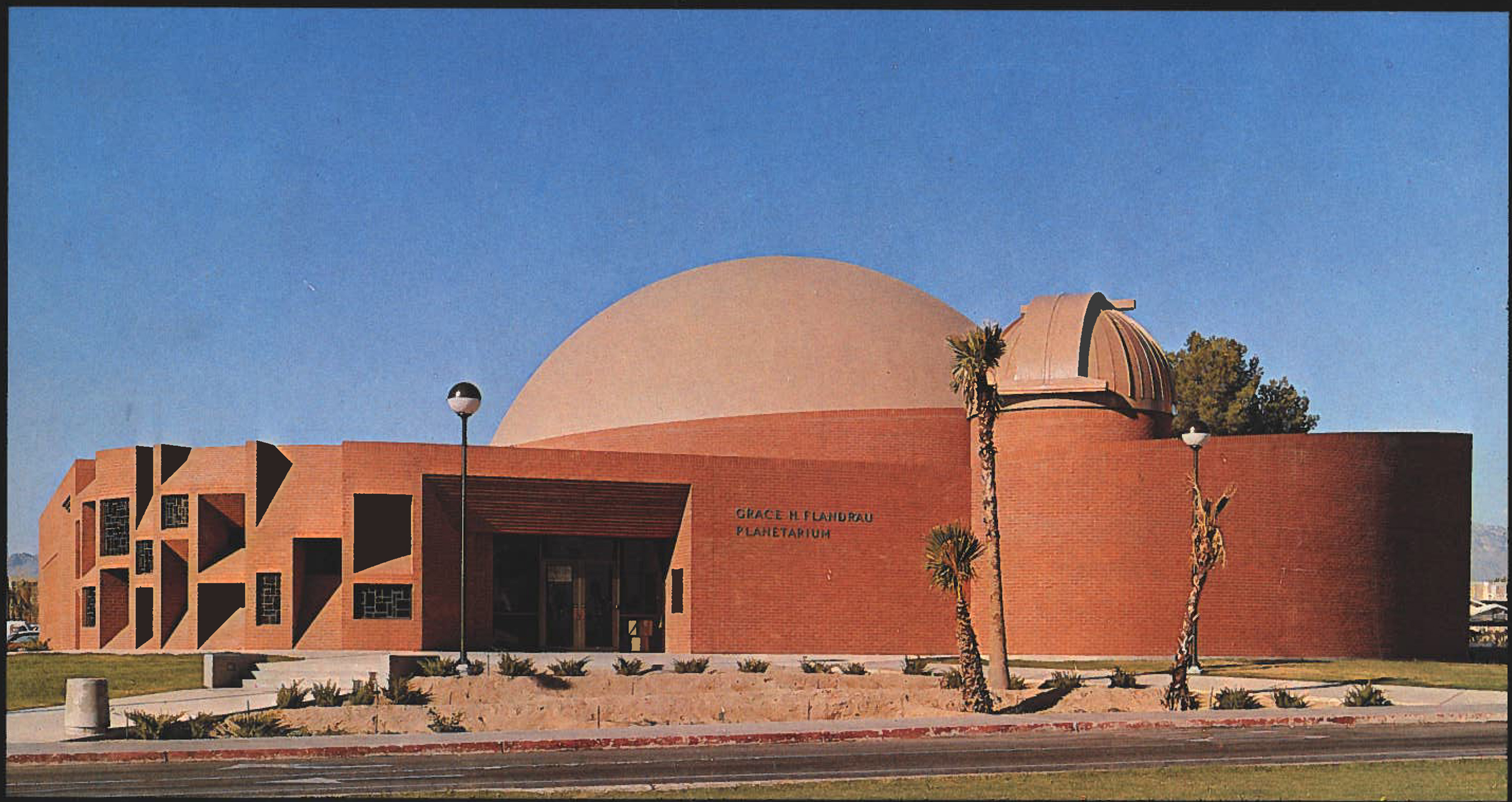
The Grace H. Flandrau Planetarium

University of Arizona

Tucson, Arizona



THE CONCEPT

The Planetarium was to be designed to have many uses. It should provide instructional facilities for University classes and for primary and secondary school students, a public theater for both planetarium programs and for the performing arts, science exhibit halls for the curious of all ages, and shop facilities to support all these functions.

In the Planetarium theater it should be possible to reproduce not only the night sky for the study and "exploration" of outer space, but to reproduce by complete hemispheric motion picture projection almost any Earth environment. Auxiliary special effects projection should be provided to enhance those programs and further to support dramatic, literary, and musical programs of types not possible on conventional stages. A sound system in the theater should be able to reproduce sound with the highest fidelity and directional control. There should be a quality public telescope available to visitors from near and far to personally view celestial objects on any clear night. Finally, the Planetarium should be conveniently located to the University and to the larger surrounding community.

With these preliminary guidelines, planning began in early 1973.

Portrait: Grace H. Flandrau (1886–1971), author and frequent winter visitor to Tucson, through whose generosity the Planetarium was launched. Inspecting the portrait is John S. Greenway, nephew of Mrs. Flandrau and Vice-President of the University of Arizona Foundation.

THE DESIGN

Design of such a facility was to be a real challenge. The campus site at the corner of North Cherry Avenue and University Boulevard was quickly selected as the most suitable. This site is virtually surrounded by the offices or laboratories of the University's Astronomy Department, Steward Observatory, the Lunar and Planetary Laboratory, the Optical Sciences Center, and the Kitt Peak National Observatory.

The building, designed by the Tucson architectural firm of Blanton and Company and built by Defco Construction Company, is striking in originality, yet blends with the traditional brick architecture of the University of Arizona campus. Construction was overseen by the University's Division of Physical Resources under the direction of John B. Trimble, to whose staff special credit is due for their assistance in carrying out of the concepts and plans.

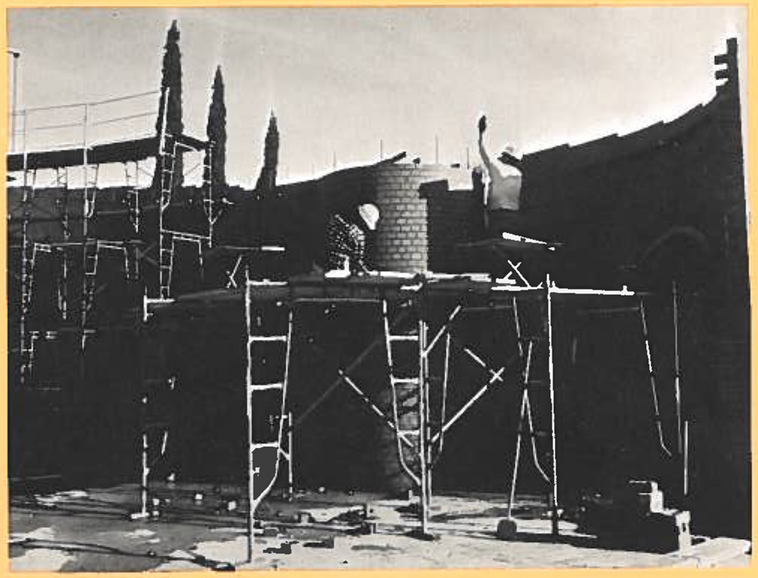
The main floor public areas of the building encompass 13,000 square feet with an additional mezzanine area large enough to serve luncheons to organized groups up to 90 members, or to accommodate classes of 130 students. A basement level containing the Planetarium work shops, Steward Observatory laboratories and offices, and mechanical space provides another 13,000 square feet.

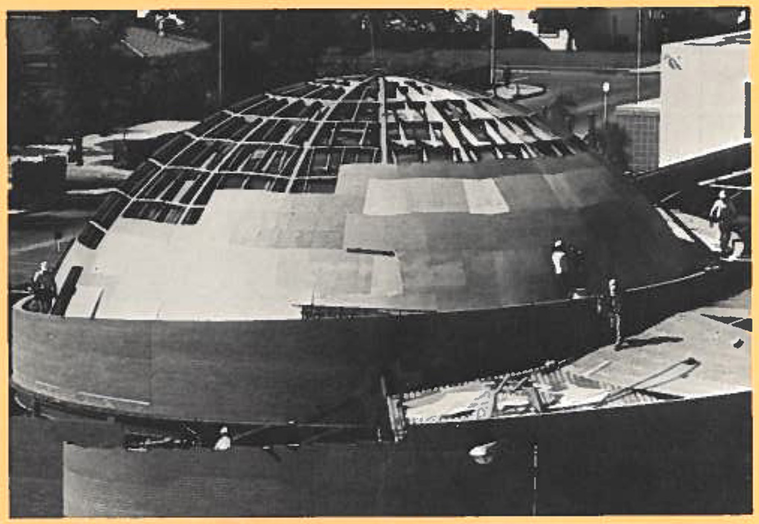
Discussing Planetarium construction plans are (l. to r.): A. Richard Kassander, Vice-President for Research; John P. Schaefer, University President; O. Richard Norton, Planetarium Director; and Rex E. Willoughby, Blanton and Company architect for the Planetarium.

September 1974:
Basement walls begin to rise, reflecting the building's shape.

January 1975: Ready for pouring the dome room floor with its radial pattern of reinforcing steel.

February 1975:
Brickwork is laid up for the Planetarium's Observatory.



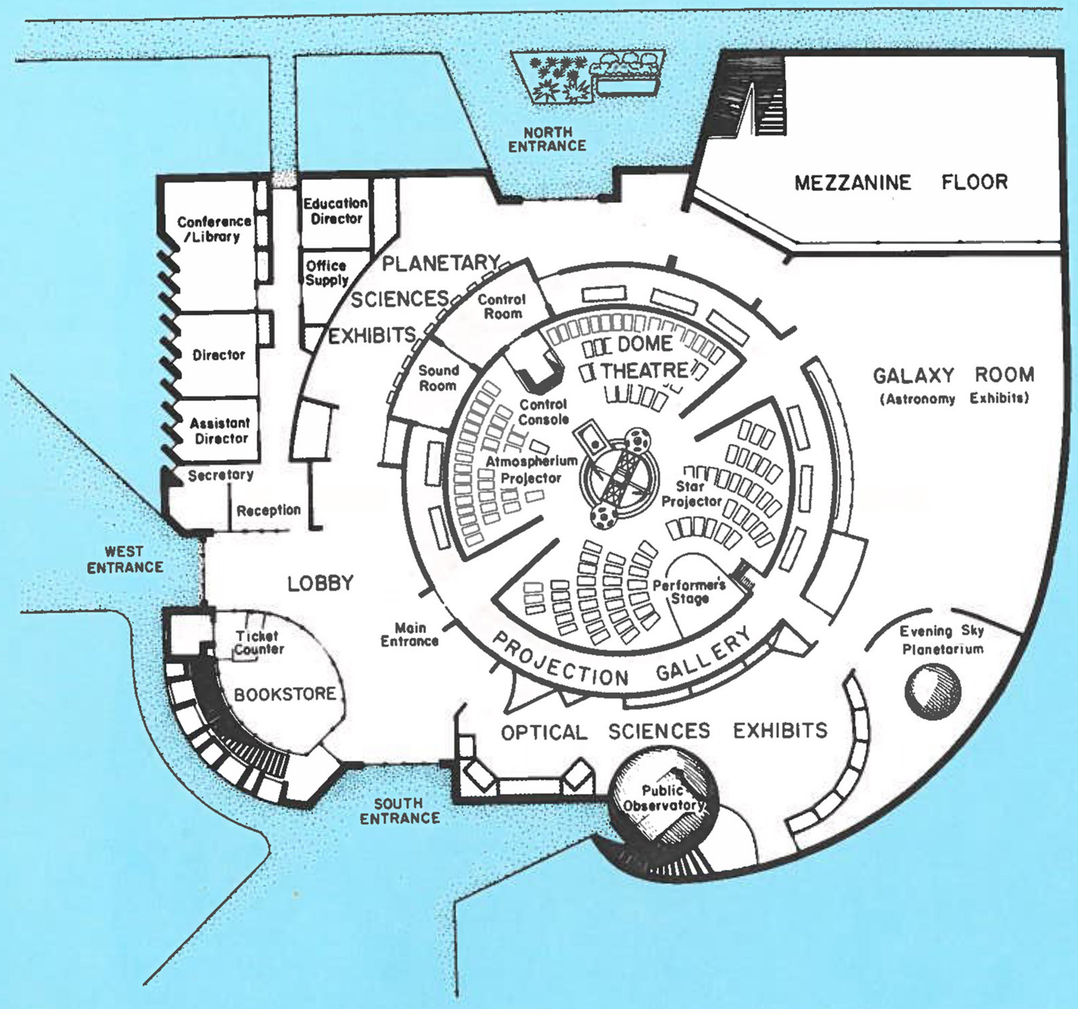


May 1975: A double plywood skin is applied to the dome.

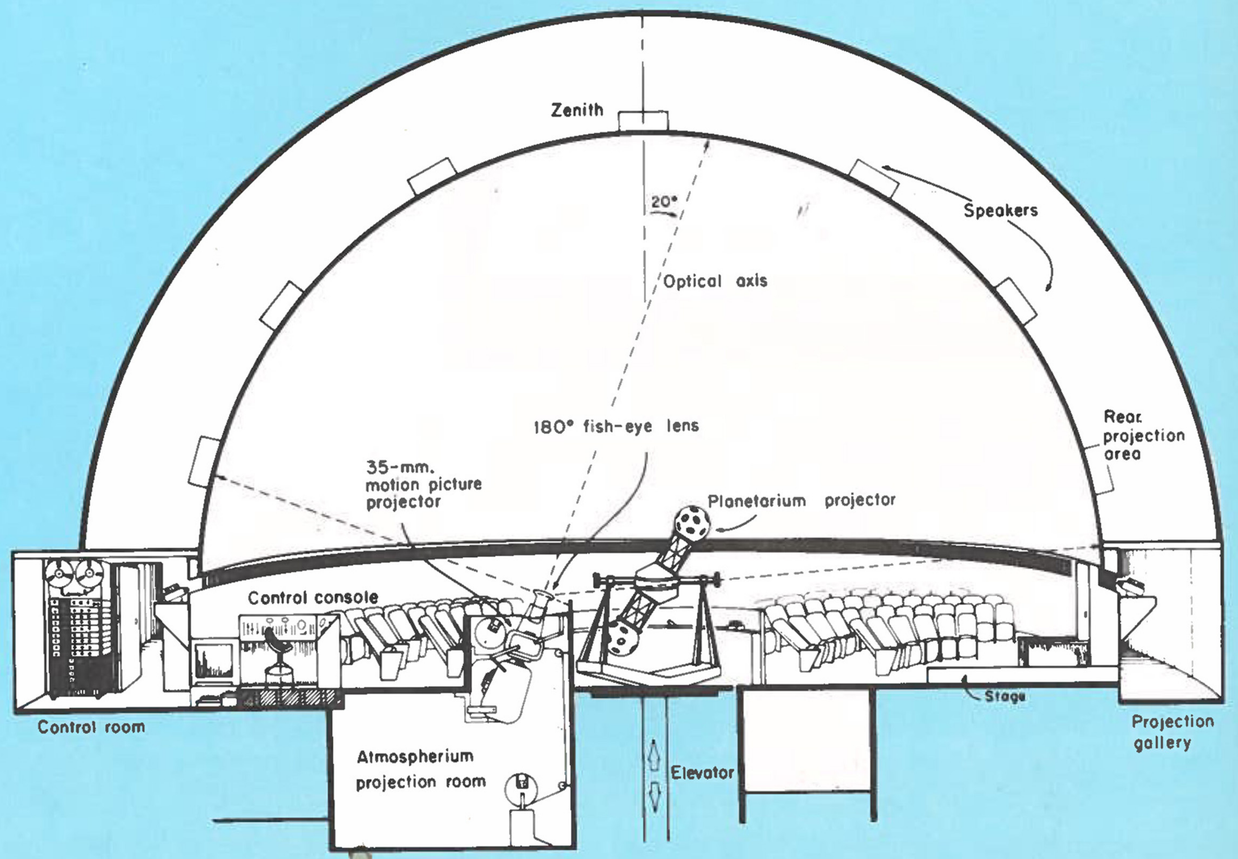
March 1975: Laminated wooden beams form the Theater dome.

July 1975: The building nears completion and landscaping begins.

A "fisheye" camera lens, similar to the one used to produce film for the Atmospherium, captures the intricate design of the dome construction.



Entirely surrounded by exhibit halls, the fifty-foot domed Theater seats 150 persons in a semi-concentric seating arrangement suitable for live performances on the stage as well as dramatic planetarium productions.



The Atmospherium projector is to one side of the Planetarium instrument and tilted slightly so as to provide the optimal viewing angle. The Planetarium instrument can be lowered partially for clear viewing of the stage or completely into the basement for maintenance. Special visual effects are projected onto the dome from the projection gallery completely surrounding the Theater.

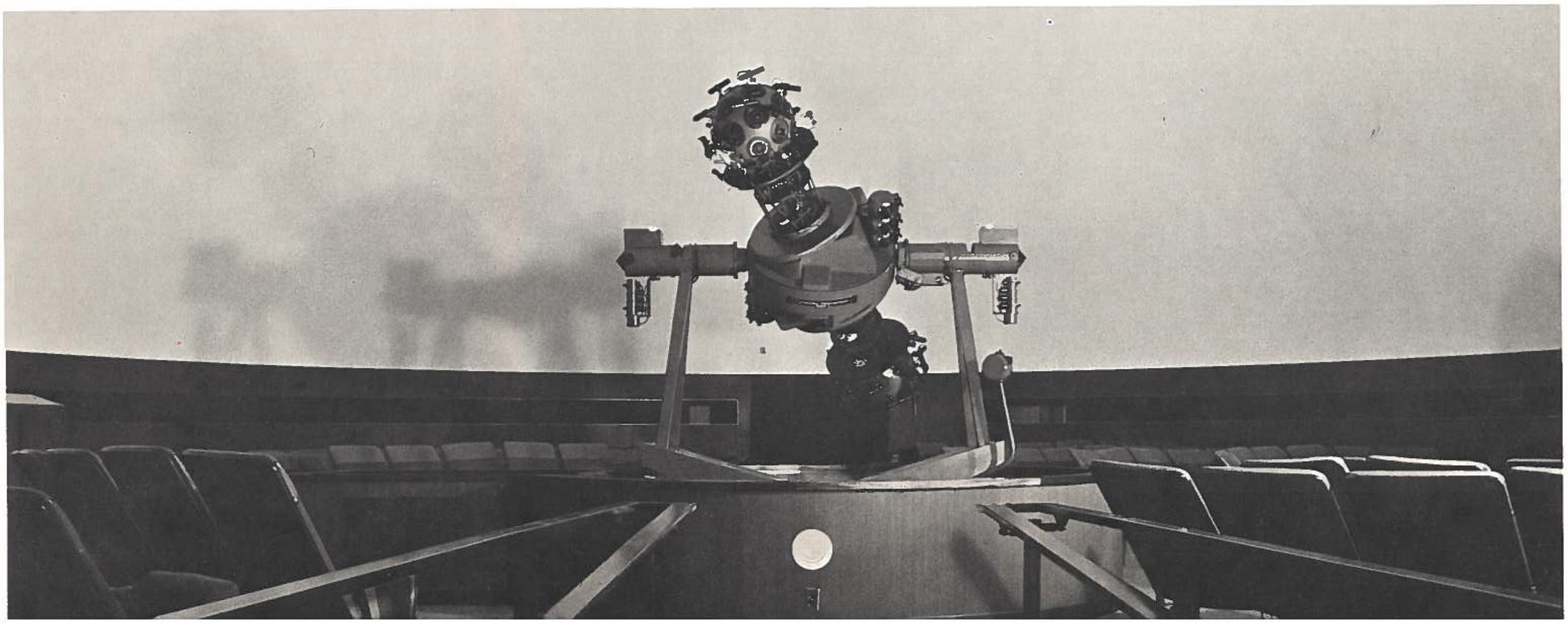
THE FACILITY

The Planetarium Instrument

The characteristic dumbbell shape of planetarium instruments is created by the two star balls which are mounted at the extremities of the planetary cages. Each star ball projects over 4300 stars, one for the northern hemisphere, the other for the southern hemisphere. The planetary cages contain projectors for the Sun and Moon in addition to the five planets visible to the unaided eye.

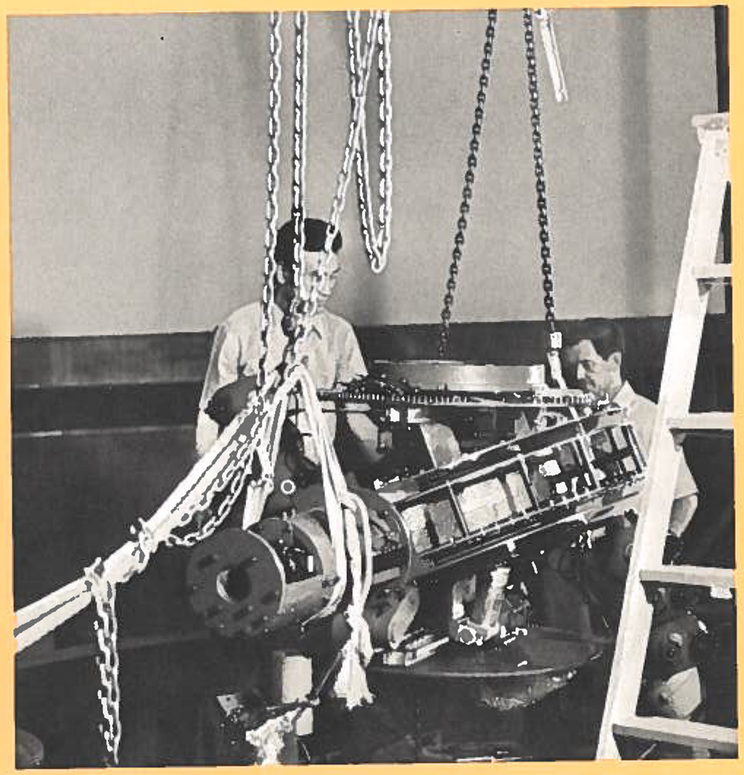
The Tucson instrument was designed specifically for the needs of the Flandrau Planetarium by collaboration between the Planetarium staff and Viewlex Audiovisuals Inc. of Holbrook, N.Y. and the Minolta Camera Company of Osaka, Japan. It contains over seventy-five individual projection systems. It is capable of portraying on the Theater dome the appearance of the night sky from any location on Earth, at any time past, present, or future. The positions of each of the stars, including those hardly visible to the unaided eye, are accurately placed to within one minute of arc. Nearly a dozen star clusters and nebulae, best seen in the real night sky with binoculars or a small telescope, are also faithfully represented . . . and indeed the detail of these objects is seen best even in the Planetarium with binoculars! Auxiliary projectors operating in conjunction with the instrument can produce variable stars, novae, meteors, comets, and dozens of colorful constellation figures.

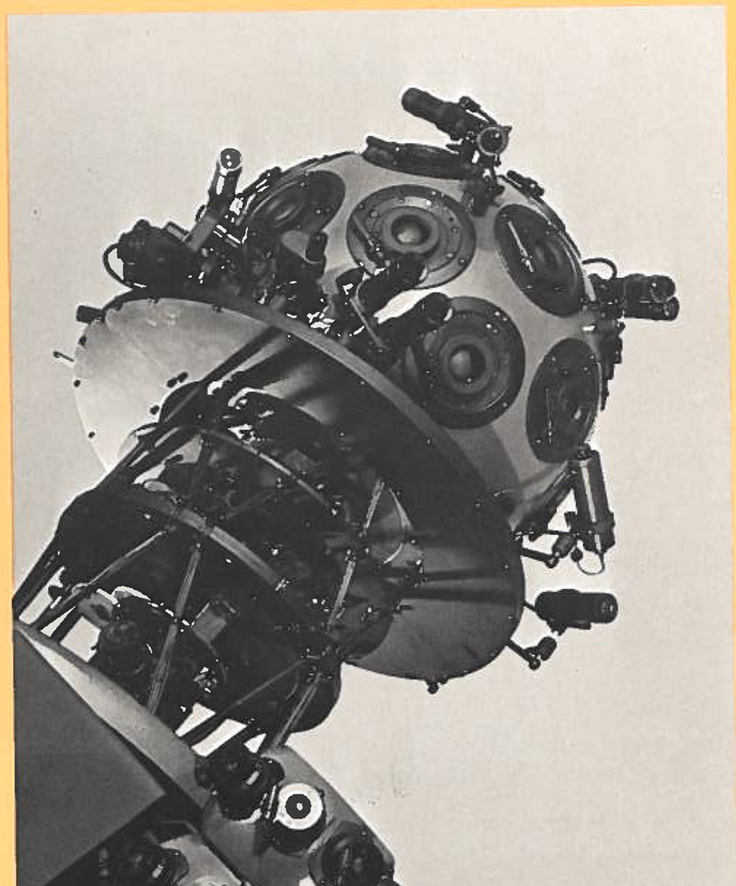
Since the Planetarium Theater is used extensively for teaching University courses in introductory astronomyn ten simplified remote control units which operate the planetarium instrument are available in strategic locations in the Theater. These permit up to sixty students to control the instrument and to solve problems in positional astronomy in response to questions posed by the instructor. Thus the Planetarium Theater becomes a student laboratory and the projector an experimental tool.



The planetarium projector is lowered to the basement for service.

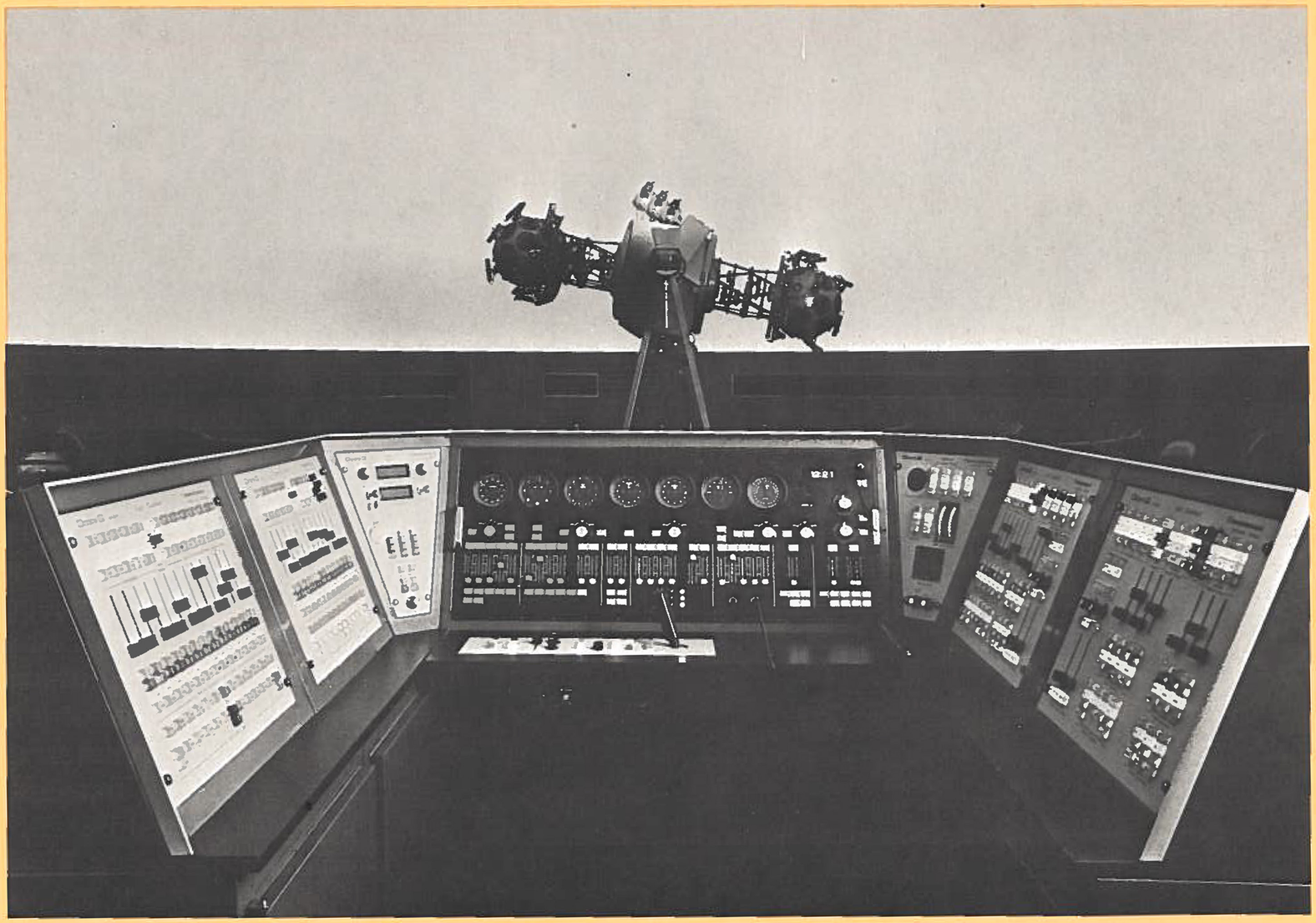
The main axes of the planetarium instrument are carefully installed under the watchful eye of Mr. A. Saeki, planetarium design engineer of the Minolta Camera Company.

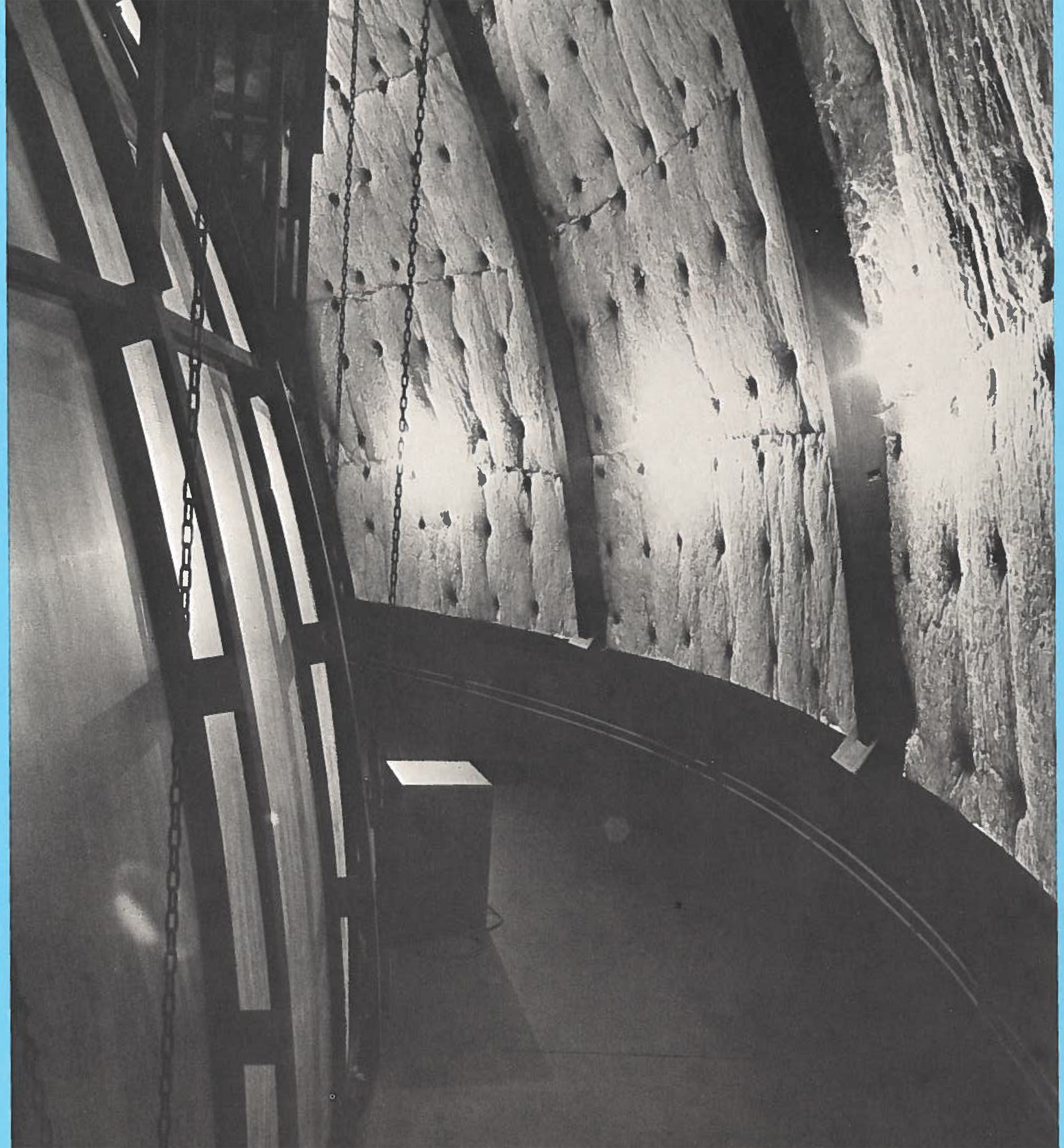




Northern hemisphere star ball and planet projectors.

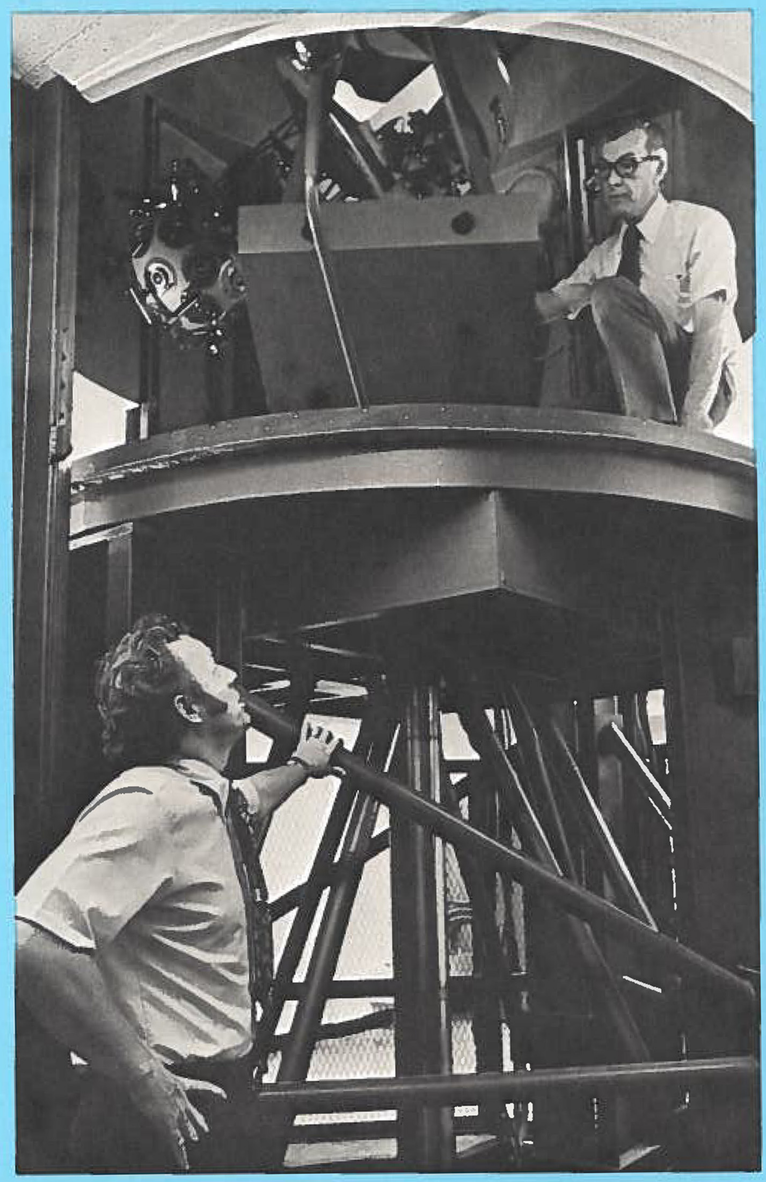
Total control of the planetarium instrument is centered in the master control console. In addition to the planetarium projector, the console provides control for over 200 special effects projectors located in a projection gallery around the perimeter of the domed Theater. So complex is the total projection requirement that a unique computer system has been developed to operate the multitude of projection devices. The computer stores the information required to control the audiovisual systems used in a program on three data tracks of a seven channel tape. The additional four channels are used for audio. The sound system features omniphonic sound, that is, sound from any or all directions. With a gyrophonic control stick the sound can be moved in any direction. After the sound has been programmed, the computer controls its motion. The console operator can manually take control of all projectors and sound equipment should a malfunction occur in the computer.





The fifty-foot perforated aluminum inner dome is entirely suspended from the larger outer dome. The five-foot catwalk space between the domes provides space for the speakers of the Omniphonic sound system, for air-conditioning, and for various special effects.

Representatives of architectural firm and
University check design of planetarium instrument hoist.



A projection gallery around the theater makes possible the use of dozens of special effects projectors.

The senior technician prepares the automation system for a new Theater program.

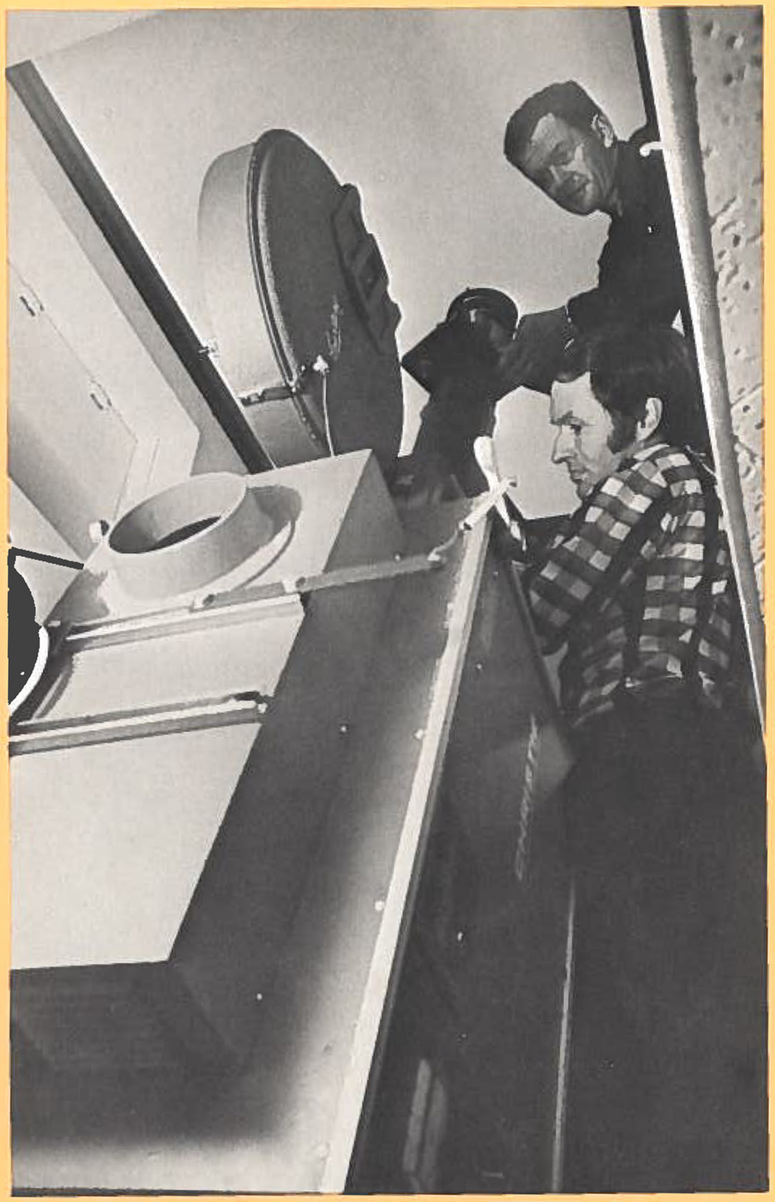
THE ATMOSPHERIUM

The ultimate experience in a theater is to be surrounded by each scene just as our natural environment surrounds us. The atmospherium projector does precisely this by projecting motion pictures with complete horizon-to-horizon coverage onto the hemispheric surface of the domed Theater. This system can transport the viewer to any environment which can be filmed . . . it can surround him with the grandeur of the great Sequoias, lower him to the floor of a volcano, place him in the center of a water droplet alive with microorganisms, plunge him beneath the oceans or launch him into outer space . . . always with a full hemispheric view available to him. This projection system produces a sort of theater-in-the-round in reverse, with the audience in the center, surrounded by the panoply of nature, movement, and dramatic action.

The Atmospherium is a specially made motion picture projector combined with an extraordinary lens designed for the Planetarium by the Optical Sciences Center of the University of Arizona. The wide-angle lens, made up of fifteen separate optical elements, has a diameter of five inches and is more than two feet long. From specially made 35mm motion picture film, it projects an image which is enlarged over 600,000 times in area onto the 50-foot diameter dome of the Theater.

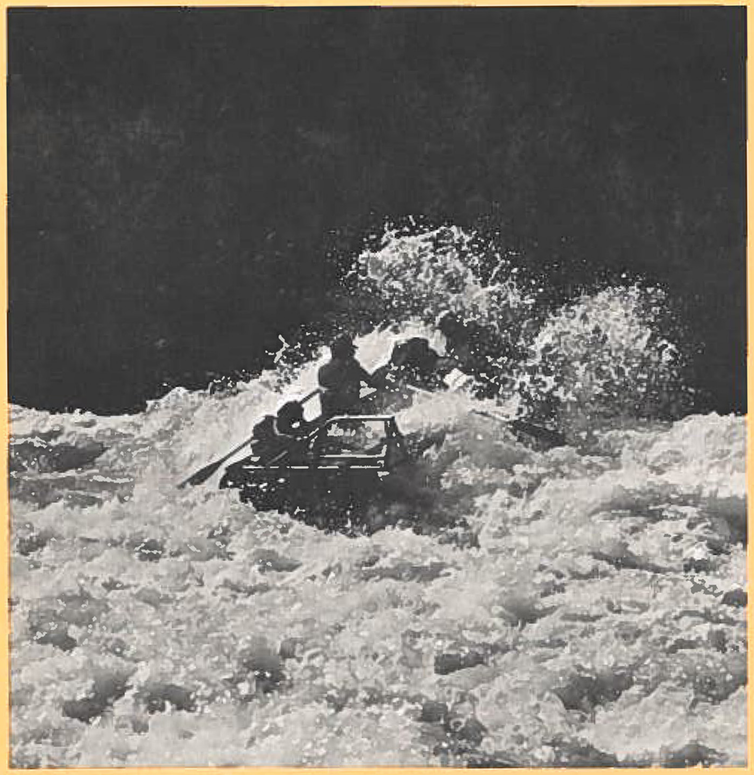
Hemispheric projection has uses beyond dramatic entertainment. It can, for example, transport an entire geology class to a vantage point within the Grand Canyon from which the classic geology of the towering canyon walls can be viewed with convenience and comfort. The marine environment can likewise be brought to the biology student or researcher with a completeness of view not attainable by ordinary narrow-angle filming. Psychological research on many aspects of perception is similarly made possible.

To produce film for the Atmospherium requires a unique camera capable of filming an entire hemisphere at any desired motion picture speed. While it may at first seem odd, filming with such a camera normally requires aiming the camera nearly vertically in order to accurately film the surrounding scene.



Richard A. Buchroeder, designer of the projection optics for the Atmospherium, prepares the projection lens for testing.

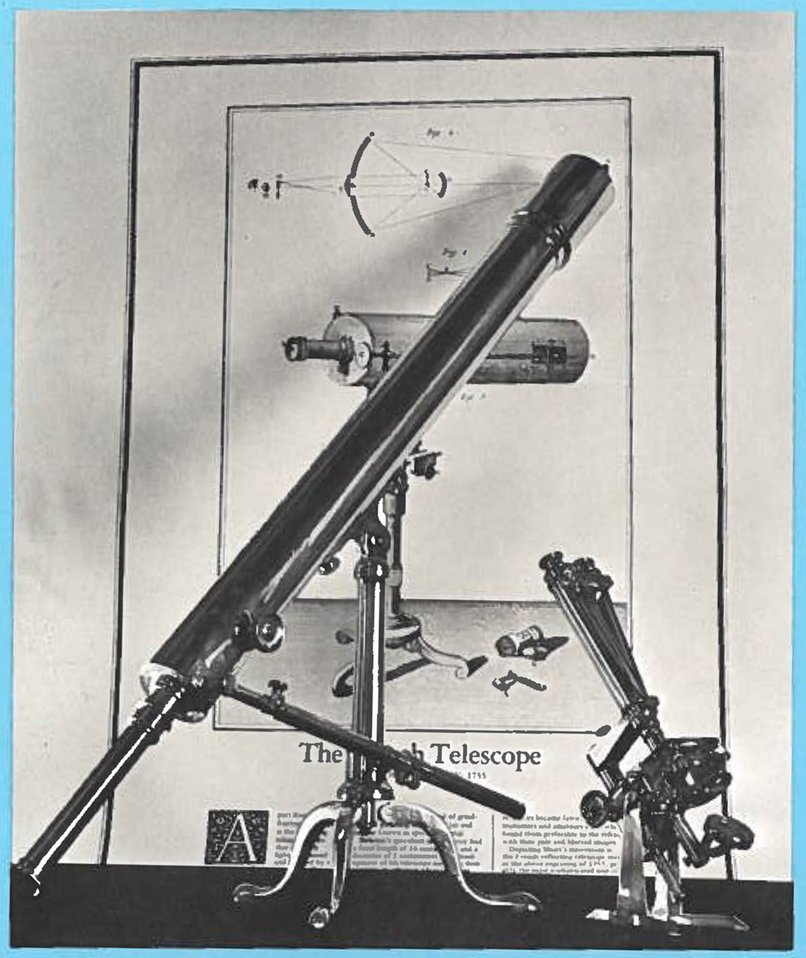
The Atmospherium camera takes a bath during running of Crystal Rapid in Grand Canyon.



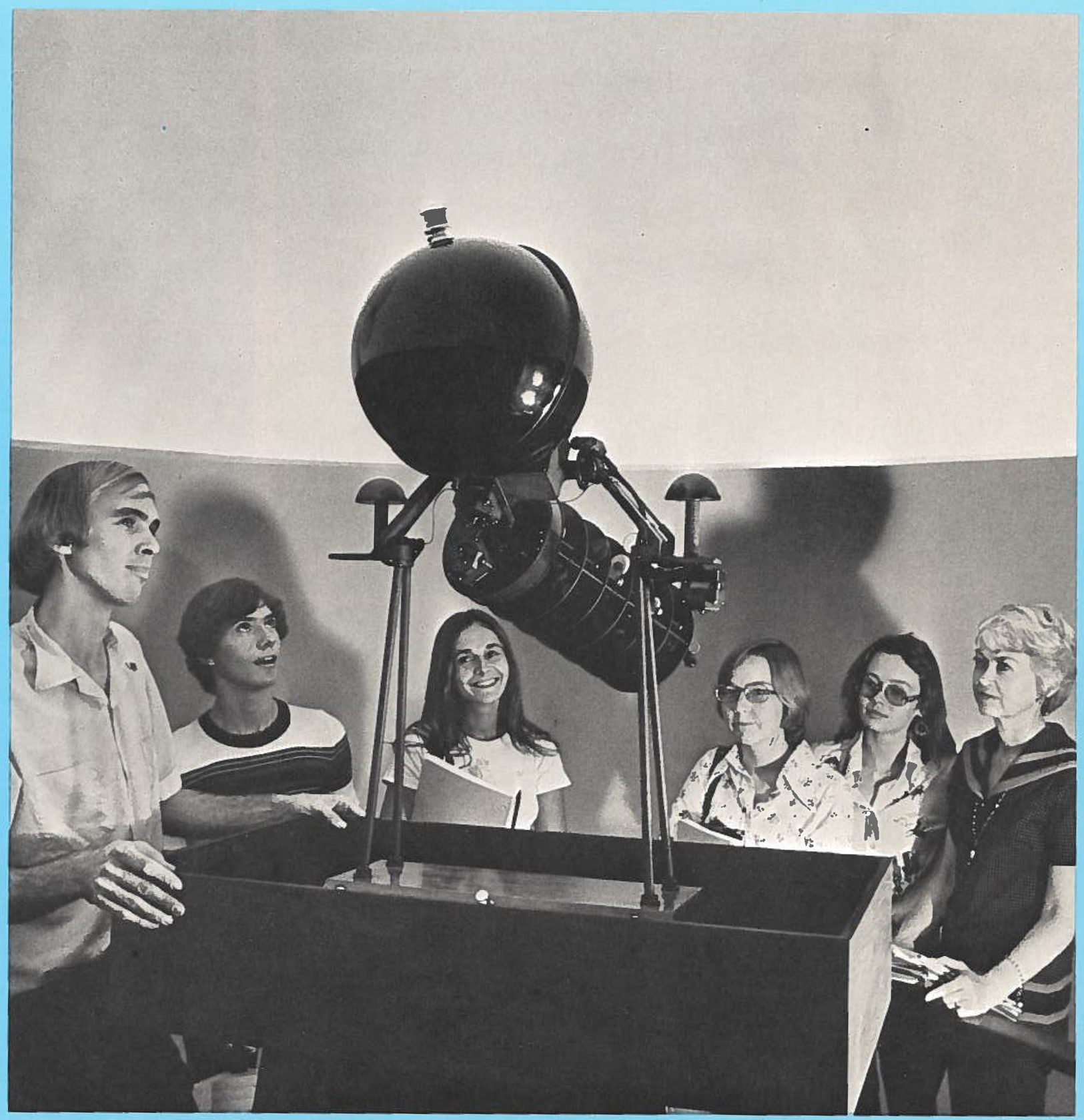
An actual frame of film taken with the Atmospherium camera while filming Grand Canyon from a helicopter. Rotor motion and portion of air speed indicator are in upper left portion of frame.

Director O. Richard Norton makes final check on camera attachment to nose of helicopter.

SCIENCE HALLS

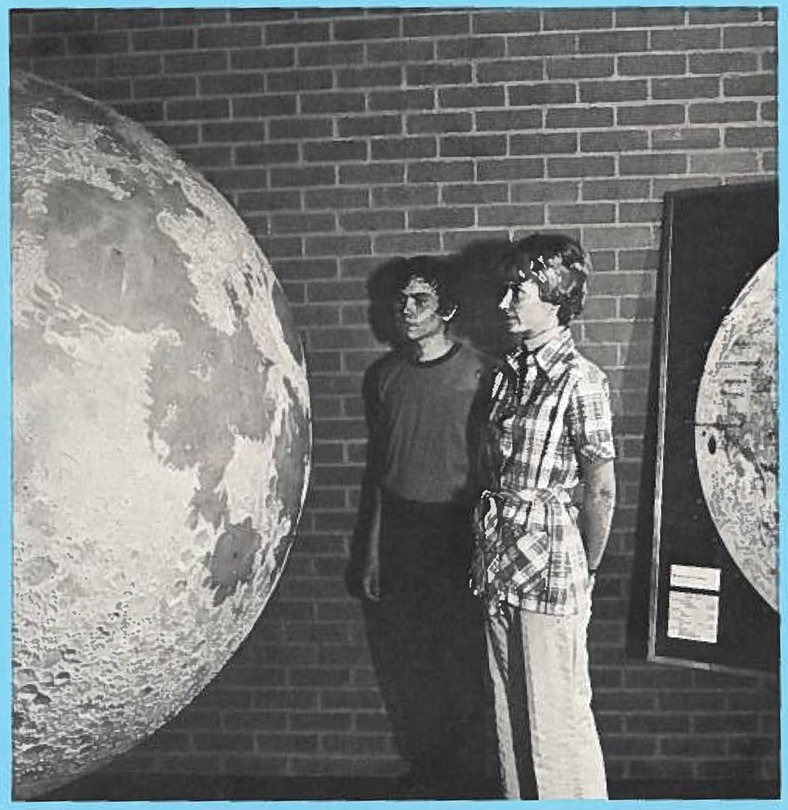


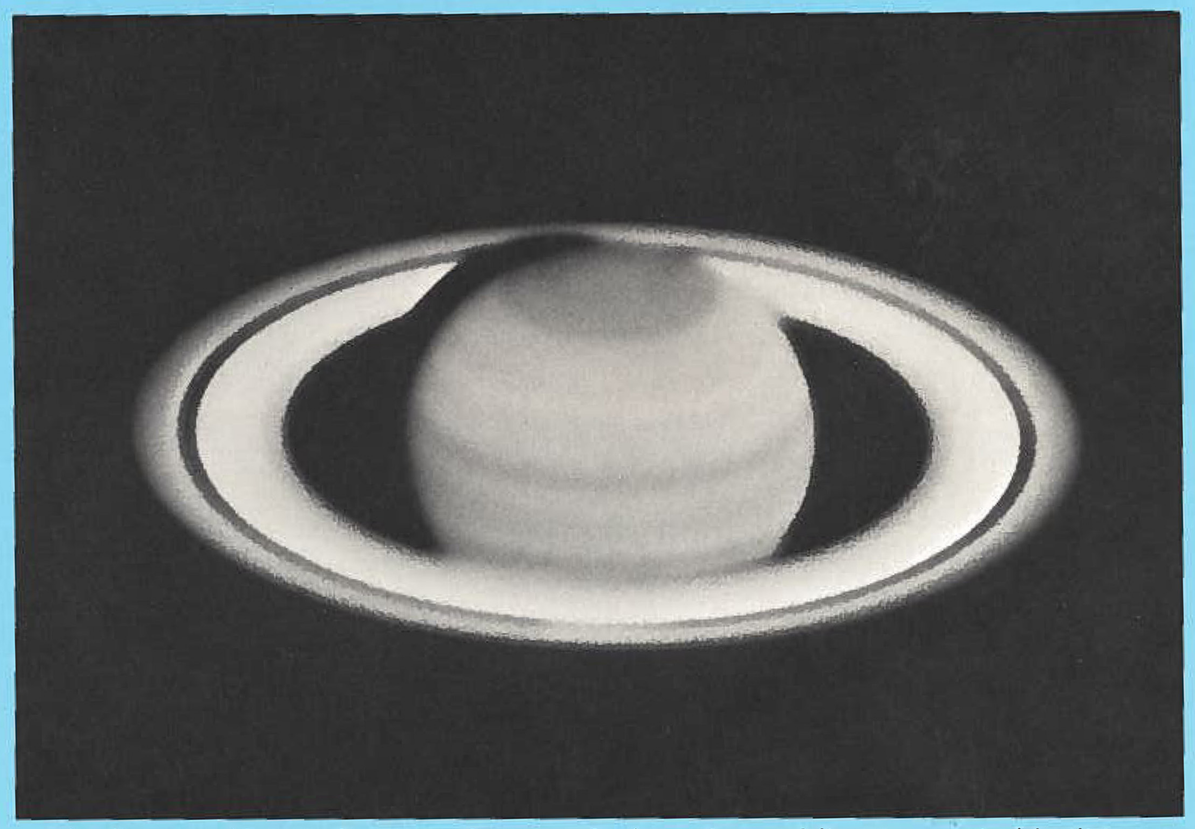
Displayed in the lobby is a fine collection of early optical instruments including this handsome 19th century telescope. Visitors may also use a detailed replica of Galileo's first 14-power telescope.



The smaller, fully automated Evening Sky planetarium permits visitors to study at leisure the current evening sky over Tucson. Students receive an explanation of the instrument from the Planetarium's curator of exhibits.

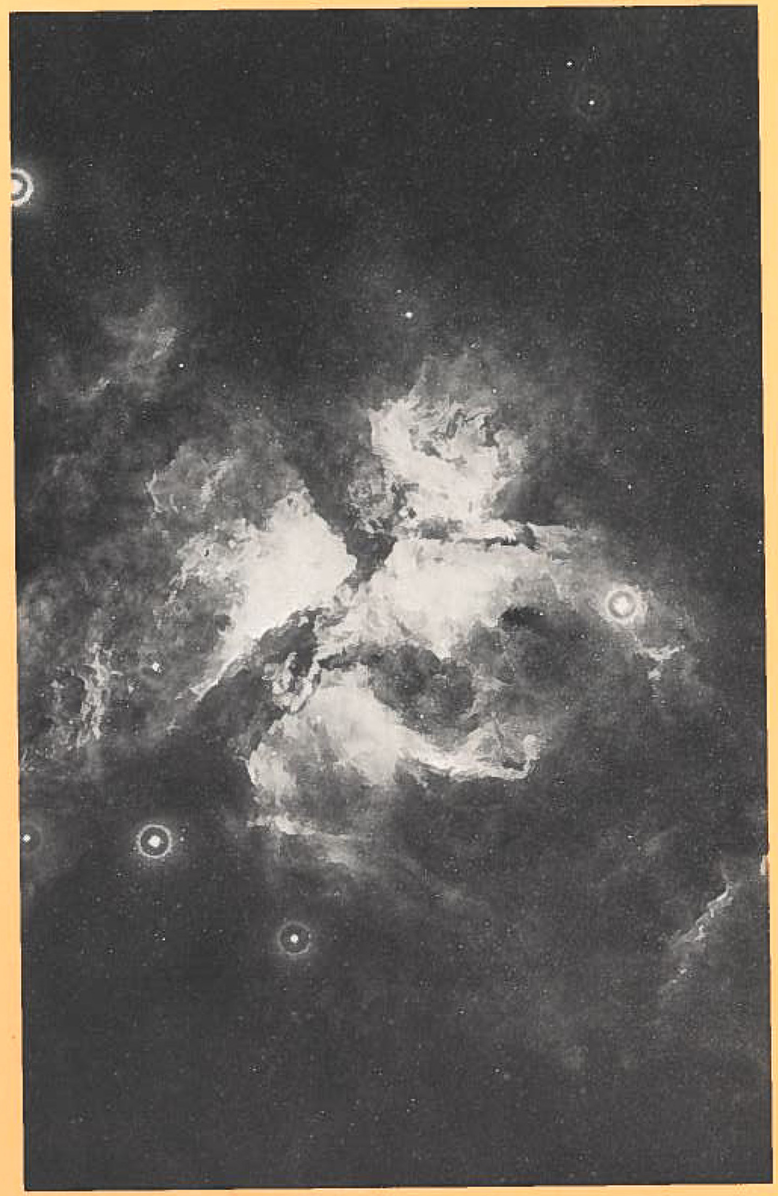
Visualizing the complexities of Earth satellite orbits is made easier by this model. It is shown here with its designer, Dr. Leon Blitzer of the University of Arizona Physics Department.





The finest and latest planetary photographs from the world's astronomical facilities are displayed in the Planetary Sciences Hall.

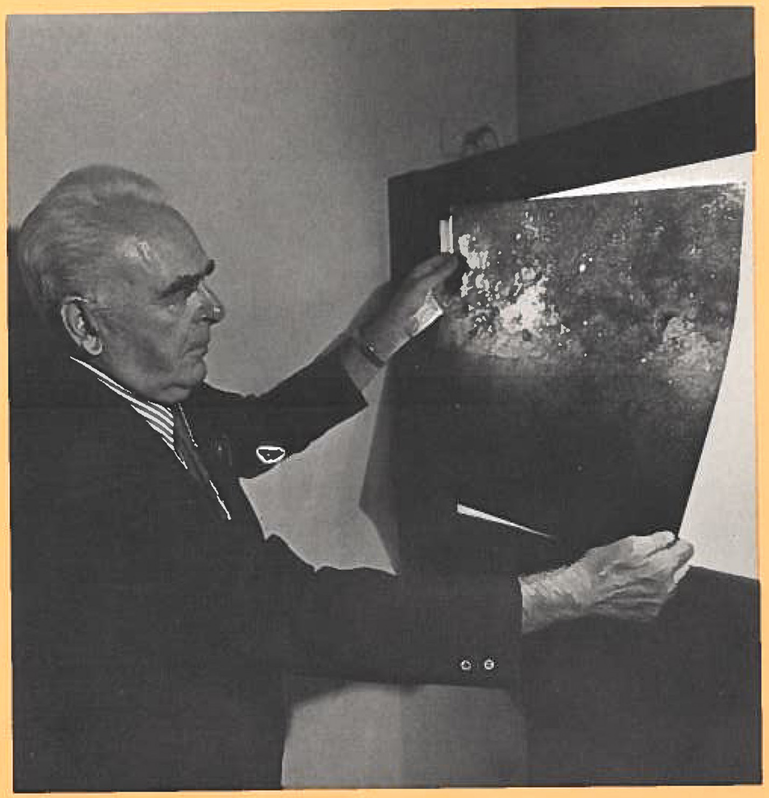
The Eta Carina Nebula. *(Cerro Tololo photo)*



Photographic mapping of the Milky Way has long been a major challenge to astronomers. One of those who has undertaken the task is Dr. Bart J. Bok, world renowned astronomer at the University of Arizona. The Planetarium exhibit compares the Southern Milky Way as photographed in the red light of glowing hydrogen gas by Dr. Bok and his associates with the Milky Way photographed in visible light by Dr. Hans Vehrenberg of West Germany. When Professor Vehrenberg completes his photography of the Northern Milky Way, this portion of the sky will be added to the exhibit.

As viewers promenade down the Milky Way, they can examine enlarged color views of some of the more remarkable objects in the Milky Way.

Dr. Bok examines film for the 24' Milky Way display.



KUIPER MEMORIAL

When the American space exploration program was just getting off to a hesitant and uncertain start, one of the most vigorous proponents of the effort to study the moon with unmanned spacecraft was Dr. Gerard P. Kuiper (1905-1973). As a noted researcher in planetary science, Dr. Kuiper joined the University of Arizona faculty in 1960 and established the Lunar and Planetary Laboratory on the campus. This laboratory has been one of the most active participants in the NASA space program, providing basic planning for many space missions and, in turn, processing and analyzing much of the data returned by the Rangers, Surveyors, Lunar Orbiters, Mariners and Pioneer spacecraft.

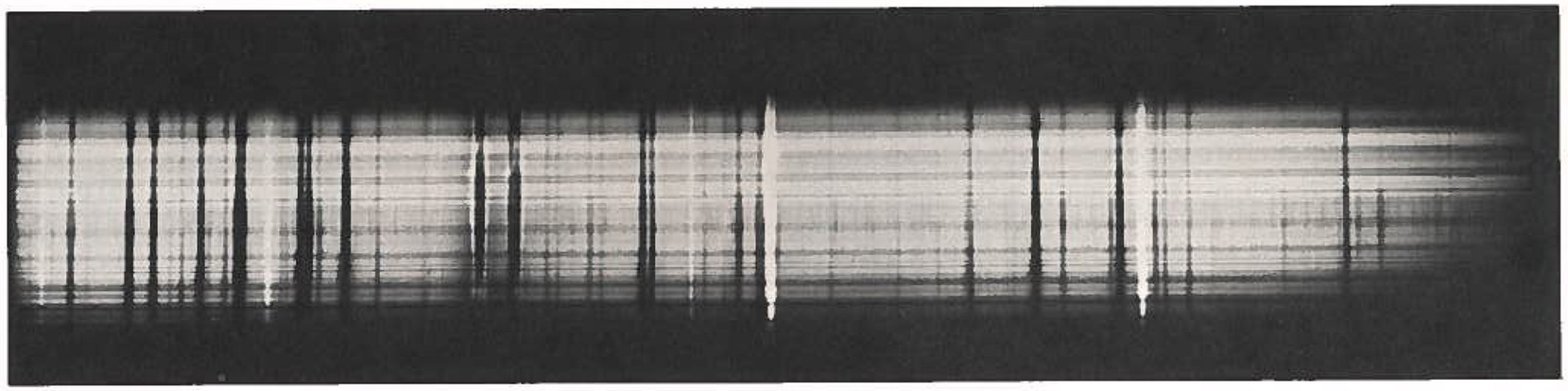
The memorial to Dr. Kuiper contains many documents attesting to his brilliant career in astronomy and to his research accomplishments. The work of the Lunar and Planetary Laboratory continues in the large building adjacent to the Planetarium with a staff of over 100 persons.

Dr. Kuiper confers with colleagues during the erection of the 61" Catalina Mountain telescope in 1965.

A bronze bust of Dr. Kuiper, along with a NASA Ranger spacecraft model, highlight the Kuiper Memorial exhibit in the Planetary Sciences Hall.

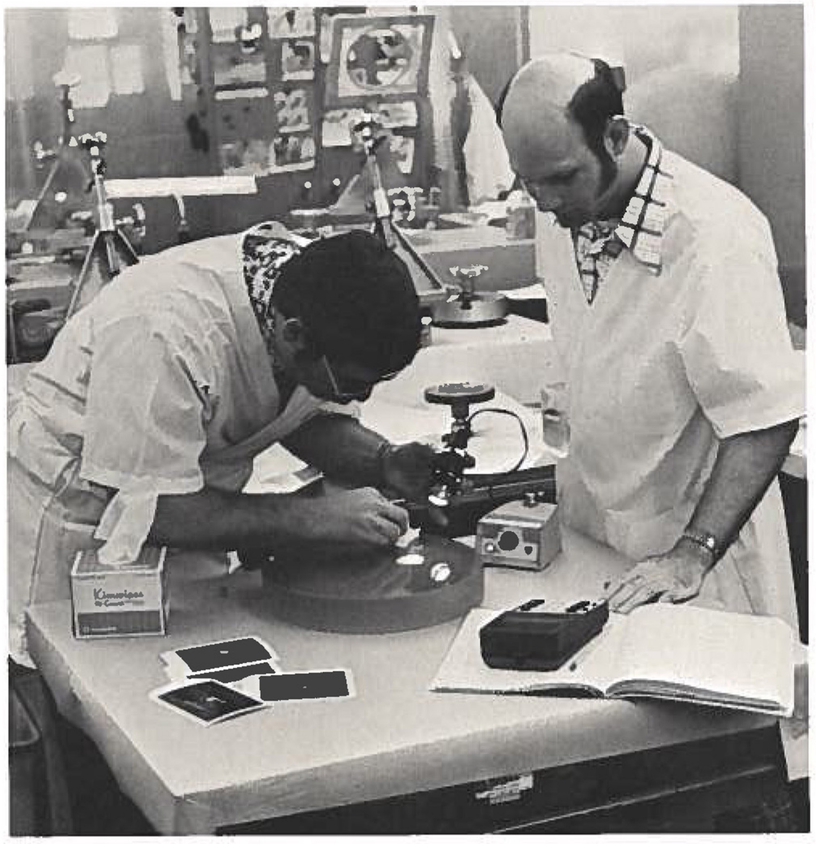
THE SUN TELESCOPE

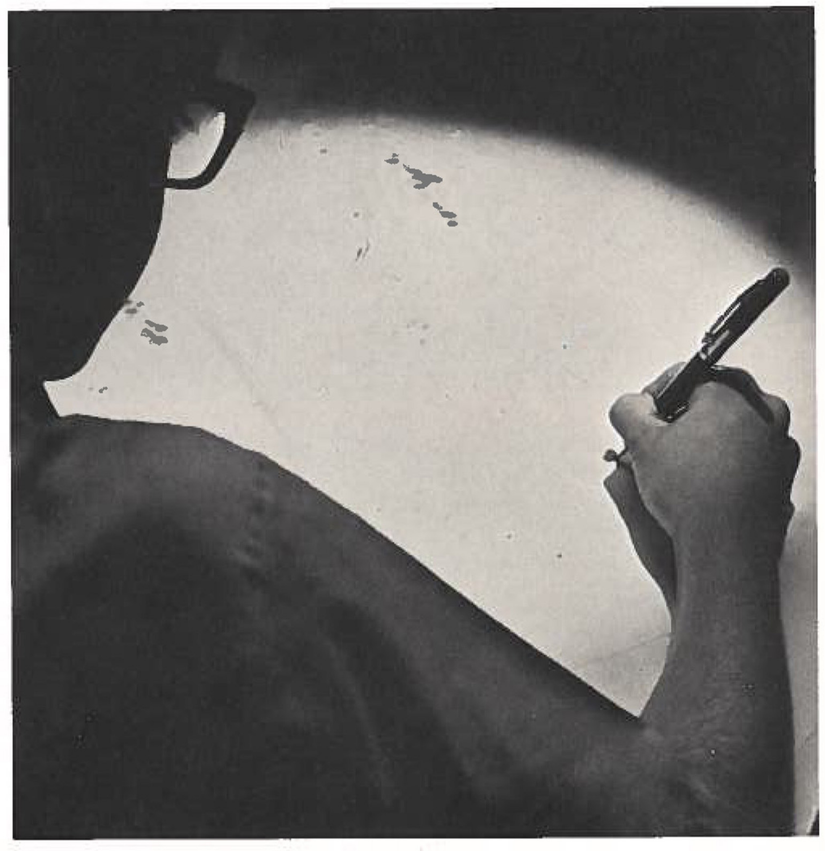
Kitt Peak National Observatory photo.



A heliostat mirror mounted on the roof of the Planetarium tracks the Sun in its daily motion across the sky to produce a brilliant shaft of light in the Galaxy Room. This light is passed through a narrow slit and reflected from a diffraction grating to form a magnificent solar spectrum. From studies of the fine dark Fraunhofer lines in the Sun's spectrum, solar physicists can determine the chemical composition of the Sun.

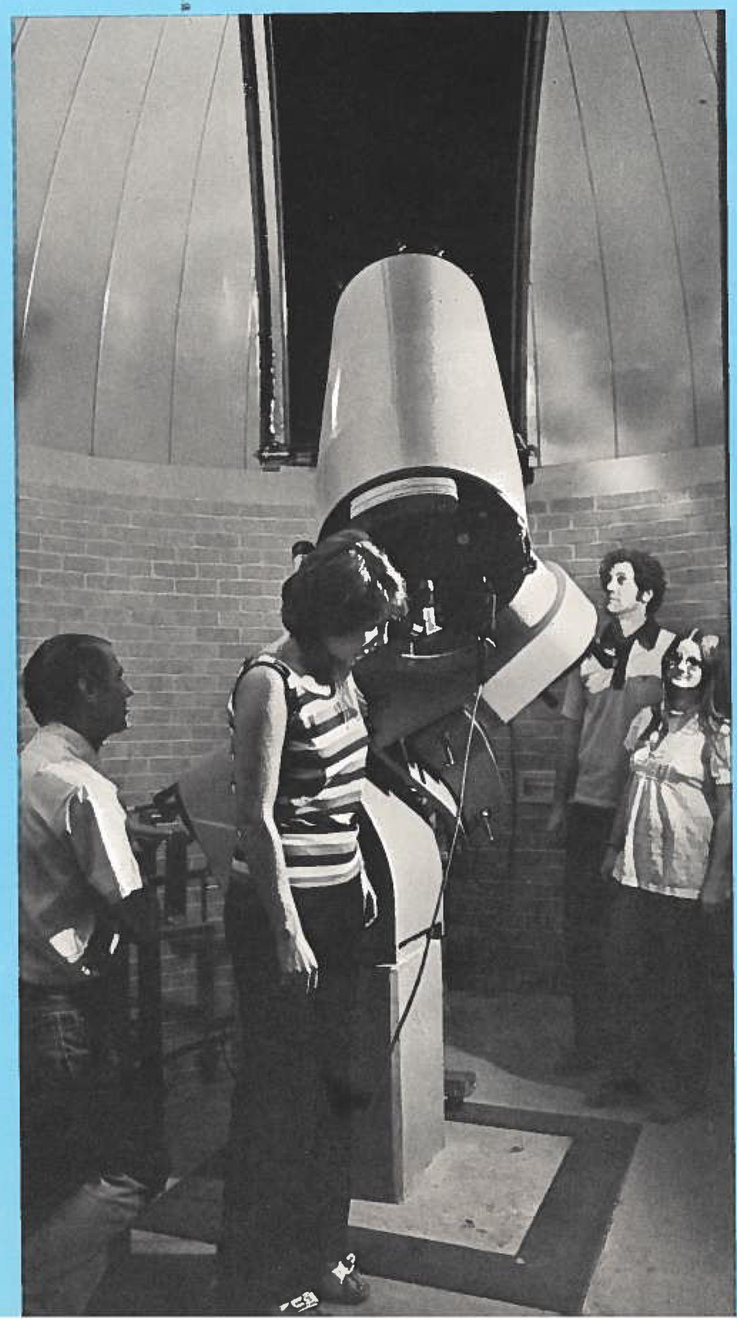
Another portion of the heliostat beam is used to form an image of the Sun. Visitors can observe sunspots which may be present. School children can trace this image on paper and follow the path of these solar storms across the face of the Sun as it rotates.



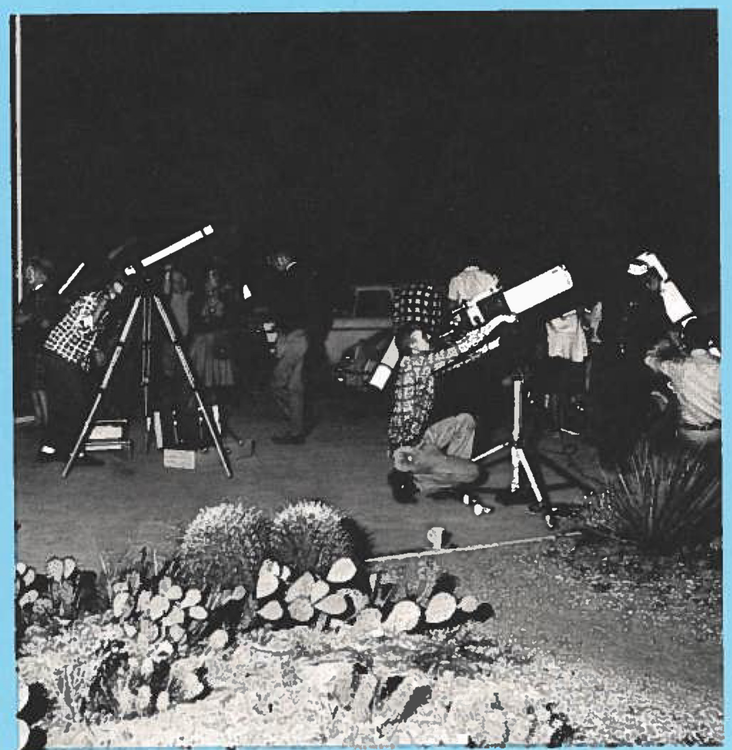


TELESCOPES

For over half a century the University's Steward Observatory has made its campus-based telescopes available for public viewing two nights per month. Now a 16" instrument of Cassegrain design is also available in the Planetarium's Observatory for nightly viewing of the sky. This instrument was the gift of Mr. and Mrs. Theodore Wickman of Tucson.



The Planetarium also provides quarters for the Tucson Astronomical and Astronautical Association, an organization of amateur astronomers and telescope makers. The Association was founded in 1952. It periodically provides classes in telescope making, as well as "star parties" to which the public is invited to see and use the instruments made by members.



SCIENCE AND ART

In a sense, all science is art, an expression of the creative intellect of Man. The graphic portrayal of nature is as old as Man, as diverse as the media and the imagination of the artist. The Planetarium uses the fine arts as an additional mode of communicating science to the public. This use of the arts in science invites a more personal involvement by emphasizing the human element.

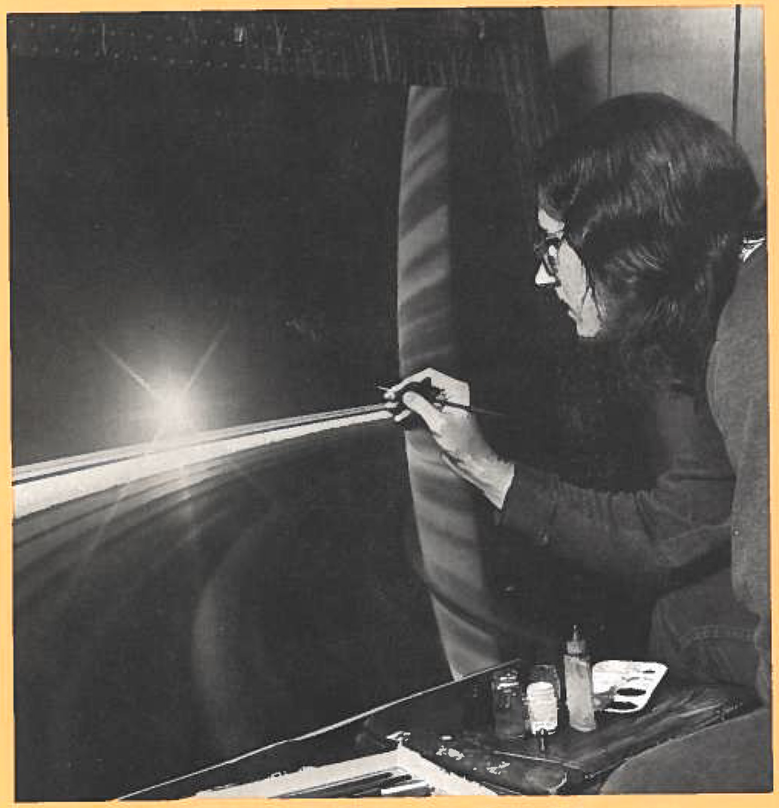
The works of several contemporary artists complement the scientific exhibits of the Planetarium, together with reproductions of early woodcuts and etchings of astronomical interest.

Of special significance is the 9 foot by 17 foot mural in the main lobby which portrays, in the style of the classical muralists, the history of astronomical thought from pre-history to the present. Painted by Tucson artist and scientific illustrator Don R. Cowen, this mural required over a year for completion. Design of the mural was developed jointly by Mr. Cowen and O. Richard Norton, the Planetarium Director. This magnificent work deserves detailed and leisurely study by visitors interested in the events, symbolism and personalities of science through the ages (see back cover). A special booklet interpreting the mural is available to the public.

Other permanent art works are those of Chesley Bonestell, sometimes referred to as the Dean of American astronomical artists; Adolph Schaller; Evelyn Sisemore; William Hartmann; and others. Dr. Hartmann is an astronomer with the Planetary Sciences Institute.

Muralist Don Cowen and Professor Inez Thrift discuss the preliminary charcoal sketches of the Planetarium mural.

Paintings of four well-known nebulas by Evelyn Sisemore flank "The Milky Way Galaxy" in the Galaxy Room.



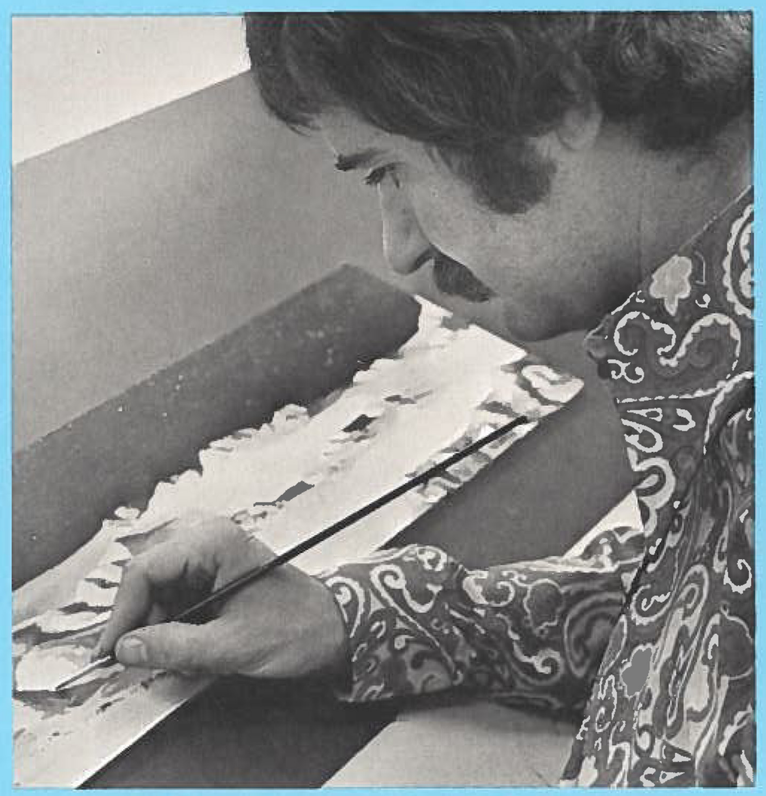
Adolph Schaller completes a scene from Saturn.

Chesley Bonestell completes work on "The Milky Way Galaxy" in his Carmel, California studio. *Wm. K. Hartman photo.*

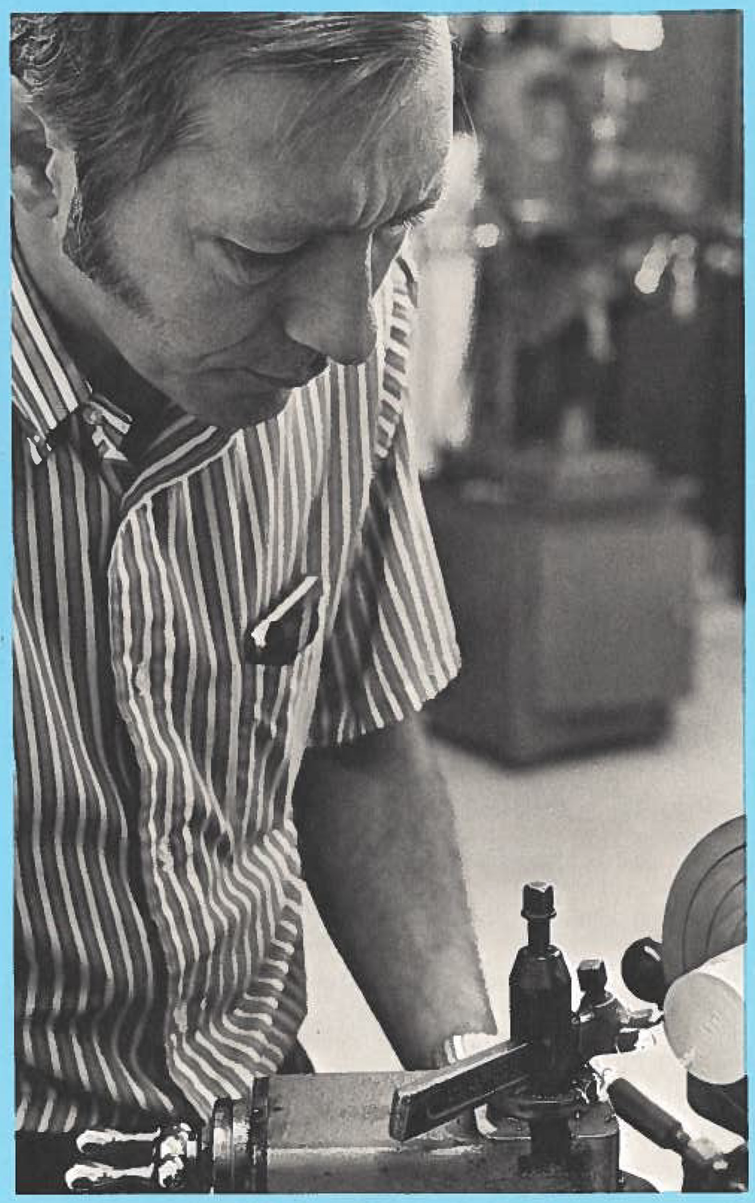
BEHIND THE SCENES

The program of the Planetarium provides not only for exhibits and public performances in the Theater, but also for instruction of primary and secondary school classes, college level classes in the sciences, and for periodic presentations in the performing arts.

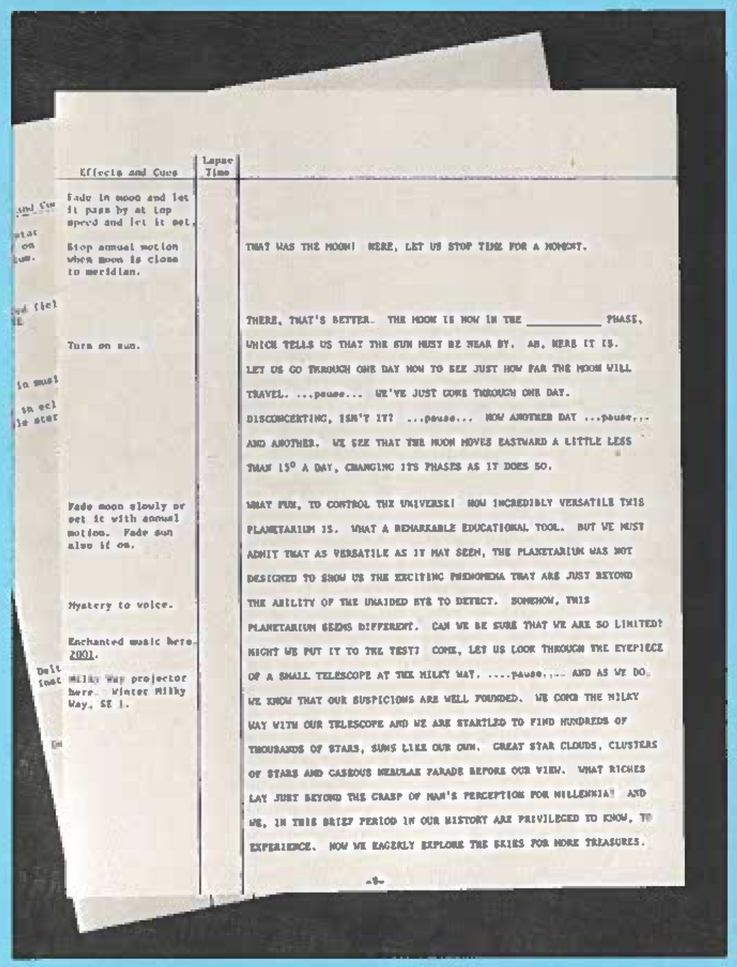
To support such an extensive commitment to the community, the Planetarium contains an exhibit shop, machine shop, electronics shop, photographic and filming laboratories, and an art studio. The resources of all these are frequently drawn upon during the development of each new Theater presentation. Programs may require 2 to 4 months of staff preparation for the research, preparation of script, field work, filming, construction of special effects projectors, recording, computer programming, and testing of a single hour-long performance.



A new Planetarium production calls for intricate new art work . . .



. . . new projection devices . . .



Effects and Cues	Lapse Time	
Fade in moon and let it pass by at top speed and let it set.		
Stop annual motion when moon is close to meridian.		THAT WAS THE MOON! HERE, LET US STOP TIME FOR A MOMENT.
Turn on sun.		THERE, THAT'S BETTER. THE MOON IS NOW IN THE _____ PHASE, WHICH TELLS US THAT THE SUN MUST BE NEAR BY. AH, HERE IT IS. LET US GO THROUGH ONE DAY NOW TO SEE JUST HOW FAR THE MOON WILL TRAVEL. ...pause... WE'VE JUST GONE THROUGH ONE DAY. DISCONCERTING, ISN'T IT? ...pause... NOW ANOTHER DAY ...pause... AND ANOTHER. WE SEE THAT THE MOON MOVES EASTWARD A LITTLE LESS THAN 13° A DAY, CHANGING ITS PHASES AS IT DOES SO.
Fade moon slowly or set it with annual motion. Fade sun also if on.		WHAT FUN, TO CONTROL THE UNIVERSE! HOW INCREDIBLY VERSATILE THIS PLANETARIUM IS. WHAT A REMARKABLE EDUCATIONAL TOOL. BUT WE MUST ADMIT THAT AS VERSATILE AS IT MAY SEEM, THE PLANETARIUM WAS NOT DESIGNED TO SHOW US THE EXCITING PHENOMENA THAT ARE JUST BEYOND THE ABILITY OF THE UNAIDED EYE TO DETECT. SOMEHOW, THIS PLANETARIUM SEEMS DIFFERENT. CAN WE BE SURE THAT WE ARE SO LIMITED? MIGHT WE PUT IT TO THE TEST? COME, LET US LOOK THROUGH THE EYEPIECE OF A SMALL TELESCOPE AT THE MILKY WAY. ....pause.... AND AS WE DO, WE KNOW THAT OUR SUSPICIONS ARE WELL FOUNDED. WE COMB THE MILKY WAY WITH OUR TELESCOPE AND WE ARE STARTLED TO FIND HUNDREDS OF THOUSANDS OF STARS, SUNS LIKE OUR OWN. GREAT STAR CLOUDS, CLUSTERS OF STARS AND GASEOUS NEBULAE PARADE BEFORE OUR VIEW. WHAT RICHES LAY JUST BEYOND THE GRASP OF MAN'S PERCEPTION FOR MILLENNIA! AND WE, IN THIS BRIEF PERIOD IN OUR HISTORY ARE PRIVILEGED TO KNOW, TO EXPERIENCE. NOW WE EAGERLY EXPLORE THE SKIES FOR MORE TREASURES.
Mystery to voice.		
Enchanted music here - 2001.		
Milky Way projector here. Winter Milky Way, SE 1.		

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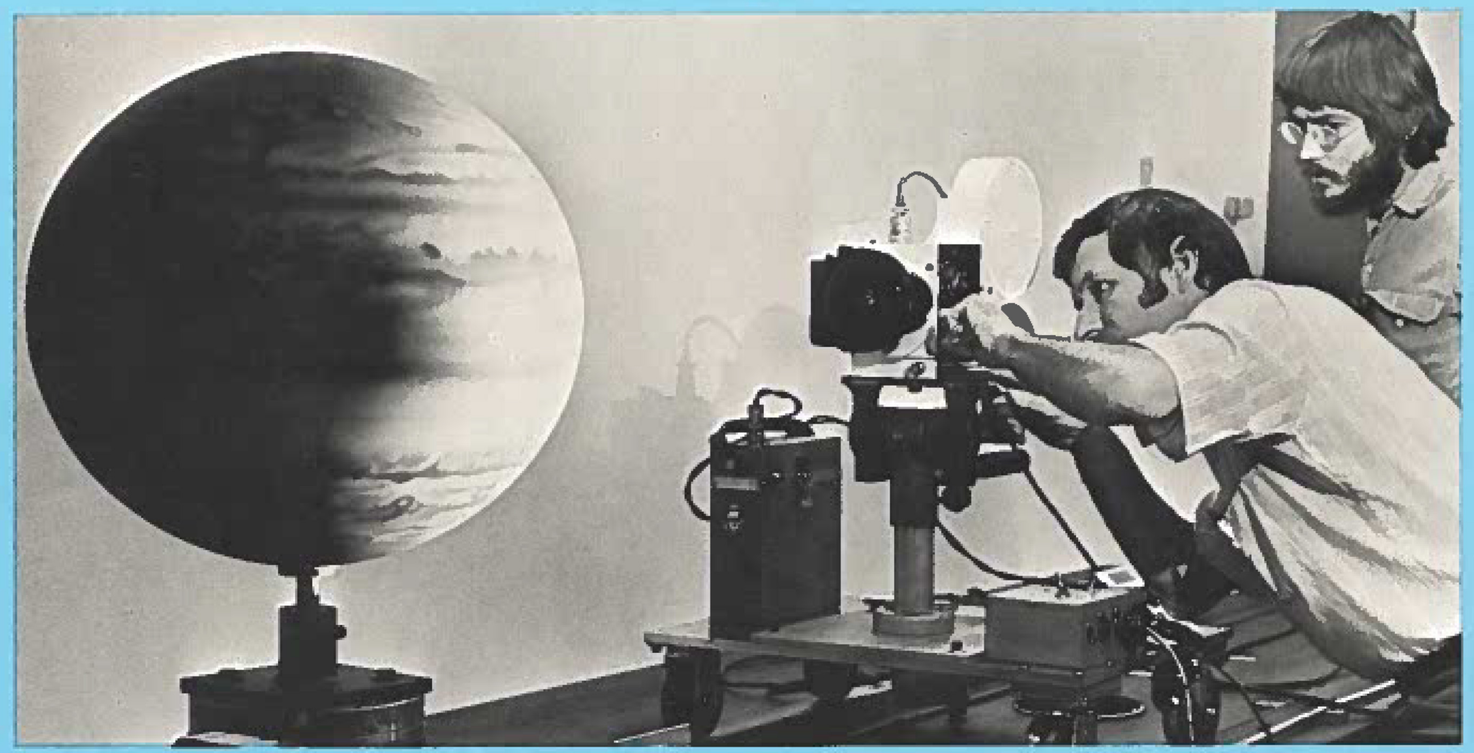
. . . new script . . .

. . . new film footage . . .

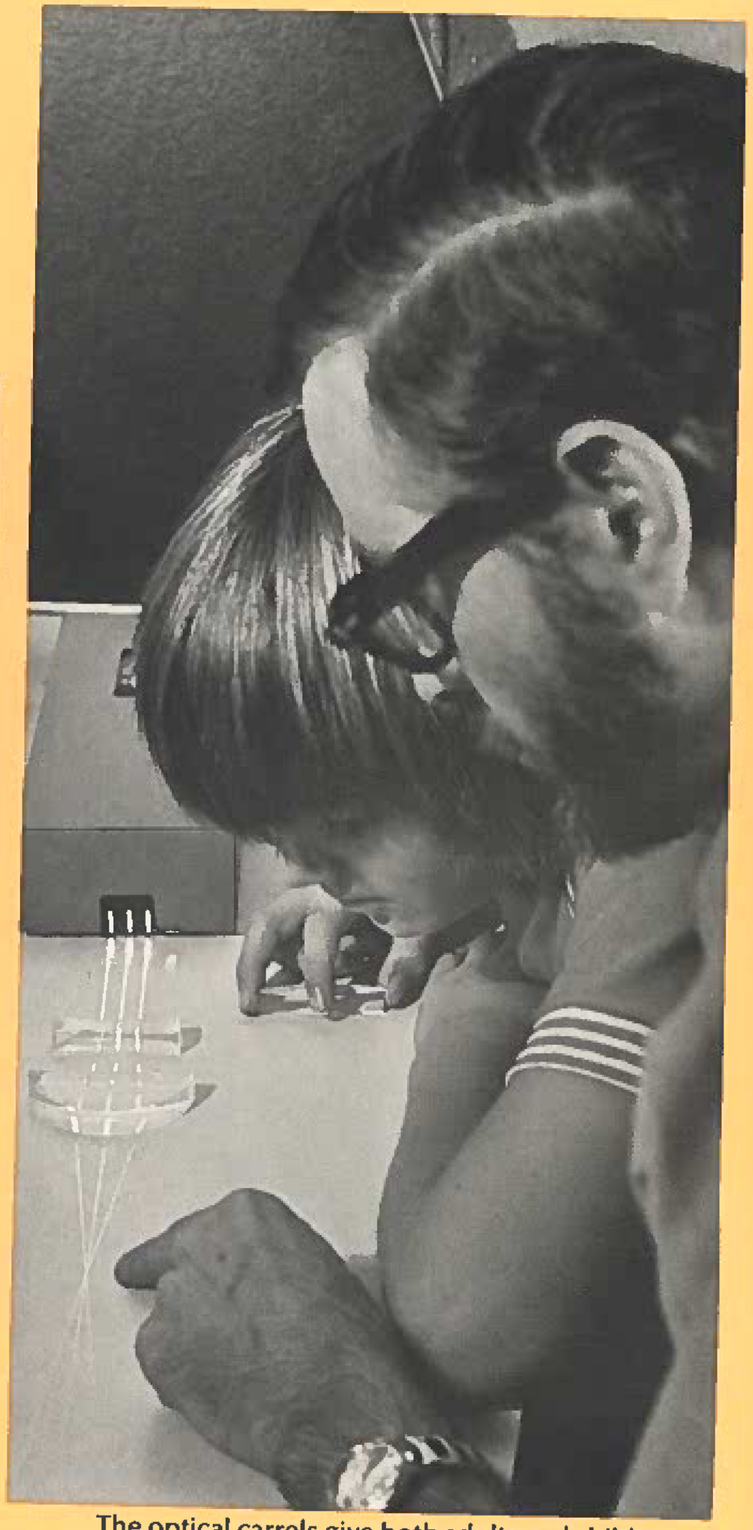


. . . and a great deal of planning.

INSTRUCTIONAL PROGRAMS

The Optical Sciences Hall is designed to permit primary and secondary school students, as well as the visiting public, to explore the nature of light and some of its remarkable properties. The exhibits also explain the characteristics of parts of the electromagnetic spectrum beyond visible light: infra-red and radio waves beyond the red end of the visible spectrum, ultra-violet and X-rays beyond the violet end. In many of the exhibits, students may operate the equipment to gather data about light to take back to their classrooms for study and discussion.

Developed in collaboration with the Optical Sciences Center of the University of Arizona, these exhibits employ some of the most advanced optical technology available to explain the nature of these radiations and of the instruments used to study them. The Planetarium gratefully acknowledges the assistance of the staff and students of the Optical Sciences Center, and especially of Dr. Stephen Jacobs, for helping to make these exhibits possible.

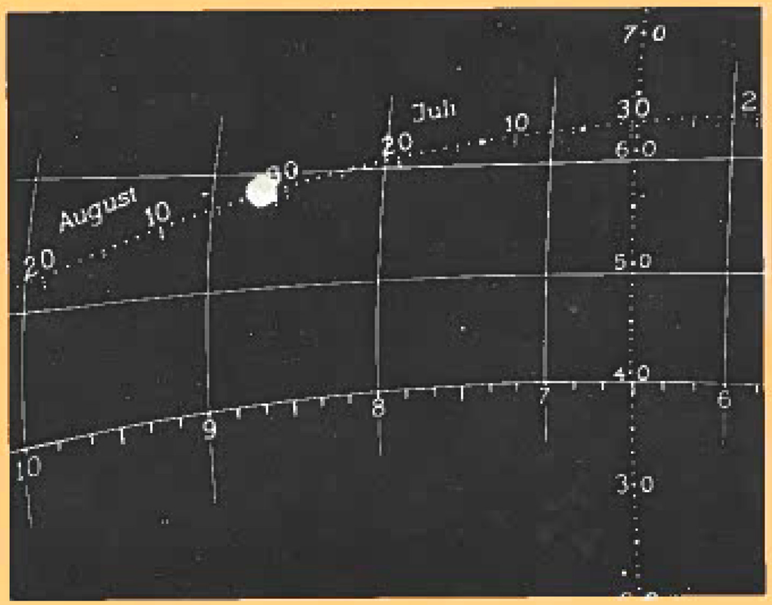


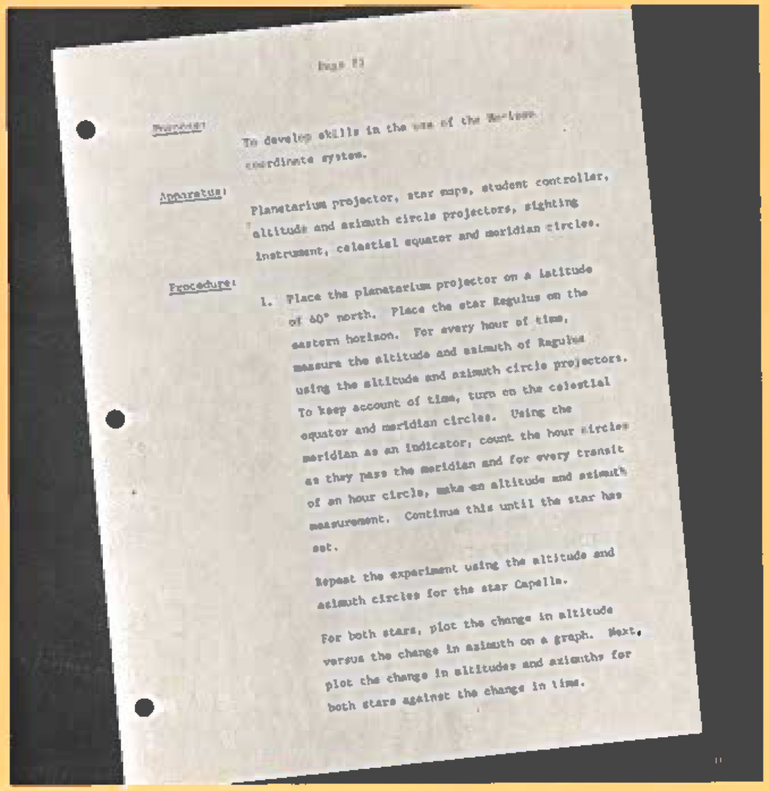
The optical carrels give both adults and children an opportunity to experiment with lenses and mirrors.

one of 60 students in astronomy classes to operate the complex planetarium projector.

It has always been difficult for students to visualize the complex motions of the sun, the moon and planets or the Galaxy itself when confined to the flat representations of book pages or blackboards. Nor is it easy to provide the student with classroom explanations of celestial motions in the real sky in the time period of a single night's observations. The Planetarium Theater, with its ability to speed up time, helps to clarify these complex subjects and further enhances the student's interest and appreciation of astronomy and space sciences.

Classes in astronomy have been taught at the University since 1892. Introductory courses in astronomy now make liberal use of the Planetarium as a teaching tool.





Purpose:

To develop skills in the use of the Ecliptic coordinate system.

Apparatus:

Planetarium projector, star maps, student controller, altitude and azimuth circle projectors, sighting instrument, celestial equator and meridian circles.

Procedure:

1. Place the planetarium projector on a latitude of 40° north. Place the star Regulus on the eastern horizon. For every hour of time, measure the altitude and azimuth of Regulus using the altitude and azimuth circle projectors. To keep account of time, turn on the celestial equator and meridian circles. Using the meridian as an indicator, count the hour circles as they pass the meridian and for every transit of an hour circle, make an altitude and azimuth measurement. Continue this until the star has set.

Repeat the experiment using the altitude and azimuth circles for the star Capella.

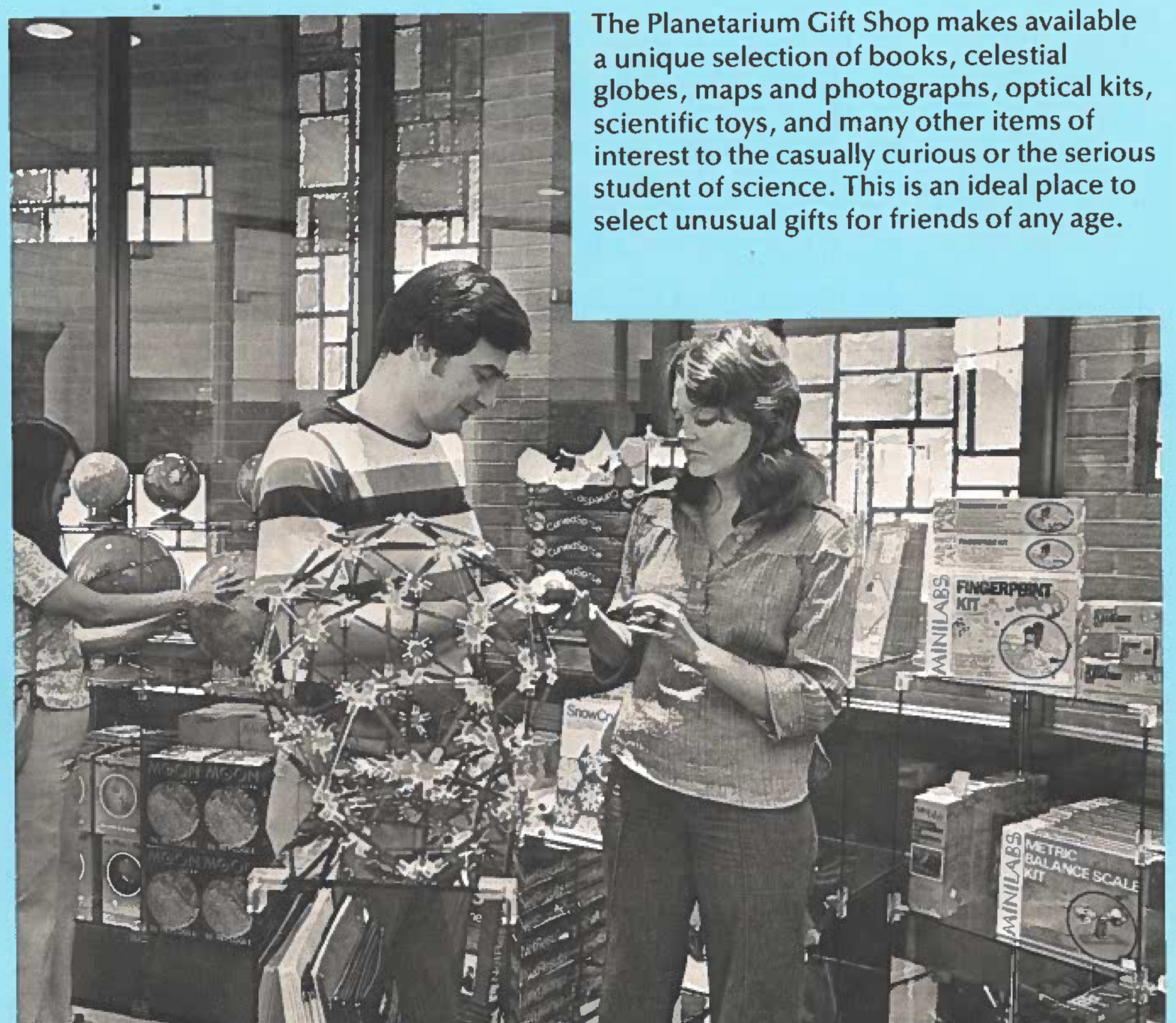
For both stars, plot the change in altitude versus the change in azimuth on a graph. Next, plot the change in altitudes and azimuths for both stars against the change in time.

THE PERFORMING ARTS

The design of the Planetarium Theater invites its use by musicians, poets or dramatists whose performances require, or are enhanced by, the remarkable sound system and special visual effects which are possible. Poetry under the stars, dramas of space exploration, music set in a virgin forest or against the gardens of Rome . . . the Planetarium staff encourages the development of new art forms which take unique advantage of the Planetarium's facilities and setting.

SPECIAL SERVICES

A mezzanine floor of the Planetarium overlooks the Galaxy Room and provides luncheon facilities for community organizations whose members wish to combine a noon meeting with a brief tour and performance in the Planetarium Theater.



The Planetarium Gift Shop makes available a unique selection of books, celestial globes, maps and photographs, optical kits, scientific toys, and many other items of interest to the casually curious or the serious student of science. This is an ideal place to select unusual gifts for friends of any age.

The present Flandrau Planetarium has been made possible by the generosity of many individuals and organizations; additional programs and projects await future funding.

Those who have made The Planetarium Experience in Tucson a reality include:

Grace H. Flandrau
Max C. Fleischmann Foundation
Tucson Public Schools
Mr. and Mrs. Theodore Wickman
Inez Thrift

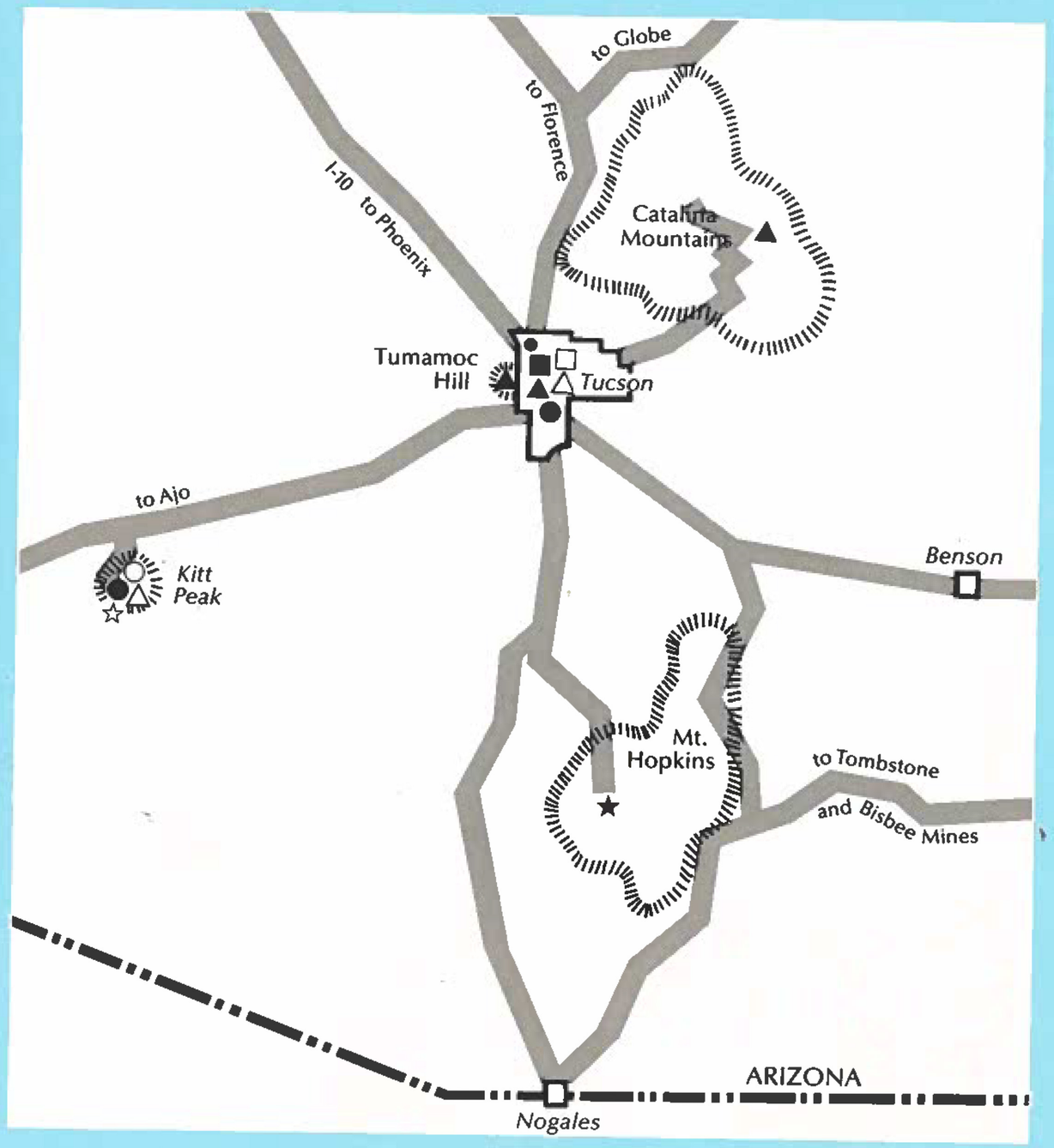
and . . .

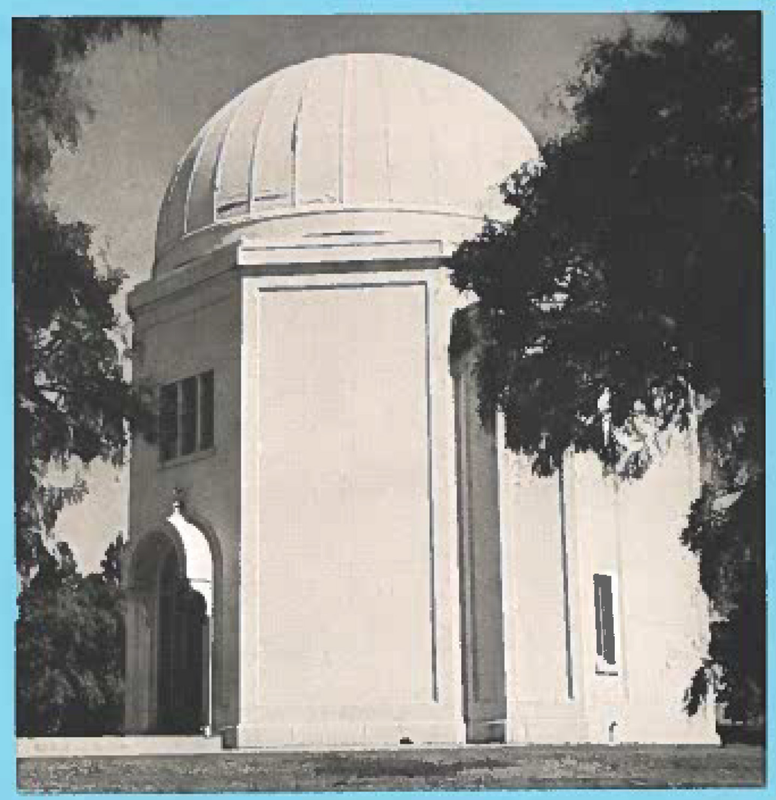
American Optical Company
Baird-Atomic Inc.
Bausch & Lomb Company
B. F. Goodrich Company
Case Western Reserve University
C G R, Inc.
City of Tucson
Coherent Radiation
Cooper Aerial Survey
Corning Glass Works
CW Radiation, Inc.
Eastman Kodak Company
E. I. DuPont Company
Ft. Belvoir Night Vision Lab
Harshaw Chemical Company
International Business Machines Corp.
Lightolier
McDonnel-Douglas Corporation
Mountain Bell
National Bureau of Standards
Optical Coating Labs, Inc.
Polaroid Corporation
Radio Corporation of America
Roh's Inc.
Schott Optical Glass, Inc.
Scripps Visibility Lab
Spectra-Physics Inc.
Sylvania Electronic Company
Union Carbide Corporation

SOUTHERN ARIZONA, THE ASTRONOMICAL CAPITAL

In Tucson and within a 50-mile radius of Tucson are the facilities of

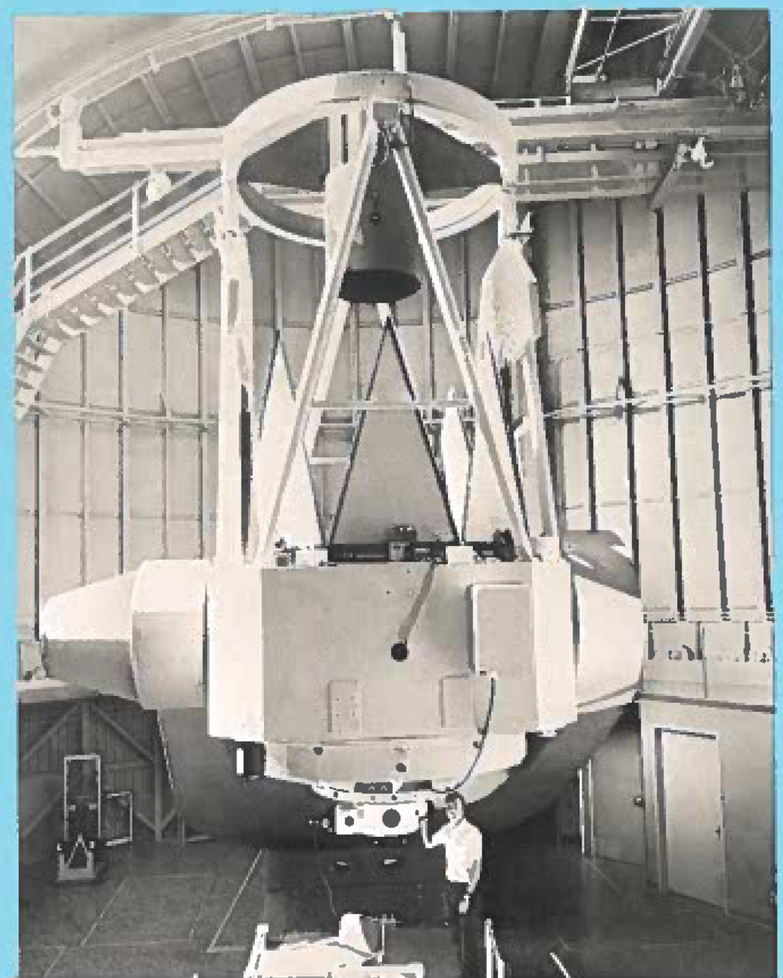
- △ Steward Observatory
- ▲ Lunar and Planetary Laboratory
- □ Department of Planetary Sciences
- ● Kitt Peak National Observatory
- ○ National Radio Astronomy Observatory
- ★ Smithsonian Astrophysical Observatory
- ☆ McGraw-Hill Observatory
- ■ Optical Sciences Center
- • Planetary Science Institute





Steward Observatory, built in 1923 on the campus of the University of Arizona.

61" reflecting telescope of the Catalina Mountain Observatory is operated by the Lunar and Planetary Laboratory.



90" reflecting telescope of Steward Observatory on Kitt Peak.

PLANETARIUM STAFF AT OPENING

O. Richard Norton .....Director
Richard R. Willey.....Assistant Director
J. Lawrence Dunlap.....Education Director
Susan M. Cook.....Secretary
Cynthia L. Allen.....Receptionist/
Gift Shop Manager
Dale E. Hall .....Senior Technician
David L. Hamory .....Curator of Exhibits
Charles J. Burkhart.....Technician
Lawrence C. Vance .....Artist
Richard W. Castle.....Exhibits Assistant
Ralph M. Kelley.....Exhibits Assistant

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Printing.....Shandling Lithographing Co. Inc.

Back Cover:

The 9′ x 17′ historical astronomical mural by Don R. Cowen in the Planetarium Lobby.
(See page 20.)