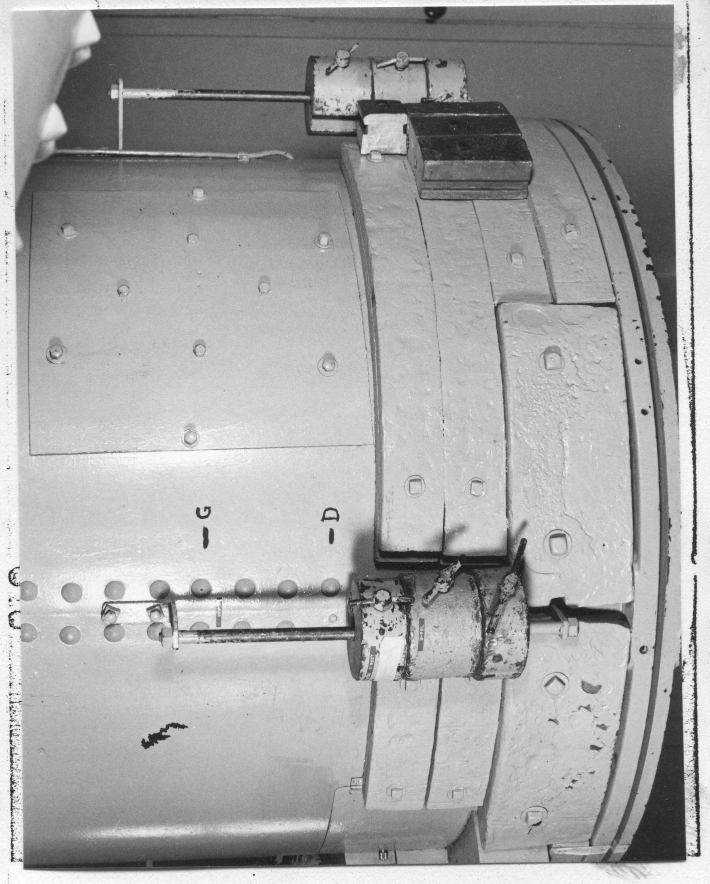


fig 76

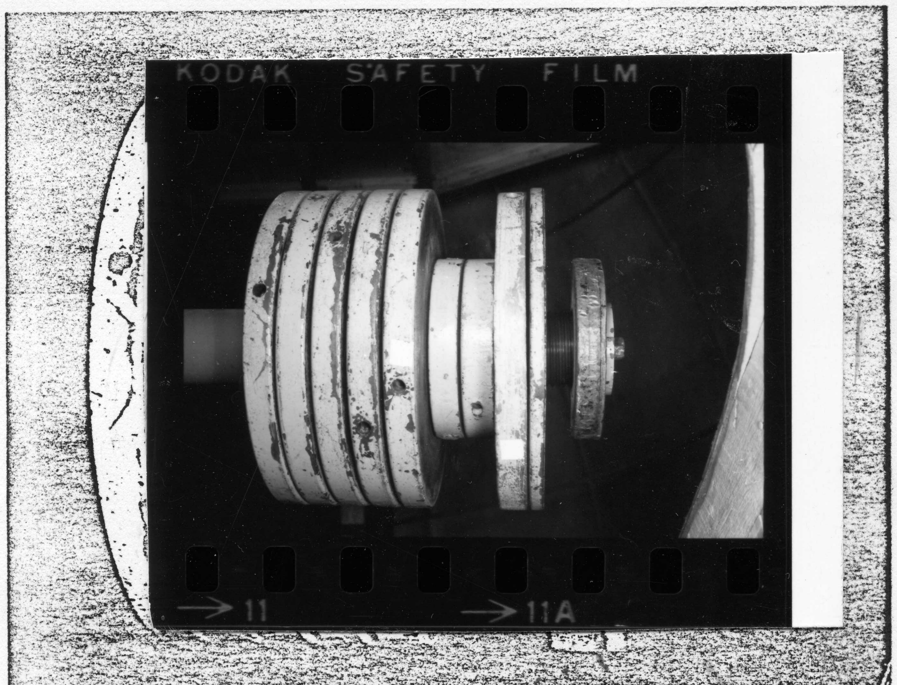
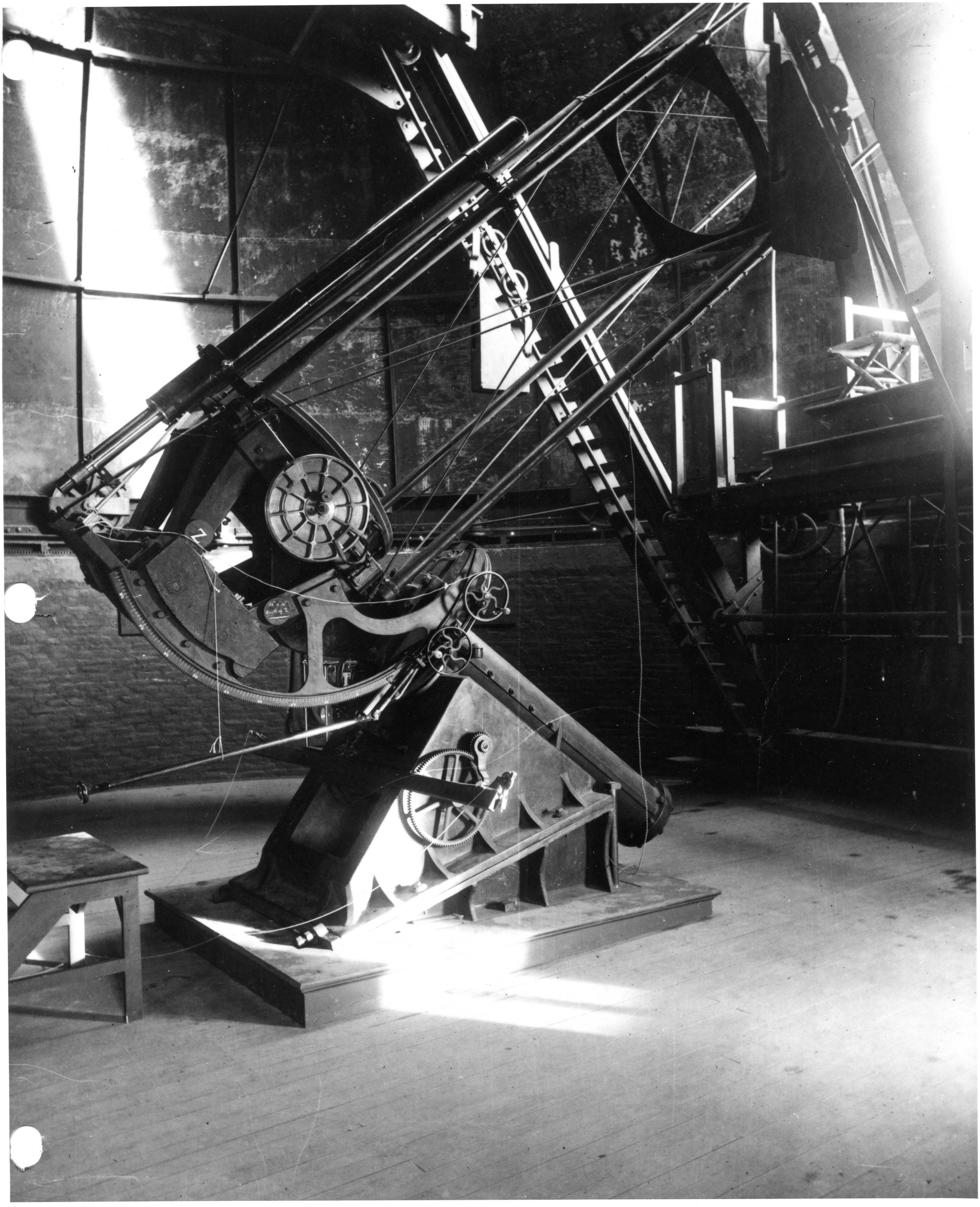


fig 77

Recommended weight distributions for photometer

I think that a man who is sane as long as he looks at the world through his own eyes is very likely to become a dangerous madman if he takes to looking at the world through telescopes and microscopes.

— George Bernard Shaw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