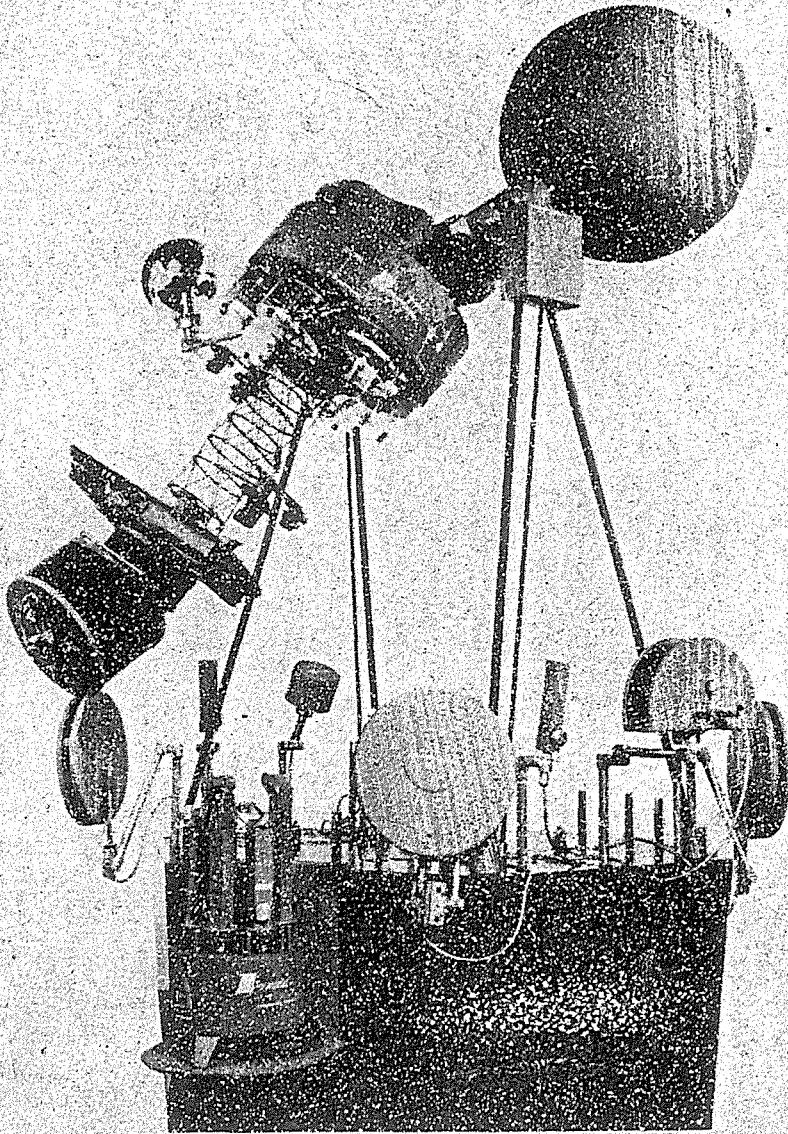


OPERATOR'S MANUAL



SERIES A3P PLANETARIUM

SPITZ Laboratories, Inc.

OPERATOR'S MANUAL

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TABLE OF CONTENTS

INTRODUCTION	1
SECTION I DESCRIPTION OF PLANETARIUM EQUIPMENT	1-1
SECTION II INSTRUMENT ADJUSTMENTS AND PREPARATION FOR OPERATION.	11-1
SECTION III OPERATOR'S CONSOLE DESCRIPTION AND OPERATING INSTRUCTIONS	111-1
SECTION IV MAINTENANCE	114-1

INTRODUCTION

Instrument Designation

This manual covers the description, operation and maintenance of SPITZ LABORATORIES, INC., Model A-3-P and A-3-P Prime Sky Planetariums. ("A-3" means that this is the third major revision of the Spitz Laboratories, Inc. Model A limited size planetarium; the "P" indicates that this instrument is equipped with automatic planetary motion). The A-3-P Prime Sky Planetarium produces extraordinarily brilliant star images through the use of a special, "PRIME" light source. This model planetarium is designed to be used with domes from 24 to 40 feet in diameter.

How to Use this Manual

Before operating the A-3-P, we recommend that the new planetarium operator use this manual and study the complete description of the planetarium as he examines each unit being described.

After he has become familiar with each unit of the instrument and its function, the next step is to make the preparations and adjustments for operation. We highly recommend that even though this has been done at the time of installation, they be reviewed again - step by step, as outlined in this manual - to firmly fix them in mind.

After following the Console Description and Operation section through as he performs the operations with the planetarium, we believe that the new operator will feel that its operation is quite straightforward.

Finally, as bulbs will burn out and electronic parts can fail, we suggest that reviewing the Maintenance Instructions before long periods of operation are begun will afford confidence that almost any problem can be met without difficulty or downtime.

SECTION I

DESCRIPTION OF PLANETARIUM EQUIPMENT

A. PLANETARIUM PROJECTOR INSTRUMENT

The planetarium projector projects the stars, planets, moon and sun onto the screen (the planetarium projection dome). It produces the planetarium sky motions which imitate the effect on the real sky of the earth's rotation, revolution, and precessional motion. It provides 360° latitude motion to enable the observer to view the sky as it would appear from any latitude. The annual motions of the planets and moon, and the apparent motion of the sun are shown.

Projected lines provide a grid of geocentric coordinates, the ecliptic and the meridian. A group of auxiliary projectors simulate, for example, satellite, twilight, or a geocentric view of the earth. Projected spots of light locate such key sky positions as the celestial pole, zenith, home latitude, or the cardinal points.

1. The Pedestal, Instrument Support, and Earth Motion Mechanisms

The pedestal serves as a base for the projector, as a housing for the junction of electrical circuits, and as a housing for the daily and latitude motion drive motors. It also provides a housing and the electrical circuitry for a remotely controlled 35 mm. slide projector.

Posts around the top of the pedestal are provided for the mounting of the celestial triangle projectors, the meridian projector, the twilight projector, the satellite projector, the zenith and latitude point projectors, the meteor projector and the projection orrery. Extra posts are for projectors the operator may add from time to time. The labelled sockets for these projectors and spares for extra projectors are located in the top of the pedestal. Four pairs of cardinal points projectors are mounted on the base plate.

The instrument support is a simple A-frame at the east and west sides of the pedestal. These supports consist of two tubes each, extending upward from the pedestal. They terminate in sockets in the bearing housings at each end of the horizontal latitude axis. These housings and the daily and latitude motion gear trains are hidden under rectangular covers.

The support tubes are as small as possible to reduce the cutoff of projected images. They also provide conduit space to carry electrical wires from the pedestal junctions to the projection instrument.

The earth motion mechanisms for latitude motion and daily motion (rotation) are found on the east and west edges of the pedestal. Each provides drive from a motor mounted under the base plate. The drive motion is transferred to the gear trains at the top of the A-frame tubes. The latitude axis shaft is turned by the gears on the east end and the daily motion shaft is driven by gears at the west end. The daily motion axis is driven by a shaft running within the latitude axis. This hidden shaft terminates in a gear and belt arrangement which rotates the daily motion axis.

2. The Planet Projector

The planetarium projector consists of two main sections. The star projector sphere and precessional motion sections are located at the north end. The central housing built around the latitude and daily motion axes separates the star projector from the planet, sun and moon section at the south end. This planet section also carries the ecliptic and coordinates projectors.

a. General Description of the A-3-P and A-3-P Prime Sky Projectors

The star projector and precessional motion section consists of a sphere mounted on a separate precessional axis inclined to the daily motion axis. This separate axis provides a rotation of the star sphere which imitates the slow wobbling of the earth's axis, or precessional motion. A pointer, near the mounting ring on the star sphere, indicates the present epoch position when the pointer is directly over the daily motion axis. The drive for precessional motion is produced by the

motor mounted under the precessional axis bracket.

The star sphere is pierced by hundreds of holes of various diameters representing 2nd, 3rd, 4th and 5th magnitude stars. All first magnitude and selected 2nd and 3rd magnitude stars are produced by larger holes in which a lens system is placed to focus the larger source of light back to the proper star size. The Milky Way is also projected by lens systems in the sphere. Canopus, Alcor, and selected southern sky stars are projected through adjustable optical wedges and mirrors. This allows positioning them in locations inaccessible for straight projection.

The sphere uses prefabricated bright star and Milky Way lens assemblies. The apertures in the bright star assemblies are color coded to denote aperture diameter. The whole unit is removed by pushing outward from inside the star sphere. Southern sky fill-in is accomplished by adjustable, double optical wedge systems. The extreme south polar stars are projected by nine mirrors mounted around the equator of the star sphere. Tinted filters impart color characteristics to some stars.

b. The A-3-P and A-3-P Prime Sky Projection Light Sources

(1) General Description: In both units the light source is mounted in a weighted cup. The adjustable position of bulb filament with respect to the edge of the cup provides a horizon cutoff and prevents star projection below the planetarium chamber horizon. The cup swings between the arms of a yoke and is easily removed for bulb replacement. Slotted pivots at the top of the cup slip off pins in the ends of the arms of the yoke. This yoke swivels on its base and the combined motions of cup and yoke provide a universal motion which keeps the cup upright regardless of the position of the star sphere.

The gimballed yoke assembly is mounted on a circular flange which is held in position within the star sphere by six hex head machine screws.

These screws pass through the base of the sphere, surrounding the precessional axis. Three screws pass through clearance holes in the sphere's base and into tapped holes in the yoke's flange. The three other screws enter through tapped holes in the sphere's base and lock against the yoke flange. The combination of jacking and locking facilitate centering of the lamp filament within the star sphere. See Section II for adjustments.

(2) The A-3-P Light Source. The A-3-P light source is an incandescent lamp - GE 1637 - with a prefocused filament and twist lock base. Before replacing a GE 1637 lamp it is best to deaden the reflectivity of the lamp base with flat black paint or with ink from a felt tipped marking pen.

(3) The A-3-P Prime Sky Light Source. The Prime Sky light source is an arc lamp of great brilliance which produces exceptionally small and brilliant projected star images. The light source cup assembly is the same size as the cup of the standard A-3-P.

As polarity is a prime factor in proper lamp performance, the light source mounting pins at the ends of the yoke are different. One is a straight pin, the other is terminated with a collar; mating slots in the light source cup assure that the polarity cannot be reversed. The slot on the positive side of the cup is covered so that it cannot receive the negative yoke pin with the collar and the positive side of the yoke and its wire is red.

A spare incandescent light source is provided with each new instrument to be used in case of arc lamp failure. It replaces the arc lamp cup in the yoke without any modification. As the two light sources are so easily interchanged, some operators might prefer to use the incandescent

light source for less important demonstrations.

3. The Planet, Sun, and Moon Projectors

General: The planetarium projection instrument represents the earth in the earth, planet, sun and moon relationships in the solar system because it projects moving images of these objects as viewed from earth.

The planet projection mechanisms are designed as models or analogs of the earth, planet and sun systems. They produce a line of sight (the line of the projection image of the planet) from the earth to the planet as it moves around the sun - wedge-shaped plates move the projected planet and moon images above and below the ecliptic in their properly inclined orbits.

The sun and moon drives simply move these projected images around the planetarium sky in their apparent motions.

The illumination of the planet and sun images comes from projectors mounted below the large plate at the bottom of the cage-like supporting section. Rheostat controlled illumination circuits change the brightness of the projected images. The sun has its own circuit and the planets are divided between two circuits - one for the inferior planets (Mercury and Venus) and one for the superior planets (Mars, Jupiter, and Saturn).

The moon image projector and phasing mechanism are mounted on the large cylindrical housing about the planet analogs. The moon image is projected by two opposing 45° mirrors on the ecliptic plate and then reflected back to the rotating mirror.

The cylindrical housing also contains the drive and electrical circuits for all the analogs. These motors are synchronized to drive the planets, sun, and moon in their proper relative speeds against the correct background of stars projected by the star sphere.

Planet Analog. The analogs for the five planets are essentially the same except for a reversal of the planet and earth position in the inferior and superior planet analogs. Each is made up of the following parts:

- a. The main plate, which is parallel with the ecliptic, rotates once for each planetarium earth or planet year, depending upon whether the

plate represents the earth (on inferior analogs) or planets (on superior). The shaft to the projection mirror projects through the center of this plate.

b. Attached to this main plate is the heliocentric longitude dial. The dial is repeated as a larger and more easily read version centered around the mirror shaft holding collar, attached to the analog plastic dust cover. The longitude degrees on these dials read in reverse from the normal chart direction because we are observing the analogs from below the solar system.

The main plate's heliocentric longitude is read from the plate indicator located at the edge of the plate next to the dial. On the outer dial a brass pointer mounted 180° from the main plate indicator transfers the reading to the outer dial. On inferior planet analogs, earth longitudes are read from the indication of this point on the dial - on superior planet analogs, planet longitudes are read by this indicator.

c. The wedge plate is located within the heliocentric dial. It provides the inclination of the planets' orbits to the ecliptic.

d. A moving arm rides on a bearing on the wedge plate. At the bottom edge of one end of this arm is a pointer to indicate heliocentric longitudes on the dial. This reading is transferred to the outer dial by an aluminum post with a scribed mark to indicate the exact degree reading. On inferior planet analogs, this arm pointer indicates planet longitudes - on superior planet analogs, earth longitudes are read from the position of this arm pointer over the dial.

At the other end of the arm is a magnet which seats the ball on the line-of-sight rod. As the arm rotates, the ball and rod move with the arm, simulating the line-of-sight which exists at any moment between the observer on earth and the planet.

e. The line-of-sight rod moves the mirror shaft because one end of the rod is inserted into a holding collar which grips the mirror shaft.

f. A cylindrical, plastic dust cover protects all of the analogs except for the mirror shaft and mirror mechanisms. A port in this cover allows replacing the line-of-sight rod ball in its magnetic seat if it is dislodged, without removing the entire dust cover.

g. The projection mirror shaft is a compound shaft with a solid rod inside a hollow outer tube. The holding collar is threaded and an adjusting screw moves the outer tube in or out without turning the tube. When properly set, the adjusting screw is locked in place by a setscrew.

h. The outer tube is locked to the mirror support bracket at the other end of the shaft by a setscrew. The solid inner rod which presses against the mirror pivot is held against the end of the inner rod by a spring.

Thus, turning the adjusting screw clockwise on the holding collar tips the mirror upward (or northward) and turning the adjusting screw counterclockwise on the collar tips the mirror downward (or southward), to adjust the latitude of the projected planet.

The Sun Projector Drive which, like the planet and moon analogs, has its motor located inside the cylindrical housing, is not an analog (model) in the true sense because it consists simply of a direct motor drive to move the sun's image around the planetarium sky in its apparent yearly trip around the earth. The shaft and mirror mechanisms are located inside the support cage. The mirror pivot is adjusted to place the sun's image on the ecliptic by turning the screw on one side of the sun mirror support. Turning the screw clockwise tips the mirror upward (northward), counter clockwise tips it downward (southward).

The Moon Projector Analog also is simpler than the planet analogs. It

need only provide a 360° revolution around the earth. However, the wedge is required to make the projected moon image travel north and south of the ecliptic. The dial around the moon wedge indicates angular position of the moon from ascending and descending nodes. As the pointer passes from $270-0-90^\circ$, the declination decreases; from $90-180-270^\circ$, it increases. A knurled knob above or at one side of the analog positions the moon in apparent latitude by rotating the wedge and dial.

The large dial at the edge of the moon main plate indicates the moon's heliocentric longitude. The reading is made from the position of the pointer screw (in the plastic dust cover) over the scale.

The Planet, Sun, and Moon Image Projectors

The planet and sun image projectors differ only in the size of the projected image and in the color filters (if any) that are used. Each is fastened to the underside of the bottom plate by a single screw. This allows the projector to swivel, placing the projected image in the center of the rotating analog projection mirrors.

The projection lamp is an assembly which is designed to insure perfect focus. The GE 251 or 261 lamp is rated for 1,000 hours of operation. This long life means that months of operation can be achieved with one bulb.

The planet and sun images are reflected up to the analog projection mirror by 45° mirrors at the front of each image projector. The mirrors are adjustable to assist in centering the projected image on the analog mirror.

The moon image projector and the moon dove prism assemblies are located at the top of the central housing. The image projector is equipped with a phasing disc which provides a continuous change of moon phase as the moon's projected image moves around the planetarium sky. An adjustable 45° mirror at the front of the projector allows centering the projected image in the dove prism in the central housing. This can be observed in the dove prism exit lens in the bottom plate of the central housing or

on a piece of paper taped to the 45° mirror which is on the ecliptic plate immediately under the dove prism.

The dove prism rotates the moon image in synchronization with its revolution around the earth so that the moon's terminator is always perpendicular to the ecliptic.

4. The Ecliptic and Coordinates Projector

The ecliptic projector is mounted at the lower, or southern, end of the instrument below the large bottom or ecliptic plate. It consists of a cylindrical projector drum with the bulb and horizon cutoff mechanisms mounted on the inside surface of the base. The ecliptic line is imprinted on the film which forms the wall of the cylinder. The ecliptic is dated to show the position of the sun at any time of the year.

The projected image is raised or lowered by moving the bulb assembly out and in of the cylindrical socket at the bottom center of the projector. It is secured in the desired position by the large headed setscrew. The bulb tube is pulled all the way out to replace the bulb. The bulb fits into the end of the cylindrical bulb assembly and is held in place by a collar-like screw cap.

The ecliptic projector is mounted to the ecliptic plate by three jacking screws in three standoff posts. They serve as adjusting screws to adjust the inclination of the ecliptic so that it aligns correctly with the projection dome. These screw heads are spring-loaded to provide a two-way adjustment motion. The screw heads are located in recessed holes in the plastic collar found around the base of the cage where it attaches to the bottom plate.

A short cord and plug provide current to the ecliptic projector. Another cord and plug complete the circuit to the coordinates projector mounted below the ecliptic projector.

The bulb inside the projector is surrounded by a cylindrical liquid level. The dark liquid cuts off light projected below the level of the planetarium chamber horizon. The inclination of this horizon cutoff can be adjusted by turning, in or out, three spring-loaded jacking screws. The large heads of these adjusting screws are found on the bottom of the projector.

The coordinates projector. Only the height, the transparency and the mounting arrangement of the coordinates projector differ from the ecliptic projector. The raising and lowering of the projected image and the adjusting of the horizon cutoff are accomplished in the same way in both projectors.

The inclination of the celestial equator to the ecliptic is provided by the angle of the mounting shaft for the coordinates projector located on the base of the ecliptic projector.

The projector is stabilized by a bracket on the top surface opposite the mounting shaft socket. Spring-loaded screws at either end of this bracket allow a slight adjustment in the inclination of the projected coordinate image. The bracket is secured to a tab from the ecliptic projector by a knurled screw.

5. The Zenith, Latitude, and Pole Projectors

The zenith and latitude projectors differ only in their mounting positions on the posts located around the top of the pedestal. The latitude projector is aimed at the Celestial North Pole point for your latitude on the meridian. It assists in bringing the stars back to the proper position for your latitude whenever a latitude motion change has been made. The pole projector image is superimposed over the latitude projector image when you return to your home latitude.

The bulb fits upside down in the projecting receptacle. It is held in place by the aluminum cap which completes the circuit to the base of the bulb. These projectors plug into labelled receptacles in the top of the pedestal.

Note that on all Jones two-pronged plugs which connect the various projectors into the two rows of sockets on the instrument base, the wider lug is the ground side and is located toward the outside edge of the base plate.

The pole projector is mounted on the extension of the latitude motion axis shaft. A two-receptacle bracket is mounted on the outer end of the shaft extension to provide circuits to the geocentric earth projector as well as the pole projector. The adjustable, universal mounting permits placing the pole projector image at the Celestial North Pole by running the instrument in daily motion, observing Polaris, and placing the pole spot

at the center of Polaris' circle.

6. The Geocentric Earth Projector.

The geocentric earth projector is the plastic sphere on which the continents of the earth are painted, mounted with the pole projector on the extension of the latitude motion shaft. It plugs into the other receptacle mounted on the outer end of the shaft extension.

The bulb assembly is a tube. The cable emerges from the lower end and the lamp fits against a contact in the upper end. The bulb is held in place by a collar-like cap. This whole assembly is held in place, to position the filament near the center of the projector, by a knurled screw in the socket. The bulb tube is simply pulled out of the projector for lamp replacement.

The double walled, liquid-filled horizon cutoff ball surrounds the bulb and prevents the projected image from appearing below the planetarium chamber horizon.

As the entire projector is attached to an aluminum rod by a universal mount, and the other end of the rod attached to the latitude motion shaft extension by another universal mount, there are ample distance and position adjustments possible to minimize occultation by the star sphere.

7. The Meridian Projector

The meridian projector projects a line marked off from 0 to 90° from the northern and southern horizons. The zenith is indicated by a large dot at the 90° position. The projector is mounted on a ball-and-socket swivel atop the bearing block of the latitude axis shaft on the same side of the instrument as the daily motion drive.

The lamp is in a tube assembly which permits removing it from inside the projector to replace the bulb. It also allows in-and-out adjustment for proper positioning the projected image of the meridian on the dome. When the bulb is correctly positioned the tube is secured by the knurled setscrew. The lamp assembly is held in the projector box by a slotted flange held in place by two studs. These are capped with acorn nuts and a pair of compression springs under flat washers which hold the lamp in its proper.

vertical position so that the bottom of the projected meridian line coincides with the spring line of the dome. The projector is plugged into the labelled receptacle in the top of the pedestal.

8. The Astronomical Triangle Projectors

The three identical astronomical triangle projectors consist of a shallow cylinder with a shuttered slot around its perimeter. The shutters cover or expose a projection film imprinted with a single thin line. The shutter can be moved around to expose any length of line in any part of the slot.

The lamp mounts at the center of the projector, and is accessible for replacement through a port in the side of each projector. The projected lines are in best focus on the dome when the lamp (GE 605) filaments are oriented to be parallel with the clear lines of the transparencies. If screwing a lamp firmly into its socket results in misalignment, use needle nose pliers to carefully twist only the socket shell into a proper orientation.

The projectors mount on any available post and are plugged into any three of the four labelled receptacles on the pedestal top. The projectors can be extended away from the pedestal top to minimize occultation of the projected line by the instrument.

As each projector produces only a single line, all three are needed to make the celestial triangle. The projectors can be used in other combinations to project lines useful to illustrate various astronomical concepts.

9. The Satellite Projector

This projector is very similar to the latitude and zenith projectors, but the image is made to move across the dome by a motor-driven arrangement of two mirrors facing in opposite directions. As one mirror loses the image, the other one picks it up. This does away with a lengthy wait between satellite projections and still keeps the proper slow motion.

The bulb is seated upside down and is held in place by the aluminum cap. The

cap also completed the circuit to the base of the lamp.

10. The Twilight Projector

This projector imitates the bands of clouds and colors of sunrise or sunset and is mounted on a post on either the east or west side of the pedestal top. The universal mount allows tipping and rotating the projector to place the projected scene on the desired part of the planetarium dome.

The bulb is again found in a tube assembly. The tube also serves as a mounting post for the projector. The knurled setscrew is loosened and the whole projector is removed to replace the bulb. This projector plugs into the labelled receptacle in the top of the pedestal.

11. The Hand Sextant

This is a hand-held projector which projects a linear scale marked off into 180° . It can be moved to project its angular measurements anywhere on the dome and proves invaluable in discussing altitude and azimuth of stars during a navigation demonstration. The "on" button is located on the tube of the projector.

The scale is calibrated by projecting the meridian and comparing with the sextant divisions to determine where it should be held in order to project correctly.

The GE 605 lamp is replaced by removing the two machine screws in the collar which holds the handle to the projector head.

12. The Meteor Projector

This projector is mounted on a post on the pedestal. It is operated from the "Meteor" switch on the left horizontal control panel. Activating the switch projects irregularly timed moving streaks of light onto the dome. A residual image fades more slowly as the streaks disappear.

13. Projected Cardinal Points

The cardinal points, N, E, S, and W, are projected onto the dome near the horizon in the appropriate directions. When the instrument is driven in latitude so that the observer's position crosses the north or south pole, a microswitch is actuated

by a cam on the latitude axis to reverse the cardinal points.

The projectors are mounted on the instrument base and are plugged into marked outlets.

The operating switch is mounted on the right hand horizontal panel of the Operator's Console. Forward motion of the switch turns on the cardinal points. Their brilliance is controlled by a rheostat knob located on the vertical panel of the Operator's Console.

14. The Projection Orrery

This instrument projects the sun and moving images of the planets Mercury, Venus, Earth, Mars, Jupiter, and Saturn. The planet images move at their relative speeds in their orbits around the sun. They are color coded to aid in differentiating between them as they are discussed.

The projector hangs from any two posts around the pedestal top, so it can be positioned to suit the desire of the lecturer. It plugs into a marked four-pronged socket located on the instrument base.

The orrery can be operated from the console by setting the operating switch on the orrery at the desired setting and then turning on the "Projection Orrery" switch on the Control Console; or the console switch can be left on and the orrery operated by moving the switch on the orrery unit itself. This switch is marked "OFF", Sun, Mercury, Venus, Earth, Mars, Jupiter, Saturn, Motion Off." It adds planet images when turned clockwise, and subtracts them when reversed.

The usual mode of operation is to turn all the planets on and operate it from the Operator's Console.

The size of each planet's orbit can be changed by rotating the prism at the top of each projector.

SECTION II
INSTRUMENT ADJUSTMENTS AND PREPARATION
FOR OPERATION

A. ADJUSTMENTS TO BE MADE PRIOR TO SETTING THE PLANETS, SUN AND MOON FOR A GIVEN DATE.

1. Pedestal Orientation

The hexagonal pedestal which supports the instrument must be located under the zenith of the dome. Because of the difficulty of plumbing down from this point, it is best to plumb to the floor from the horizon at the four major compass points. Lines run from north to south and east to west cross at the dome's center. This point is marked and the positions of the lines within about 18" of the center are marked on the floor or on tapes laid on the floor. The hexagonal pedestal is positioned at the center with two points on N-S lines. The centers of two flat sides will lie E-W. The pedestal will be bolted to the floor through oversized holes in the interior base so that fine adjustments in orientation can be made, if required, after observations are made of the celestial north pole.

If the planetarium projection dome has seams, it is best to select one of these for North. The projected meridian will then coincide with this seam at least in the north and it provides a convenient reference point. In Spitz 24' domes there are 20 panels around the spring line, and there are seams at N, E, S, W. In Spitz 30' domes there are 25 panels and south will lie midway between seams. In the 40' dome there are 36 panels, and as in the case of the 24' size, there is a convenient seam at each cardinal point.

2. Instrument Settings

In the A-3-P and A-3-P Prime Sky planetariums the earth is the basic reference point in space and all celestial objects are projected as they would be seen from

earth. Thus, the instruments covered by this manual must project the stars, planets, sun and moon as seen from earth at any moment in time.

We begin with the stars on the celestial sphere, and relate the solar system to the stars. In setting up the instrument the celestial coordinates and the ecliptic are projected against a certain background of stars for this epoch of time. As the instrument provides precessional motion, we must be certain that we are operating at the right point in precessional motion when demonstrating for this epoch.

a. Setting the Planetarium Precessional Motion for Present Epoch

- (1) Precessional motion is produced by turning the knob on the vertical control panel clockwise for "forward in time" motion and counter-clockwise for the reverse motion. In the forward mode the stars move eastward along the celestial equator.
- (2) Operate precessional motion until the aluminum pointer near the flange at the base of the star sphere points directly at the center of the end of the daily motion shaft. To refine this adjustment, bring the north ~~eastern~~^{western} star of Orion's belt, Mintaka, to 5-1/2 hours right ascension after the coordinates projector has been adjusted as described below. When properly set, Polaris should make a circle of 2° diameter around the Celestial North Pole when the instrument is operated through 24 hours of daily motion.

b. Centering the Star Lamp within the Star Sphere

If at the present precessional epoch and at "home latitude" Polaris does not describe a circle of 2° diameter on the dome (use the meridian and/or hand sextant for measurement) it is necessary to adjust the position of the star light cup. See Section I-A-b for a description of the yoke's mounting by jacking and locking screws. Run daily motion until the size of Polaris' circle and the position of its center (Celestial North Pole) are established. Drive latitude and daily motions until the star sphere's flange is horizontal.

Slightly loosen the three nuts on the jacking screws and back off the screws. Move the locking screws in or out single or in combination as required to tilt the internal star yoke flange so that the lamp cup moves within the sphere in the direction required to bring Polaris to a point one degree from the pole. Tighten all six screws and lock nuts and return the instrument to home latitude. Run daily motion to check the size of Polaris' circle. This procedure may require repetition to achieve a close adjustment. In checking the Polaris circle it is best to use dome seams or the meridian as points of reference. After the Polaris circle has been established, the pole projector may be adjusted to locate its spot in the center of this circle. Again, this adjustment is made at home latitude.

When the Polaris adjustment is made it is also established that the celestial north pole is true north for the instrument. If this point does not coincide with a desired dome seam or some other desired planetarium chamber orientation, the entire pedestal should be rotated as required and securely bolted in place. If during 90° of latitude change, Polaris moves from the north horizon to the zenith in a line not parallel to the meridian, shims should be placed under one side of the pedestal before bolting down tight.

c. Aligning the Ecliptic

As the ecliptic projector is mounted first to the bottom of the cage section of the instrument and then the coordinates projector is mounted on the bottom of the ecliptic, the ecliptic projector must be adjusted first.

By means of Polaris' circle it has been established that the instrument is aligned along the N-S axis. Before the ecliptic can be adjusted, the moving portion of the instrument must be aligned by means of the daily motion drive along the E-W axis. Use is made of the two southern sup-

porting rods because they now lie parallel to this axis. Any reliable straight rod may be taped to the rods, but perhaps the easiest device to use is a piece of string. Tie it across the rods so that: it lies over the southernmost surface of each rod, is level, taut, and is approximately 11 inches above the base plate. The plate on which the ecliptic drum, sun, and planet projectors are mounted is known as the ecliptic plate. Adjacent to the winter solstice of the ecliptic projector this plate has a straight edge which lies parallel to the axis of the spring and autumnal equinoxes. Adjust daily and latitude motions until this edge is very close to and parallel with the straight line established between the support rods and the summer solstice is toward south. When the ecliptic projector is turned on, its line should intersect the horizon at due east and due west. A temporary piece of dark tape on the dome at these points will assist in a chamber sufficiently darkened to give visibility to any projected lines.

The ecliptic projector is held to the plate by three jacking screws and compression springs in three standoff posts. The slotted tops of the screws are reached by a narrow screwdriver through holes in the bakelite flange on the bottom of the wire cage section. The posts are located at the equinoxes and summer solstice.

To adjust the projected ecliptic, first adjust the two screws along the equinoctial axis until it cuts the dome at the east and west horizon or is equally toward the north or south. If required, loosen the set screw which holds the protruding lamp holder tube and adjust the lamp in or out of the drum to bring the ecliptic south or north. It is now correct along the equinoctial axis.

To adjust the ecliptic along the axis of the solstices, the meridian must first be correctly aligned so that it passes due north and south, its zenith

spot is at the zenith of the dome and the lamp is vertically oriented so that the bottom of the line coincides with the spring line of the dome, in the north and south.

Drive latitude motion until the ecliptic line at the summer solstice is at 70° on the meridian. Drive daily motion through half a day until the winter solstice is at the meridian and observe where it crosses. Because the earth's axis is inclined $23\text{-}1/2^\circ$ to the ecliptic, the projected ecliptic should now be 47° from its starting point, or at 23° latitude. For measurement, carefully calibrate the hand sextant and use its 1° increments superimposed on the meridian's 10° spacing. If the ecliptic has made an excursion of more or less than 47° , divide the error by two and by adjusting the one solstice jacking screw, move the line by this amount in the proper direction. Check results by starting with the winter solstice at 20° altitude and driving daily motion to the summer solstice which should now cross the meridian at ~~70°~~ 67° .

NOTE: Accurate ecliptic alignment is fundamental to all subsequent adjustments because it is the reference line for the adjustment of coordinates, stars, sun, moon and planets.

The liquid horizon cutoff within the ecliptic drum must be adjusted prior to installation of the coordinates. With the instrument at "home latitude" and with either equinox at the meridian, adjust equally the three panhead screws on the bottom of the drum. Turning the screws clockwise will lower the reservoir within and the projected ecliptic will show lower on the dome or chamber walls. The ecliptic cutoff, except for depth, is identical with that in the coordinates drum. The latter is easily removed by loosening the three thumbscrews on the bottom of the drum and the spring loaded jack screw arrangement will be easily observed.

If the wire filament holder within the PR 12 lamp should cast a shadow on a critical portion of the ecliptic, rotate the lamp holder carefully without altering its vertical position until the narrow shadow falls on a non-critical area. In or out movement of the lamp will alter the position of the projected ecliptic.

d. Sun Adjustment

On the moving mirror assembly for the sun there is a small slotted or Allen screw which tilts the mirror (clockwise northward) to correct its latitude to coincide with the ecliptic. This screw is on the right side when facing the mirror and is reached by inserting a screw driver or Allen wrench through the cage and pushing the horizon cutoff shade gently aside. This latitude adjustment is made at any time, but must be finally checked after the sun's path has been brought parallel (above or below) to the pre-aligned ecliptic.

Aligning the sun's path is affected by the three screws under the mirror attached to the optical projector. A little practice with a more accessible planet projector mirror will demonstrate the affects accomplished by each screw. Several cardinal principles will facilitate adjustment of the sun, moon, and planets:

1. Make all adjustments when the projected image is at the ends of two crossed axes at right angles to each other. These axes are parallel and transverse to the optical axis of the projector.

When the rotating mirrors are positioned parallel to the stationary adjustable mirrors on the projectors, turning the "No. 1" screw on the bottom of the latter moves the image normal to the ecliptic at either end of the "parallel axis". When the rotating mirror is turned 90° the image projects along the "transverse axis" and the upper two screws are used. If screw

No. 2, upper left, is turned in or clockwise, the image will move up or down toward the ecliptic but also to the left. This latter horizontal motion must be counteracted by moving screw No. 3, upper right, an equal distance in the opposite direction so that the resultant effect has been to move the image normal to the ecliptic.

2. All adjustments of mirrors are made so that images move at right angles to the ecliptic at the four points discussed above and when these are correct, all points between will be correct.
3. Adjustments made for an image at the two ends of one axis, if the motion has been normal to the ecliptic, will not affect the normal motion at the ends of the other axis. For example, if a planet projected parallel to the optical axis of its projector is 3° below the ecliptic at 7 hours R.A. and 1° above at 19 hours, its excursion is 4° . Moving screw No. 1 so that the planet moves down 2° to 1° below at 19 hours will not affect its latitude at 1 hour and 13 hours or 90° away, but will move it only parallel to the ecliptic at these points. Conversely, if it projects along the transverse axis to 1 and 13 hours and is at zero and -4° respectively, moving screws 2 and 3 in opposite directions will bring it to -2° without affecting its latitude at 7 and 19 hours.

The significant result in this example is that the image now has the same latitude at all four points and is said to move parallel to the ecliptic. The latitude is now corrected to zero as discussed elsewhere.

4. Correction of latitude is made at either end of either projection axis to the extent of one half the error for that axis. Thus, moving the image downward at one end of, say, the parallel axis, will move it upward by the same amount at the other end.

Before adjusting the sun's path it is important to note that the position of the GE PR 12 lamp in the projector plays a vital role in aligning the light beam as it leaves the projector. Any angular error is multiplied as the beam passes from mirror to mirror to dome. If a replacement lamp filament is oriented differently from its predecessor, the projected image will follow a different orbit and mirror readjustment may be required. However, reproducible orbits are possible if each lamp is carefully centered before any other adjustments are made.

First be sure that the wire filament support within the lamp's glass envelope is positioned away from the front of the projector barrel. Inspection of the lamp will show that this wire filament support is either adjacent to or 180° from the notch in the lamp seating flange. Observation of the object lens in the outer end of the projector barrel will show the shape of the filament image and whether or not it is well centered.

The lamp should be rotated so that the filament is neither transverse to nor parallel to the optical axis. A narrow U or V shape is best, and affords maximum brilliance without being too large to say on the mirrors.

If the center of the filament image on the lens is a proper shape but off center, bend the lamp seating flange. Bending

it upward along its entire perimeter seats it deeper in its socket and lifts the image on the object lens. Bending one side of the flange up or down cocks it to one side and moves the image left or right on the lens.

The foregoing discussion of lamp orientation applies equally to the moon or any other projector using a PR 12 lamp and where brilliance and accuracy of projected position are important.

e. Adjusting the Coordinates

The projector drum is slipped carefully onto the shaft which protrudes from the bottom of the ecliptic projector, and the knurled thumbscrew tightened. The Jones plug on the short cable is plugged into the receptacle on the bottom of the ecliptic drum. The horizontal bar on the top of the projector is fastened securely to the tang projecting from the bottom of the ecliptic adjacent to the winter solstice.

The coordinates are projected onto the dome and aligned with the previously adjusted ecliptic. Moving the drum up and down on the main supporting shaft adjusts along the solstitial axis until the dotted line representing the equator is $23\frac{1}{2}^{\circ}$ below and above the summer and winter solstice positions of the projected ecliptic. Adjusting the two spring-loaded jacking screws at either end of the horizontal bar atop the drum adjusts the equator along the equinoctial axis so that it crosses the ecliptic at 0 and 12 hours R.A. If the coordinates are all too high or low to meet these conditions loosen the setscrew which holds the lamp holder at the center of the bottom of the drum. Pushing the lamp assembly further into the drum will lower the coordinates on the sky and vice versa.

The lamp assembly may be rotated so that the narrow shadow cast by the

PR 12 lamp's wire filament holder does not fall in a critical area.

f. Adjusting Star Declination

When the star light source was centered so that Polaris described a circle of proper size during 24 hours of daily motion, the six adjusting screws protruding below the mounting flange were used. At that time the coordinates and ecliptic had not been adjusted and the lamp could not be adjusted up and down along the precessional axis so that the stars would project onto the dome at their proper declinations. With the coordinates adjusted to the properly aligned ecliptic, drive daily motion until 5 or 6 hours right ascension is at the meridian in the south and the instrument is at your home latitude. Mintaka, or Delta Orionis, the northwesternmost of the three stars of Orion's belt, should be one half degree south of the equator. Precession must be set for the present epoch so that this star is at 5-1/2 hours R.A. If Mintaka is not at its proper declination, the three locking screws for the star lamp assembly should be equally loosened and the three jacking screws equally adjusted in or out so that the lamp is raised or lowered along the sphere's precessional axis and the projected stars will be lowered or raised on the dome to their proper declination.

As in adjusting the Polaris circle, this procedure should be followed when the sphere mounting flange is horizontal. The instrument is always brought back to home latitude to check results. To assure equal turning of the three jacking screws it is best to mark one side of each hex head with a marking pen so that the turns may be counted. The three screws which have the lock nuts are the jacking screws. After final adjustment, tighten the three locking screws and the three lock nuts so that the lamp assembly flange within the sphere is held securely in place.

g. Adjusting the Moon Projector

1. The Projected Image

The moon projector involves an optical train which is more com-

plex than that of any other unit of the instrument, and an understanding of the entire system should precede any attempt at adjustment.

The PR 12 lamp should first be positioned in its socket by rotating it and/or bending its flange so that its filament image is well centered in the optical axis and it appears as a narrow U or V in shape. To check this filament orientation place a paper on the first 45° mirror located at the bottom of the cage on the ecliptic plate. Advance the moon lamp rheostat at the console and run the moon phasing motor by console switch until the image is full. Moving the paper upward will improve the focus of the filament image.

The first switch to the right of the moon projector atop the center section controls the dove prism drive. This causes the moon's image to rotate and will be used in subsequent adjustments. The next switch to the right drives the moon's rotation mirror and will be used to bring the moon to any right ascension on the dome for subsequent checks.

On the outer side of the projector barrel about 2" ahead of the lamp socket is a slotted screw head in a horizontal slot. Loosening this screw permits sliding the internal condenser lens system for optimum adjustment. The forward position results in maximum brilliance and maximum image size along the optical system. If the image is so large that it cannot be maintained on all mirrors when the rotation and/or right ascension switches are actuated and after all other final adjustments are made, it may be necessary to sacrifice some brilliance by sliding the condenser lenses slightly toward the rear of the projector.

The motor and gear box on the inner central portion of the projector barrel are the moon's phasing mechanism. The synchronous drive passes vanes across the beam from the lamp.

Near the front of the barrel is another screw-and-slot which permits sliding an internal cylinder holding the transparency which imparts the moon's features. Loosening and sliding this screw will result in optimum focus.

At the far right end of the projector barrel and within a metallic dust cover is an adjustable mirror to reflect the image downward. Protruding through this cover are three jacking screws and lock nuts for adjustment. The beam passing downward from this mirror through the dove prism must be centered lest it pass off one side of the prism and/or describe a circle instead of a rotating spot on the first mirror on the ecliptic plate below as the dove prism rotates.

If the center section cover is removed, any or all of the three-prong plugs may be disconnected so that the motors they control will be free of all driving power and from the braking effect which is constantly applied when the annual motion control on the console is in the off position and the key switch is on. Its purpose is to maintain synchronization of all drives by preventing coasting of the analogs. There may be times when an individual drive should be eliminated from the annual motion system, as when a motor or analog develops a defect or when adjustments are being made. When checking alignment of the moon's optical system it will be necessary to drive the dove prism either by its switch or by disconnecting its plug and manually turning the dove barrel within the center section.

The dove prism, when rotated once, imparts two rotations to the moon image. If the image is not properly centered through the prism axis, the path of the two circles described will not coincide and because the image thus covers too large an area, it may be partially lost off one of the mirrors and the projected moon may appear to be eclipsed.

The path of the rotating image may be observed by taping a piece of paper across the 45° mirrors on the ecliptic plate. The image at this point is a slightly defocused U-shaped lamp filament. Turn the dove until the arms of the U face away from your point of observation and place a dot in its center. Rotate the image in steps of 90° placing a central dot at each step until two complete rotations have been made. The circles described by the eight dots should fall within an area of about $1/4''$ diameter. If the upper adjustable mirror needs correcting, slightly loosen the lock nuts and turn the jacking screws as required to make the two image circles on the paper coincide as nearly as possible. Remove the test paper, and the projected moon will rotate in place on the dome when the dove is rotated.

2. Latitude Adjustment

During the course of its revolutions around the earth the moon passes 5° above and below the ecliptic because of the inclination of its orbit to the plane of the ecliptic. Within the plastic dust cover of the moon analog is a brass bar which passes through a ball held in place by an 0-80 Allen setscrew through a brass collar. A small dial identical to those in the planet analogs surrounds a wedge. A line between 0° and 180° on this wedge is midway between the high point at 270° and the low point at

90°. As the wedge rotates in annual motion drive, when 0° or 180° passes under the ball no latitude is transmitted to the rotating mirror through the rod-and-tube linkage and the projected moon should be at a node or on the ecliptic. At 270° it should be 5° above and at 90° it should be 5° below. This check is best made where the ecliptic is normal to the meridian, or at one of the solstices, and the divisions of the meridian can be used for reference. If the moon does not make an excursion of 10°, drive the moon analog by switch or manually until the brass pointer bar and ball are under the removable access door. To do this manually, disconnect the moon plug in the center section, reach in with two fingers and rotate the large pinion gear over the analog. Loosen the setscrew which holds the ball on the rod and move the ball toward or away from the rod's pivot in the center post of the analog. Motion toward the pivot increases the excursion. The knurled knob atop the center section directly over the analog rotates only the wedge and will be used to check its excursion with relation to the ecliptic. Be sure to tighten the setscrew once the adjustment has been made.

3. Noding the Moon

Any misalignment of the moon's optical train can result in its crossing the ecliptic at times other than when the ball and pointer are aligned across the flat of the wedge - or when the pointer is at 0° or 180°.

First, by visual inspection check the alignment of the tube between the analog and rotating mirror assembly. With ample illumination in the room, move around the instrument and compare this tube with the taut wires within the cage, the sun tube, and

the tubes for all planets. This important check of all tubes can be made at this time for the planets as well as for the moon. If any correction is required, loosen the screws which hold the slotted inner ends of the V-shaped support brackets to the cage section and slide the brackets as required to perfect the alignment.

As in the case of sun and planet adjustment, the crossed axis procedure is used in nodding the moon. Turn up the moon rheostat and run the analog until the rotating mirror projects its beam in a line parallel to a line between the two 45° mirrors on the ecliptic plate. This line will be referred to as the optical axis. Turn the knurled knob to rotate the moon's wedge until the zero is at the pointer at the outer end of the line-of-sight rod. Note the moon's latitude-- it should be on the ecliptic at this time. Note also its exact east-west location with reference to some vertical line of the ecliptic. Drive the analog through 180° of R.A. The pointer will be at 180° on the wedge and the moon will be at the opposite end of the axis parallel to the optical axis. "Zero" the wedge by rotating it until zero is again under the pointer. Between observations of the projections it will be necessary to drive the instrument in latitude or daily motion to bring the moon and ecliptic to any convenient position at least 30° above the horizon. After observations have been made at each end of the parallel axis, repeat the procedure for each end of the transverse axis. For these positions the analog is driven to positions 90° from the two original positions and the wedge always zeroed with respect to the pointer. The analog can be driven by switch or manually

if the center cover is removed and the moon R.A. drive plug disconnected. If at all four points the moon is on the ecliptic (wedge always zeroed) it is said to be noded and when it moves through annual motion the moon will consistently cross the ecliptic as the 0° and 180° wedge points cross the pointer. If at all four points at the ends of the parallel and transverse axes the projected moon is equally above or below the ecliptic, correcting the latitude adjustment is all that is required.

For the moon and planets the latitude adjustment is identical. The central post of the analog terminates about $1/4''$ below the plastic dust cover. This post is tapped to receive the brass stem and small knurled knob fixed on the top of the tube which supports the rotating mirror assembly on its lower end. An 0-80 slotted brass setscrew in the post holds this stem in place. Loosening the setscrew permits turning the knurled knob further into or out of the post. This action moves the tube vertically over its stationary internal rod and tilts the rotating mirror. Raising the tube toward the analog moves the projected image northward on the sky, and vice versa. The setscrew is always gently tightened after latitude correction. Tightening against the stem threads may slightly dislocate the image vertically so that more than one attempt may be necessary.

In the case of the planets, torque applied to the stem, tube, setscrew, and post assembly is transmitted to the line-of-sight rod and may dislodge the steel ball from its magnetic socket. It is best to use two hands when adjusting latitude. With one hand hold the post while turning the setscrew or knob.

If the moon was not on or equally above or below the ecliptic at

the four points discussed above, correction is made at the 45° mirror on the ecliptic plate immediately below the rotating mirror. It is helpful to make a tabulation of the four positions, estimating the number of inches or degrees of displacement from the ecliptic. The letters P and T will indicate the positions at the ends of the parallel or transverse axis. For example, the positions of the moon might be P +4, P-8 T -5, T +1. The total excursions are 12 (inches or degrees) along the P axis and 6 along the T axis. Moving the image down one half the P total at P +4 will bring it to P -2 and the same procedure will move it up 6 units to P -2 at the other end of the axis and the P positions are consistent. Along the T axis the excursion was 6. Moving the image up 3 at T -5 will move it down by the same amount at T +1 and the new positions will be consistent at -2 for all four positions. Using the latitude adjustment described above, bring the moon up 2 units to the ecliptic at any point (so long as the dial is zeroed as it was for ALL noding observations) will assure that when driven in annual motion from the console or by switch at the instrument it will follow a consistently correct path.

A single screw under the ecliptic plate holds the second 45° mirror to the plate and loosening it slightly permits lifting and rotating the mirror. To correct the moon position along the T axis, rotate the mirror while observing the projected moon. To correct along the P axis, tilt the mirror as required by shimming under the front or rear of the mirror mounting block.

Note that rotating the mirror moves the image normal to the ecliptic along the T axis but horizontally along the P axis. Conversely, tilting corrects vertically along the P axis but only

horizontally along the T axis. Observing exactly where the moon is located with reference to marks on the ecliptic before corrections are made will assure that when tilting, for example, no rotation is inadvertently introduced.

h. Adjusting the Planets

1. Latitude Adjustment for the planets is the same as for the moon.
2. Mirror Adjustment - Alignment of the mirror support tube is critical, as in the case of the moon. The tube must be parallel to the beam from the projector's adjustable mirror after final nodding adjustments or the beam may leave the rotating mirror, causing a dim planet image.

The bracket which holds the adjustable mirror to the bottom of the projector barrel (like the sun) should be aligned parallel to the projector unless subsequent adjustments necessitate some twisting by loosening the cap screws. This mirror should be adjusted toward or away from the end of the projector barrel so that the planet beam passes upward through the center of the hole in the ecliptic plate. A piece of thin paper over the opening will show the beam's location as it leaves the adjustable mirror.

The projector is held to the ecliptic plate by a single screw which, when loosened, permits swivelling the entire projector. The adjustable mirror should be centered under the hole in the ecliptic plate because this opening is immediately under the rotating mirror assembly and the center of the analog.

3. Elongation - The rotating mirror is held to the tube from the

center of the analog by an 0-80 setscrew and must be aligned so that the beam from the mirror to the dome is parallel to the line-of-sight rod within the analog dust cover. Note that in the case of the two inferior planets the mirror points away from the center of the analog. Those for the superior planets point toward the center.

To check this alignment, turn on the coordinates and the planets. By switches and/or planet setting knobs drive each analog until both earth and planet indicators are at 90° or 270° on the dial, depending upon which location is more easily read on the inner dial. The following tabulation shows at what right ascension (R.A.) the projected planet should appear when its indicators are at the given heliocentric longitude (H.L.)

<u>PLANET</u>	<u>H.L.</u>	<u>R.A.</u>
Mercury	270	6
Venus	90	18
Mars	90	6
Jupiter	270	18
Saturn	270	18

Only Mercury and Venus lie along the solstitial axis of the instrument and should show exactly on the hour circle. The superior analogs, being off center from this axis, should show their projected planets a couple degrees off the proper side of the hour circle to compensate for this fact. For example, the Mars analog is offset to the left of center and the planet should be at approximately 6 hours 10 minutes R.A.

If a planet does not appear at its proper R.A., loosen the rotating mirror assembly setscrew and rotate the mirror as required before retightening the setscrew. The mirror is spring loaded to keep the

analog arm in contact with the wedge, so it will be necessary when making this adjustment to hold the rotating mirror upward as it is rotated into position lest it drop downward off the end of the tube.

4. Freeing Latitude Axis - When making adjustments to the planets, moon, etc. and it is necessary to observe these bodies in more than half the sky (as in nodding or setting up for a particular date), rather than run the instrument repeatedly in daily or latitude motion it is often advantageous to loosen the latitude drive so that the entire instrument can be swung manually through its supports. Remove the dust cover from the support block adjacent to the extended latitude axis carrying the pole and geocentric earth projectors. Fixed to the large brass gear is a split shaft collar which clamps to the shaft by means of a recessed Allen cap screw. Loosening this screw slightly permits rotating the instrument about the latitude axis. Loosen until slight pressure is required, but the instrument does not move freely. Always exert pressure on the upper central cage section - NEVER on the ecliptic plate or any component below the planet analogs.

If the cardinal points projectors are controlled by a microswitch actuated by a cam attached to this split clamping collar, it is necessary to bring the instrument back to its original latitude position before retightening the capscrew. If this setting should need correction, tighten the cap screw when the cardinal points move to their alternate mode just as the celestial north pole passes the zenith.

Caution: If this procedure is used to loosen the latitude drive temporarily, ALWAYS be sure before retightening that the large

brass driven gear has not moved along the latitude shaft.

It must at all times maintain its position so that it is centered with the driving worm gear. The shaft should be marked before loosening the cap screw in the split collar.

5. Noding the Planets

Prior noding of the moon and setting of the sun will have utilized certain procedures and concepts which are common to the planets. For example, it is the wedge within the heliocentric longitude dial which imparts inclination to the planets' orbits with respect to the ecliptic. And the projected images are observed at four places along the ecliptic - at the ends of the parallel and transverse axes.

Again, a simple tabulation of the image positions will prove helpful to determine the quantity and direction of correction required at the end of each axis. The image is brought to a series of four positions on or equally above or below the ecliptic and, if required, latitude correction is made as described in the discussion of noding the moon. The adjustable mirrors on the projectors are identical to that on the sun and are adjusted in the same manner.

The heliocentric longitude for the ascending nodes for the planets are given in the Ephemeris, page 176, and are printed on the band which surrounds the top of the cage section of the instrument, adjacent to the switches which control the planet in question. The descending node is 180° away, and may be used where it is more convenient and accurate to do so. More accurate settings are possible when using the inner dial and when the appropriate indicators are toward the outside of the instrument.

The ascending and descending nodal positions on the wedges are indicated at the appropriate heliocentric longitude values by scribed lines or by small dots on the sides of the wedges.

Because it is the wedge which defines the inclination of the orbits of the planets, and the arm rotates around the wedge, it is in all cases the brass arm pointer which must be related to the nodal positions on the dial. This pointer hangs below one end of the arm and its point is close to the dial for easy reference.

A thorough understanding of the analogs will assist in the remaining adjustments - noding and setting up the instrument for a specific date.

(a) Each is an analog of a portion of the solar system and the three significant positions represent those of the sun, earth, and a planet. In all cases the sun's position is at the center of the arm, wedge, and inner heliocentric longitude dial. The arm rotates about this center, carrying a cylindrical magnet with a cupped outer end in which rides a steel ball. This ball, being the nearer planetary element to the sun, represents the position of the nearer of the two planets under consideration for a specific analog. Thus, for Mercury and Venus the ball represents those planets, because the earth is farther away from the sun. For the three superior planet analogs the ball represents the earth, for the earth is nearer the sun. The third significant position is at the center of the analog and is seen as a post which protrudes from the center of the large thick colored plate and is continued downward by the tube-and-rod assembly which terminates in the rotating mirror. This position is farthest removed from the sun and is therefore the earth on the Mercury

and Venus analogs and the planet for the superior analogs.

Observation of the analogs while running will show that the ball rotates around the sun and both these elements around the plate post. The arm pointer always indicates the heliocentric longitude for the ball - whether it represents a planet or the earth. The plate or post longitude is indicated by a scribed cylinder or two small holes located near the perimeter of the plate and always maintained in a position adjacent to the dial.

A moment's reflection on the foregoing and a little practice will infallibly tell the operator which indicator he will set for which element of the solar system for a given analog. For example:

Mercury Analog:	-	Ball - Arm Pointer - Planet
		Post - Plate Indicator - Earth
Mars Analog:		Ball - Arm Pointer - Earth
		Post - Plate Indicator - Planet

(b) The outer dial on the plastic dust cover of each analog is a duplication of the dial within and is provided to make setting easier when the internal indicators are in positions which are away from the operator and difficult to read. The brass pointer fixed to the plate duplicates the reading of the plate indicator; the scribed flat aluminum pointer duplicates the setting of the inner arm pointer.

(c) The 1/16" diameter brass line-of-sight rod passes through the steel ball and terminates in the central post, thus at all times duplicating the observer's line-of-sight from the earth to a planet at any time for which the analog has been set up. The

tube and rod assembly transmit this line and orbital inclination to the rotating mirror which in turn reflects each planet's beam of light from the projector onto the dome.

(d) The individual impulse switches for the analogs impart full speed forward annual motion to the entire analog mechanism so that earth and planet indicators move forward on the dials. For the superior planets the accompanying knurled knobs drive only the planet portion of the system and the earth indicator remains stationary. This is also true for many instruments with respect to the inferior analogs, but a recent development utilizes a switch and motor drive for the planet as well. The operator can thus bring either earth or planet indicator to any setting, but in the superior analogs he must first set the earth by switch, then the planet by hand.

Noding the superior planets is somewhat easier, so it is best to adjust these first. Drive the Saturn analog arm pointer (earth) to 113° or 293° on the dial. At these points the arm lies across the wedge so that the projected planet should be on the ecliptic (zero latitude). Turn the planet knob to bring the projected planet to the four positions along the projected ecliptic which are at the ends of the parallel and transverse axes (when the beam from the rotating mirror is parallel and transverse to the optical axis of the projector). Tabulate the four latitude positions of the planet as described above in the discussion of moon noding. If it is on the ecliptic at all points, no correction is required. If not, correct by adjusting the projector mirror (see sun adjustment above). When all four points have the same latitude, adjust the latitude to zero. Procedures for Jupiter and Mars are identical

except that the node values are $100^\circ - 280^\circ$ and $49^\circ - 229^\circ$ and the planets will be projected at different points along the ecliptic because their projectors lie at different angles on the instrument. As noted above, the instrument may be driven in daily and/or latitude motion, or the latitude axis may be loosened in order to observe the ecliptic and planets well above the horizon.

In instruments having motorized earth drives for the inferior planets the same noding technique is used. However, it is the planet drive which brings the arm pointer to the node values (48° and 228° for Mercury and 76° and 256° for Venus) and the earth drive then brings the projected planets to the desired points along the ecliptic.

For those instruments having manual inferior planet drives before noding see Addendum No. 1 at the end of this section.

B. Setting the Instrument for a Date

1. The Sun

Having selected a date for which the instrument is to be set, drive daily motion to put this portion of the projected ecliptic above the horizon. Actuate the sun switch on the instrument or the annual motion switch on the console until the sun resets on that date. The first of each month is marked by a line. Other dates will be estimated with reference to these lines or all elements can be set for the first of a month and then the entire system driven in annual motion to any other selected date. Bear in mind that all annual motion motors are tied together electrically so that when the annual motion switch is used all elements are driven simultaneously to their proper places in the sky. This means that once one element - sun,

moon, or any planet - has been set for a date, all others must be set by individual switch and/or manual knob.

2. The Ephemeris

For subsequent setting of the moon and planets it will first be necessary to refer to the Ephemeris or similar source and it is advisable to use a tabulation similar to the one sent with the instrument. For many years the Ephemeris page numbers have remained practically unchanged and are given for quick reference. A current copy is supplied with each instrument. Because the supply is often exhausted early, it is suggested that copies for subsequent years be ordered from the printer several months in advance.

3. The Moon

Beginning on Ephemeris page 68 is a table which gives the apparent right ascension for the moon for any hour (use zero hour) of the date chosen. The projected moon is driven by its right ascension switch to the proper right ascension as related to the projected coordinates.

Beginning on page 52 is a table giving the moon's apparent latitude for the chosen date; again use zero hour. On the setting tabulation record this latitude. By referring backward and/or forward in time determine whether the latitude is increasing or decreasing and indicate this on the setting table. Turn the knob over the moon analog to drive the wedge until the moon reaches its proper latitude. Be sure to turn the wedge forward so that the divisions on the wedge dial are ascending. Note that in order to eliminate gear backlash effects, all elements are set originally in the forward direction. When annual

motion is driven forward, there will be no backlash in the gear trains. Reverse drive will introduce varying amounts of backlash. If, in setting an analog, the operator inadvertently overshoots a correct setting either go all the way around again (if a motor-driven setting) or back up (if a manual setting) well past the setting and again approach it in the forward direction. When uncertain which way to turn a knob for "forward", observe the direction in which the dial divisions pass the indicator.

After the moon is set in right ascension and latitude, return to the three-position moon phasing switch on the console. This switch has three positions. To the left all electrical circuitry to the phasing motor is broken and no phasing will result under any circumstances. In the central or upright mode the moon phases automatically in synchronization with the balance of the annual motion system. In the righthand position the switch drives only the phasing motor. In the central or automatic position the DC braking voltage is applied to one motor winding whenever the annual motion switch is off. After phasing the moon manually, turning back to the second position thus stops the phasing drive instantly. If the switch is returned rapidly from position three to one, there will be no braking and the drive will coast slowly to a stop.

The final steps in setting the moon are: first phase it manually (third or full right switch position) to first or third quarter and observe the alignment of the moon's terminator with relation to the projected ecliptic. It must be perpendicular to the ecliptic and the lower right quadrant must be the brightest. Driving the dove prism switch ("Moon Rotation") on the instrument will ro-

tate the moon to meet these conditions. The last step is to observe the moon's position with respect to the sun and use the manual phasing switch to bring it to the correct phase.

4. Setting the Planets

Refer to the Ephemeris and complete the setting tabulation with the following data:

(a) Earth Setting

From the table beginning on page 18 record the sun's longitude for the selected date. This datum is geocentric longitude. Add or subtract 180° from this figure to derive the earth's heliocentric longitude. Drive the planet analogs individually by switch until this value is set at all earth indicators. For the inferior planets this is the plate indicator; for the superior planets it is the arm indicator. The alternate indicator next to the dial located on the dust cover may be used but are not as accurate as those within.

(b) Planet Setting

From the Ephemeris tables on pages 160 to 175 record the longitude (heliocentric) to the nearest degree for each planet for the date chosen. Interpolation may be necessary for the superior planet data, depending upon what date is selected for setup.

Drive the analogs individually to these values. Move forward to the proper setting in all cases so that gear backlash is consistently eliminated for all analogs. If the correct value is inadvertently passed, back up

and come forward again or, in the case of the motor-driven planet indicators, go on around again to the proper setting. The inferior planets are driven manually or by motor, depending upon the model of the instrument. The arm indicator represents the planet. The three superior planets are driven manually and the plate indicator is used.

The five analogs are now set for a specific date with all earths and planets properly positioned about the sun and the line-of-sight rods simulating the lines of sight between the earthbound observer and the planets.

C. Fine Adjusting Projected Positions

The foregoing settings may be made in full chamber illumination. Referring to the tables on Ephemeris pages 178 to 217, record the Apparent Right Ascension (to the nearest minute) for each planet for the chosen date. Project the planets and coordinates on the darkened sky and compare the positions of the planets with the Ephemerides. Some displacements may be found due to the instrument's circular rather than elliptical orbits, inaccuracy of setting, etc. To fine adjust the projected planets to their correct right ascensions, drive the planet portion of the analog as required, taking care that this final position is always approached in the forward direction.

D. Alternate Setting of Planets

Steps b and c may be combined into one step if care is taken to understand the analog's functions and the resulting projected proper and retrograde motions on the dome. Once step a has set up all earths, the planets may be driven individually by hand or motor

as described above until each comes to its correct apparent right ascension on the projected coordinates grid. Attention to the Ephemerides for a few days before and after the setup date will indicate whether the planet is in proper or retrograde motion. The projected planet must be moving in the correct direction when brought to position, and its heliocentric longitude will closely correspond to the values tabulated in step c.

5. Using Annual Motion

With the sun, moon, and planets set for a date and the annual motion indicator on the console zeroed, the annual motion switch on the console is used to drive the entire system forward (clockwise) or reverse in time to any other desired date. The indicator on the console moves with the system and shows the algebraic sum of all forward and reverse movements since it was last zeroed. Bear in mind that the all setting was done in the forward direction and that when driven in reverse differing amounts of gear backlash will be imparted to the analogs and slight inaccuracy may result in the projected positions. This is canceled out as soon as the system is again driven forward.

6. Tie-In

Provision has been made to tie in the annual motion system with the daily motion drive so that as the instrument rotates through one 24 hour day, pulses actuate the annual motion drive so that the sun moves one degree and the moon 14° along the ecliptic in the proper direction. To use this feature it is necessary to lift the toggle switch on the front of the annual motion drive chassis to the IN position.

To calibrate the tie-in system it is best to use the large dial on

the perimeter of the moon analog plate. In the plastic dust cover is a pointed indicator which is related to the dial. Bring any hour circle of the coordinates system to the meridian. Read the moon dial and be sure the tie-in switch is IN. Advance daily motion through 360° or one day until the original hour circle is back on the meridian. The moon dial should have advanced 14° .

If adjustment is necessary, a rheostat on the annual motion chassis is used. It is identified by a $1/4''$ shaft projecting from the rear of the chassis. Turning the adjustment clockwise increases the duration of the pulses delivered to the annual motion system. Adjust this rheostat until the moon moves approximately 14° during one day. If finer adjustment is required, use a similar rheostat found on top of the annual motion switch within the console.

(Some earlier instruments have only the one tuning rheostat on the AM chassis.) Before adjusting tie-in, it is best to turn the tuning rheostat(s) to the middle position. The tie-in feature may be eliminated at any time by moving the AM chassis switch to OUT.

ADDENDA TO SECTION II

1. Noding of Inferior Planets on Instruments Having Manual Planet Setting Knobs

Refer to page II-25

Earlier A-3-P instruments employ a manual setting knob for each inferior planet rather than a motor drive. The same basic techniques are used in observing and tabulating the planets' positions with reference to the ecliptic when at the ends of the parallel and transverse axes. By experiment it will be ascertained what combinations of heliocentric longitude for the earth and planet will result in successively projecting the planet to the ends of these axes. Each time the earth is driven by motor, the planet indicator (on the rotating arm) must be brought manually to the nodal heliocentric longitude as indicated by the dots or scribed lines on the sides of the wedge (48° or 228° for Mercury and 76° or 256° for Venus). Deviations above or below the ecliptic are recorded and corrected as outlined in the text for analogs which are driven by dual motor drive.

SECTION III
OPERATOR'S CONSOLE DESCRIPTION
AND
OPERATING INSTRUCTIONS

A. General Description: The operator's console is divided into two main functional divisions:

1. The Operator's Control Panels (Two): The vertical panel (actually it is slightly slanted away from the operator for convenience) and the horizontal panel.

All knobs turn clockwise to the "Full On" position. All step switches turn clockwise for forward or normal motion, and counter clockwise for reverse motion. All lever type switches throw forward or upward for "on" and, where double, throw to the rear for a reverse action. This uniformity greatly accelerates the process of learning to know the instrument controls.

2. The Electronic Component Section: This second functional division is enclosed within the operator's console. It includes not only the electronic components, but all the necessary terminal strips and cables to connect the controls to power sources and then on to the projector instrument operating mechanisms.

As this section is completely installed and inspected at the time of the installation of the planetarium by Spitz men and needs no further handling, we will leave the description and function of this section to the manual division on MAINTENANCE INSTRUCTIONS. The planetarium operator need not concern himself with this section unless a malfunction occurs. (See Maintenance Section)

B. The Vertical Control Panel

This panel is divided into three rows of controls and a row of fuses. Each control

is labelled and the labels are backlighted for easy identification in the dark.

1. The Top Row of Controls (from left to right)

a. DAILY MOTION SWITCH. This is a reversible, continuous action switch which increases daily motion rotation of the projector instrument around the daily motion axis from a barely perceptible motion to a rate of one rotation per minute. The switch knob is turned clockwise for forward rotation and counter clockwise for reverse rotation. The higher speeds are provided for quick setting of the instrument.

b. ANNUAL MOTION SWITCH. This, too, is a reversible, continuous action switch which, when turned clockwise, increases the forward annual motion of the sun, moon and planets from approximately one year in five minutes to one year in one minute. Counter clockwise turning of the knob reverses annual motion at the same rate.

c. ANNUAL MOTION INDICATOR. As annual motion is performed, either forward or backward in time, the indicator moves one division for each year of motion. The indicator needle can be manually positioned by the knurled knob protruding through the face of the dial. Generally, the needle is set on "0" for the annual motion position to a preset date.

d. LATITUDE MOTION. This is another reversible, continuous action switch. The instrument may be rotated continuously about the latitude axis in either direction. (Take care that no auxiliary projectors on the base posts interfere).

e. CLOCK. The clock face is lighted when the panel lights are turned up. It can be quickly reset by the knurled knob protruding through the dial face. This clock will continue to run even when the key switch is off.

f. PRECESSION. This switch provided forward precessional motion when

the knob is turned clockwise and reverses this motion when turned counter clockwise. The center position is the "off" position.

g. MOON PHASING. This is a 3-position switch which controls the phasing mechanism on the moon image projector. The center position provides automatic phasing of the moon as the projector performs annual motion. The clockwise position provides a continuous change of phase while the moon remains in the same right ascension position (most useful for a discussion in which the phases are named and for setting the moon). The counterclockwise position stops the phasing disc and the moon image will remain in the same phase as annual motion proceeds.

h. SIGNAL. This is a single throw lever switch which is "on" in the up position of the lever. Generally, it rings or lights a signal so that attendants outside the chamber can prepare to assist the audience in or out of the planetarium.

2. The Middle Row of Controls

Each of these controls is a rheostat inserted in the circuit as labelled. Turning the knob clockwise increases the current flow to maximum as it reaches the end of its rotation. From left to right the controls supply regulated current to these image projectors: STARS, SUN, MOON, INFERIOR PLANETS (Mercury and Venus), MERIDIAN, COORDINATES, ECLIPTIC, and the three CELESTIAL TRIANGLE projectors.

3. The Bottom Row of Controls (from left to right)

These rheostat controls operate in the same manner as those in the row above. From left to right they supply current to the following projectors: TWILIGHT, GEOCENTRIC EARTH, SATELLITE, the three SUPERIOR PLANETS (Mars, Jupiter, and Saturn), and CARDINAL POINTS. The balance of the row is made up of three single throw switches that supply unregulated current to the LATITUDE, POLE, and ZENITH projectors.

The Satellite control is unique in that it includes a 110V on-off switch for the motor drive and a 6V rheostat for the lamp. AS the knob starts its turn the switch clicks on. AS it progresses clockwise the lamp brilliance increases. When turning the satellite off, be sure to turn the knob to its full counterclockwise position so that the switch clicks off.

4. The Row of Fuses

a. General: There are seven fuse holders in the row at the bottom of the vertical panel, each labelled as to the circuit the fuse protects. The fuse holder caps light up when a fuse blows as a signal to the operator that there is a malfunction in the circuit. During a lecture, it will probably not be possible to remove the malfunction which caused the fuse to blow, so the operator should, if possible, eliminate the part of his demonstration which requires the use of the circuit in difficulty. If the fuse signal light is disturbing during the balance of the demonstration, it can be turned off by twisting the cap.

The malfunction in the circuit should be repaired before the circuit is put into operation again. (See Maintenance Section)

The blown fuse is removed by rotating the cap $1/4$ turn and pulling it and the fuse from the holder. The new fuse is inserted in the cap tube and the fuse and cap locked in place by reversing the removal action.

b. The Fuse Holders and Fuses Used:

1. STARS: 3 ampere fuse
2. SUN AND MOON: 1 ampere fuse
3. AUX 1: $6-1/4$ ampere fuse. This circuit provides 6-volt supply to the satellite, geocentric earth, and twilight projectors.
4. PLANETS: 3 ampere fuse

5. AUX 2: 6-1/4 ampere fuse. This circuit supplies 6-volt supply to the coordinates, ecliptic, astronomical triangle, and the cardinal points projectors.
 6. AUX 3: 6-1/4 ampere fuse. This circuit provides 115-volt supply to the moon phasing, precessional motion, and satellite motors.
 7. MAIN: 10 ampere fuse. This circuit provides electrical supply to the entire instrument except the clock.
- c. Key Switch: This key operated switch provides 115-volt supply to the entire instrument except to the cove lights and the clock.

C. The Horizontal Control Panel

This panel is separated into two side panels by the red transparent reading light panel. The most obvious feature of each side panel is the large, circular knob of the cove lighting control.

1. Cove Light Controls - Yellow and Blue

The control knobs operate the large capacity variable transformers mounted on the platforms under the horizontal panels.

The left control knob is labelled YELLOW and controls the straw-colored lumiline lamps in the cove. The right control knob is labelled BLUE and controls the moonlight blue lamps in the cove.

2. Pointer

The gun-like pointer projects the arrow which is an essential means of communication between the operator and audience. The pointer plugs into a receptacle in the upper right surface of the kneehole on the operator's side of the console. The brightness of the projected arrow is controlled by the rheostat labelled POINTER located near the forward left corner of the reading light panel.

3. Panel Lights

Red panel lights are found behind the vertical panel and under the two side

sections of the horizontal panel. They furnish the illumination for backlighting the engraved captions under the controls of all panels. The brightness of this backlighting is controlled by the rheostat labelled PANEL LIGHTS at the near left corner of the reading light panel.

4. Reading Light

The reading light panel provides a low level backlighting of lecture notes when it is necessary to refer to them in the darkened planetarium chamber. The brightness is controlled by the rheostat labeled READING LIGHT in the near right corner of the reading light panel. The red light provided does not appreciably affect the dark adaptation of the eyes.

5. Cardinal Points

The four compass points, N, E, S, and W are projected onto the dome from the cardinal point projectors mounted on the top of the pedestal. The cardinal points are turned "on" by a forward throw of the switch just to the right of the reading light panel marked CARDINAL POINTS. The brightness of the projected image is varied by the rheostat knob at the center of the bottom row of controls on the vertical panel labelled CARDINAL POINTS.

Each projector projects either of the two cardinal points 180° apart, that is, NS, EW, SN, or WE. When sufficient latitude change has been made to require reversing the points on the dome, a microswitch at the end of the latitude axis automatically switches the circuit to the reversed set of projection letters on the projectors. The microswitch operating position can be adjusted to make the reversal of cardinal points suit your local or desired latitude situation.

6. "In Use" or "Wait" Switch

This switch is used to turn on a lighted sign outside the planetarium chamber. When lighted, this sign indicates to visitors that a show is in progress and that the chamber should not be entered. The switch is located at the forward, right corner of the horizontal panel.

7. Lever Switches

Along the forward edges of the two horizontal panels are ten switches which control the correspondingly marked sockets on the instrument base. Those for the Projection Orrery, Meteor, Bolide, Comet, Eclipse, Aurora, and Auxiliary are single-throw double-pole. On one side of each is 110V for motors and on the other 6V for lamps.

The two Constellation switches are double-pole double-throw and control four 6V circuits for lamps only.

An eleventh switch to the extreme right marked IN USE is single-throw and controls a 110V circuit to the terminal strip within the console. From this point it may be used to control a fixture at the entrance.

8. RIP or Spare Powerstats

Immediately forward of the panel lights and reading light rheostats are two knobs controlling two powerstats. Where Room Illumination Projector rings are supplied around the instrument base in lieu of cove lights on the dome, these are the controls. If cove lighting is supplied, these powerstats may be used to control 110V auxiliary projectors. Their circuits lead to the terminal strip within the console. Note that the capacity of each powerstat is 1.75 amperes.

9. Electrical Drawings

A complete set of electrical drawings is supplied with each instrument. These will be helpful in troubleshooting electrical problems and in making use of

the auxiliary controls discussed above. The operator should consult these drawings before connecting to the terminal strip inside the console or using the auxiliary sockets on the instrument base.

D. Additional Console Controls

On either side of the console drawer is a small square removable panel. The one to the left is used when the installation includes a slide projector. On this panel is an ON - OFF switch to actuate the entire projector system, an electronic rheostat to control the lamp only, and a socket into which the remote control cable is plugged. The fan is ON when the switch is on and should be left running until the lamp is cool.

The panel to the right of the drawer is supplied with four blanked holes in which the operator can mount switches to control such optional chamber circuits as those for room lights, receptacles, or special effects.

SECTION IV
MAINTENANCE

A. General Description

1. The Spitz Yearly Maintenance Contract

A yearly maintenance and inspection service is provided by the Spitz Service Department. A laboratory-trained maintenance man will give your instrument a thorough inspection, cleaning, and will repair or replace all parts or units not up to standard. Write to Spitz Laboratories, Inc., Yorklyn, Delaware, for information on this service.

2. Cleaning

a. Dusting the Star Sphere

A soft, flexible brush of the large household painting variety is ideal for dusting the perforated surface of the star sphere. This should be done as often as required to keep dust from clogging the star holes.

NOTE: If it is suspected that a star hole has been clogged, a piece of tracing paper or onion skin typing paper passed over the sphere in the suspected area will reveal a partially stopped up star hole. Clean with a fine wire or needle.

b. Cleaning Star Sphere Lenses

A smaller, soft bristled brush (of the soft, water color type) will remove dust from the projection lenses and mirrors without removing them from the sphere.

Lens tissue rolled into a small tube will generally remove any film that may collect on the lens surface.

c. Cleaning the Planet, Sun and Moon Lenses and Mirrors

Projected image brightness is reduced when image projector lenses and analog projection mirrors are covered with dust or film. The small soft water color brush previously mentioned is ideal for cleaning these lenses and mirrors. The mirrors are front surfaced and, even though overcoated, should be cleaned with lens cleaning tissues or soft brushes to prevent scratching the surfaces. Water or alcohol, or a mixture of the two are effective cleansing agents.

d. Pedestal and Control Console

The broad wood, plastic and painted surfaces of these components should frequently be dusted. A damp cloth, wet with water and a mild soap solution will remove fingerprints and film when necessary. Wood surfaces will benefit from a periodic waxing with paste wax. (Care should be taken to keep water and other cleaning agents from entering the receptacles and other devices mounted on the pedestal and console.

3. Lubrication

In general, a minimum of lubrication is required, and lubrication, except in the few places listed, is to be avoided.

a. Mechanical Horizon Cutoffs

These shield-like devices cut off the projection below the horizon by the sun, moon, and planet analog mirrors. They depend upon a free-swinging motion to perform properly.

Once a week the horizon cutoff bearing around the analog shaft should be dusted and blown clean. Once a month, after the cleaning operation, a small drop of lightweight machine oil should be placed on the bearing.

b. Daily Motion and Latitude Motion Gear Trains

These gears are located at the ends of the latitude axis under easily removed covers. Every six months they should be inspected and a good grade of light grease added when necessary.

c. Daily Motion Belt Drives

This mechanism is enclosed in a rectangular housing at the center of the latitude axis. The cover is labelled: REMOVE COVER TO LUBRICATE. Once a year inspect the belt for wear, and replace if necessary. Then lubricate the gear train with a lightweight greast.

4. Bulb Replacement

a. A-3-P Prime Sky Light Source Replacement

The light source cup assembly is completely removed by lifting the hook-like hangers at the top of the cup from the pins at the ends of the yoke which supports the cup in the center of the star sphere. Access to the light source is through the round door in the star sphere.

Temporarily replace the Prime Sky light source with the incandescent spare light furnished with the instrument. Telephone, telegraph, or write Spitz Laboratories for a replacement.

When installing the replacement Prime Sky light source cup, match up to the color code red mark on the cup with the red wire, or red painted yoke arm, to maintain polarity. The red coded "plus" side of the light source cup hanger will not fit over the collar on the "negative" yoke arm.

b. A-3-P Incandescent Star Bulb Replacement

Remove the bulb cup from the yoke arm pins by lifting and guiding the slots in the cup hanger hooks off the pins. Remove the prefocused GE 1637 bulb by turning the twist-lock base counterclockwise. Insert the

new bulb by reversing the process and replace the cup on the star sphere yoke. The lamp flange should be painted or inked to prevent excess reflections.

On some older instruments a GE 1600 bayonet-based bulb was used. On it the cup could not be removed from the yoke, so it is necessary to remove the star sphere itself from around the light cup in order to replace the bulb. Four knurled screws hold the star sphere to its base. The sphere must be guided outward (north) as well as upward to follow the angle of the yoke.

Some flat black paint or ink from a metal marking pen eliminates reflection from the bulb base - a reflection which could cause double projection resulting in fuzzy stars.

c. Sun, Moon, and Planet Bulb Replacement

1. Remove the lamp assembly and replace with a new GE 261 pre-mounted bulb assembly - rated for 1,000 hours of operation.
2. On older instruments the prefocused GE PR 12 bulb is used. It is inserted base-up in the image projector receptacle with the filament placed towards the front of the projector. Tighten the aluminum cap in place and hold a piece of white paper close to the projector mirror to examine the projected filament image. It should make a bright, U-shaped and well centered image. If it does not, turn the bulb or replace with another bulb until a good filament image is projected. Now, examine the image projected onto the dome. On projectors using achromat lenses in the end of the barrel, if it is a little fuzzy, turn the projector lens in or out until the image becomes sharp. (Actually, some operators prefer a slightly fuzzy image to add to the realism of the projected planet.

- d. Zenith, Pole, Latitude, and Satellite Projectors
Follow the same procedure as with the planet projectors to replace the PR 12 bulbs used in these projectors.
- e. Meridian and Geocentric Earth Projector Bulbs
To replace the PR 12 bulbs in these projectors, loosen the setscrew which holds the bulb extension tube in place. Pull out the tube and unscrew the tube cap. Before tightening the setscrew, and after replacing the bulb and extension tube, turn on the projector and check the placement of the projection with respect to other celestial reference points. Often a slight turn of the bulb extension tube will make a better filament alignment and produce a sharper projected image.
- f. The Coordinates Projector Bulb
Loosen the setscrew in the base at the bottom of the projector and pull out the bulb extension tube. Loosen the cap and replace with a new PR 12 bulb. To properly position the projected coordinates, turn on the stars and the coordinates projector. Move the bulb extension tube in and out until the 5 hour, 30 minute R.A. and 0 declination are on the star Mintaka in Orion. Check to see that the Vernal and Autumnal Equinoxes fall at 0 and 12 hours on the celestial equator.
- g. The Ecliptic Projector Bulb
The coordinates projector is first removed and the bulb is replaced in the same manner as for the coordinates projector. To align the projected ecliptic, turn on the ecliptic projector and the sun and move the bulb extension tube in and out until the ecliptic line falls on the sun.
- h. Astronomical Triangle and Twilight Projectors
These projectors use the GE 605 screw-base bulbs. The bulb is reached through the round ports covered with hinged round doors in the sides of the triangle projectors. On the twilight projector the bulb screws into

the end of the bulb extension tube which is held in place with a set-screw. The bulb for the twilight projector is red gelatin coated.

B. Malfunctions - Symptom...Cause... Remedy

1. No Power to the Operator's Console

Possible Cause and Remedies:

- a. Planetarium chamber main power off: Perhaps a fuse blown. If not, a switch inadvertently thrown on the circuit breaker panel. Have electrician determine cause and repair.
- b. Key switch on console burned out: Replace key switch or temporarily connect both wires to the same terminal screw on the back of the switch.
- c. Main power circuit fuse burned out - Lighted: Replace 10-amp fuse. If it goes out again, check for short in the 110-volt circuit or an overload to the instrument and repair.

2. No Projected Image from an Instrument or Auxiliary Projector

- a. If the control panel fuse in the circuit in question has not burned out, the bulb has probably burned out or is making a poor contact. Replace bulb or clean bulb and projector contacts. Be sure bulb receptacle collar is fastened firmly in place in the projector barrel. If not, twist the collar back to the position where lead-in wires cannot short out and glue in place with epoxy cement. A short in the projector will blow the fuse. If the short cannot be located and repaired, return the projector to Spitz for a replacement.

3. Poorly Projected (Fuzzy) Star Images

- a. Reflection from bulb base: Coat base with dull black paint or ink.
- b. Dust clogged star holes: Clean.

- c. Humidity wrinkled color filters on bright stars: Replace star lens assembly or, on older instruments, replace filter only.

4. Planets or Moon - Run out of Proper Synchronization

Run a synchronization test on the suspected planet, or all the planets, sun and moon.

With the electrical drives bring planets, sun and moon up to the meridian, driving in forward motion always. (With outer planets save time by bringing planets close to the meridian with knobs and finishing with electrical drive). Now, drive a year forward in time with annual motion control. Stop. Drive a year and a month or so back in time, and finish by driving the planets to the meridian in forward motion. This will reveal a planet, sun, or moon that is not moving properly, for it will not come back to the meridian with the others.

Possible Causes and Remedies:

- a. The clutch on the superior planets or the moon knob shafts could be slipping. Turn the knob to detect slippage. Tighten the clutch by loosening the setscrew on the clutch nut. Tighten the nut and tighten the setscrew. (All are located on the threaded portion of the knob shaft).

On the moon double motor drive, check to see that the setscrews on the gears connecting the two motors to the analog drive are not loose, causing the gears to slip.

- b. Ball is not moving freely on the line-of-sight rod: Clean rod with fine crocus cloth and lubricate lightly with light machine oil.
- c. Lack of 45-volt D.C. braking voltage. Causes planets, sun and moon (and precessional motion) to coast. This coasting is most easily detected in the star sphere precessional motion: Check fuse

on annual motion speed control chassis. Replace, if blown. If it blows again, ask Spitz for a replacement chassis.

- d. If none of the above is found to be the cause of improper annual motion, replace the motor on the unit which does not perform properly in the synchronization test. (Furnish the name of the planet, sun or moon motor desired, as their lead-in wires from the terminal strip to analog mounting position are of different lengths). It may be more convenient for you to replace the whole analog.

5. Moon Image will not Remain Properly Aligned with the Ecliptic

A line drawn between the poles of the moon should remain nearly perpendicular to the ecliptic. If it does not, the fault lies with the dove prism mechanisms.

Possible Causes and Remedies:

- a. The bearing around the dove prism tube is dirty or not properly lubricated, causing too much of a drag on the dove prism drive motor. Clean and lubricate, or replace the mechanism.
- b. If the bearing moves freely, the fault is with the drive motor. Replace the motor.

6. Slippage or Jerky Motion in Daily or Latitude Motions

(On recent instruments be sure that the daily motion tie-in switch on the side of the DM-LM chassis is in the "out" position before checking daily motion).

- a. Open the pedestal door and watch the motor for the drive in question to see if it is performing smoothly. If not, check the brushes and replace if badly worn or, if necessary, replace the motor.
- b. Next check to see that all the setscrews in the linkage between the motor and gear train are tight. This is the most frequent cause of

slippage. Then check the setscrews in the gears of the gear trains at the ends of the latitude axis.

- c. For daily motion, if these efforts do not correct the slippage, remove the cover from the daily motion drive box surrounding the daily motion axis on the latitude axis. Check the belt and the setscrews in the drive mechanism. Lubricate the drive gears.
- d. If jerky daily motion persists, replace the drive belt.

7. Daily Motion or Latitude Motion Drives Fail to Provide Speed Changes

- a. Check daily or latitude control switches for burned out contacts. Replace.
- b. Check the drive motors for worn out brushes. Replace or replace motor.
- c. If the switch and motors are in good shape and the DM-LM chassis has blown a fuse and continues to blow fuses when replaced, order a replacement chassis from Spitz.

C. ORDERING REPLACEMENT PARTS OR UNITS FROM SPITZ

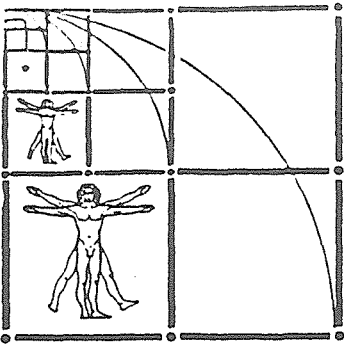
Address: ~~Spitz Laboratories, Inc.~~
~~Yorklyn, Delaware 19736~~

Telephone: ~~Area Code: 302-239-5212~~

Telegraph: As above.

Call, telegraph or write Spitz Laboratories, Inc. to request a replacement part or unit. Give a complete description of the unit (name, location and use) and describe the trouble as completely as possible. State the urgency with which you need the replacement (this determines the method of shipment to you).

At the same time, carefully pack the part or unit from your instrument and send it to Spitz Laboratories so that you can receive credit on the exchange.



SPITZ SPACE SYSTEMS, INC.

U.S. ROUTE 1 CHADDS FORD, PENNSYLVANIA 19317 U.S.A. (215) 459-5200
TELEX / TWX: #710 760 0100 SPITZSPACE

XENON ARC LAMP WARRANTY

The Xenon Arc Lamp is guaranteed for 30 days from date of shipment against defects in material and workmanship. Any lamp which fails to ignite or otherwise becomes inoperable due to defects in material or workmanship will be replaced if returned within the warranty period. The entire obligation of Spitz Space Systems under this warranty is to replace defective lamps or, at its option, to credit the purchaser. This warranty is in lieu of all other warranties whether expressed, implied or statutory including implied warranties of merchantability or fitness. It extends only to buyer when purchasing directly from Spitz Space Systems, Inc.

It is suggested that the lamp be installed and tested immediately upon receipt by the customer.

WARRANTY #
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