INTERNATIONAL SOCIETY OF PLANETARIUM EDUCATORS

the PLANETARIAN

The Stars and Myths of Ancient China

P'AN-KU, the legendary son of CHAOS and architect of the Chinese universe creating the world, assisted by the Dragon, Tiger, Bird, and Tortoise.

ispe

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Mr. Walter Tenschert
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Mt. San Antonio College
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EDITOR: Frank Jettner
Circulation Director: Ron Hartman
Feature Editors: Von Del Chamberlain, M. Chartrand, L. DeVries, T. Gates, J. Geoghegan, O.R. Norton, G. Reed, G.L. Verschuur
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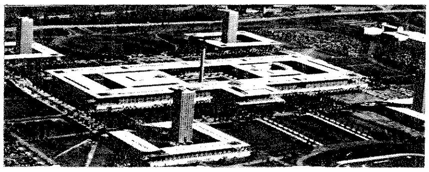

thoughts from fcj

The American Astronomical Society has underway a program to broaden the public understanding of astronomy. One facet of this program was the creation of traveling exhibits for planetariums, museums,and schools. Being project coordinator for this part of the program, I needed input on such things as: topics, physical size, suitable media, costs, and problems that have occurred with previous exhibits. Thus in February of 1974, a "Survey for Planning of Traveling Exhibit Program Among North American Planetariums" was sent out to 620 planetariums in schools, colleges, museums, and other institutions. This editorial is in response to my promise to all those who kindly replied.

The survey was broken down into two parts. The first part, Background Data, dealt with type, size, and attendance figures for the various institutions. The second part, The Traveling Exhibit Program, dealt with the aforementioned subjects (topics, physical size, etc.). The data from the individual questionnaires was punched onto computer cards and our Univac 1108 did the dirty work of sorting and statistical analysis.

To see whether the number of different institutional types were represented accurately in the survey returns, we compared the results of the survey with data taken from CATNAP II*. As can be seen in Table 1 there is fairly good correlation between the percentages taken from CATNAP II and the survey.

The vast majority of institutions offered planetarium shows for the public; from two-thirds of all the schools to over nine-tenths of all of the museums (a not unexpected result). The number of shows offered varied from about 1 per week (for schools) to about 9 per week (for museums). There was a rather wide range in these values -- from 2 per year for schools with small domes to 61 per week for museums with large domes.

We noted,too, that on the average, all the different institutional types had an increase in public attendance for 1972 compared with 1971, but a small decrease in public attendance for 1973 compared with 1972 (see Table 2).

Looking at the last line of Table 2, we see that there is a large potential for a traveling exhibit program. Extrapolating the weighted 1973 average for the 894 planetariums in CATNAP II, we arrive at a total attendance of over 11 million.

*CATNAP II is an acronym for "A Catalog of North American Planetaria", Norman Sperling, ISPE Special Report No. 3 (1973).

TABLE 2:

Average Public Attendance

Year	1971	1972	1973
School	2073	2301	2154
College	5970	6318	5735
Museum	34012	38414	38032
Other	51984	59722	57370
Weighted Average	11683	13074	12606

The amount of display space available for exhibits varied a great deal -- from 0 to 100,000 sq. ft. Most felt, though, that they would be able to come up with space for a traveling exhibit. This ranged from about two-thirds (of the schools) to better than four-fifths (of the museums).

Now down to the nitty-gritty-- Would your institution request the use of an exhibit? This was divided into four categories, as seen in Table 3.

A general trend can be seen in all four institutional types -- as the financial obligations increase, the number that would use the exhibit decreases, and the number that

TABLE 1 : Comparison of Number and Type of Responses of AAS Survey with CATNAP II

	School	College	Museum	Other	Total
CATNAP II	467 (52.2%)	268 (30.0%)	127 (14.2%)	32 (3.6%)	894 (100.0%)
SURVEY	105 (40.1%)	98 (37.4%)	45 (17.2%)	14 (5.3%)	262 (100.0%)

wouldn't use it or didn't know if they would increases. In other words, for the traveling exhibit program to reach as many people as possible, it should cost as little as possible.

When designing the exhibit, consideration should be given to wall and floor space. A little over half of the institutions felt wall space was a principle concern in the planning.

The average amount of time that the different institutions would wish to keep an exhibit varied from three to eleven weeks, with four weeks being the time most often picked.

The results of the question, Have You Ever Used a Traveling Exhibit Before? was interesting. Only a quarter of the schools and colleges made use of a traveling exhibit, whereas 4 out of 5 of the museums and other institutions made use of one. Most of the exhibits (about two-thirds) came from NASA, the rest coming from various organizations and companies. There were relatively few constructive criticisms of these exhibits that could be applied to the proposed AAS program.

The last question dealt with topic selection that would be useful. Topics most requested were: the moon, planets, comets, cosmology, galaxies, and radio astronomy. There were also requests for extraterrestrial life, tools of the astronomer, space probes, history of astronomy, Skylab experiments, and stellar characteristics.

To incorporate as many of the dozens of suggested topics as possible -- as well as being as versatile as possible -- we proposed to form three of four "families", each composed of some number of modular exhibits which together describe one aspect of astronomy. An institution could then use as many modules of a family as it requires.

In conclusion, during the December 1974 meeting of the Council of the American Astronomical Society it was decided not to pursue the Travelling Exhibit Program for an indefinite period, the cost factor and the resulting competition for available funds for other Society projects being the primary reasons. Naturally we were disappointed, and as this issue is put to bed we are looking for other potential sponsors. Perhaps this is something ISPE could try to tackle itself.

Frank C. Jettner and
Martin B. Richardson

TABLE 3: Would Your Institution Request the Use of a Traveling Exhibit

A) If All Expenses Were Paid?

	school	college	museum	other
Yes	77 (78.6%)	79 (86.8%)	40 (95.2%)	12 (85.7%)
No	5 (5.1%)	2 (2.2%)	1 (2.4%)	1 (7.1%)
Do Not Know	16 (16.3%)	10 (11.0%)	1 (2.4%)	1 (7.1%)

B) If Cartage and Insurance Were the Only Expenses?

	school	college	museum	other
Yes	43 (45.3%)	57 (64.0%)	37 (88.1%)	9 (69.2%)
No	9 (9.5%)	6 (6.7%)	2 (4.8%)	2 (15.4%)
Do Not Know	43 (45.3%)	26 (29.2%)	3 (7.1%)	2 (15.4%)

C) If A Nominal Rental Fee, Cartage, and Insurance Were Charged?

	school	college	museum	other
Yes	14 (15.6%)	28 (31.5%)	18 (47.4%)	4 (30.8%)
No	17 (18.9%)	19 (21.4%)	5 (13.2%)	3 (23.1%)
Do Not Know	59 (65.6%)	42 (47.2%)	15 (39.5%)	6 (46.2%)

D) If A Rental Fee at the Self-supporting Level Were Charged?

	school	college	museum	other
Yes	4 (4.6%)	8 (9.6%)	6 (16.2%)	2 (16.7%)
No	27 (31.0%)	31 (37.4%)	10 (27.0%)	3 (25.0%)
Do Not Know	56 (64.4%)	44 (53.0%)	21 (56.8%)	7 (58.3%)

Checklist of Planetary Configurations, 1975

WITH REMARKS ON VISIBILITY AND SUGGESTIONS FOR PHOTOGRAPHY

by Robert C. Victor, *Abrams Planetarium, Michigan State University*

The following table of events can be used to check the performance of annual motion systems of planetariums and, by using solar conjunction dates, for setting these systems.[1] For each event, the table lists the civil date in Eastern Standard Time, the elongation expressed as angular distance east or west of the sun, the magnitudes of the objects when visible, and remarks on visibility for an observer at latitude 40°N.

Planets move relatively slowly against background stars, so mutual conjunctions of planets or of planets with stars will be of interest for several days before and after the actual event. The remarks on visibility should help the teacher select the best events for student observation. Much of the content of those remarks was derived from the 1975 Graphic Time Table of the Heavens[2], a valuable aid for the planet watcher.

The checklist includes: conjunctions, oppositions and quadratures for superior planets; inferior and superior conjunctions and greatest elongations for inferior planets; greatest brilliancies of Venus; the two lunar eclipses visible in North America; and mutual conjunctions of planets and of planets with stars in celestial longitude (not right ascension). Conjunctions in longitude generally coincide with the appearance of closest approach since planets usually move nearly parallel to the ecliptic.

Of special interest will be the close approach of Mercury to Venus during January; for six consecutive evenings (January 15-20) they appear less than 1° apart. This event does not appear on the list of configurations in the American Ephemeris and Nautical Almanac, because there is no conjunction in right ascension; Mercury gets within 1^m in R.A. of Venus but then slows down and backs off.

From February through early July Venus sets after the end of astronomical twilight (sun 18° below horizon) and is visible against a dark sky. It will be possible to obtain an interesting series of photographs of Venus against background stars as it passes, in succession, Jupiter, the Pleiades, Aldebaran, Saturn, Pollux, and Regulus.

From mid-September 1975 until mid-February 1976 Venus can be photographed against a dark background in the predawn sky. Watch it pass Regulus, Spica and Antares.

For constellation photography, or a series demonstrating the change of position of a planet, try 15- to 30- second exposures using High Speed Ektachrome and a fast lens (50mm f/1.2 to 2.8) wide open when the sky is dark. Photograph Venus at intervals of about a week, Mars twice monthly, and Jupiter and Saturn once monthly.

Mercury against a twilit sky is a tricky subject to photograph, bracket your exposures to be safe. The visibility of Mercury at its various elongation is well illustrated by the Graphic Time Table. By marking Mercury's rising and setting curves with the planet's magnitudes from page 4 of the Ephemeris, you will be better able to estimate the first and last dates of visibility of Mercury at each apparition.

It might be very instructional to obtain a long series of slides showing Mars beginning with its emergence from morning twilight (December 1974), continuing through opposition (December 1975), and ending with Mars' disappearance into evening twilight (July 1976). Unfortunately, until after mid-May 1975 Mars will be no more than 5° above the horizon as morning twilight begins. It will be difficult to get background stars until then. The current visibility cycle of Mars will be a very interesting subject to photograph from September 1975 through March 1976, when the planet goes through a direct-retrograde-direct sequence in Taurus and Gemini (see diagram). With careful planning, all your photographs taken during that 7-month interval can show the same star background in the same position in the camera's field of view, with the position of Mars as the only difference. I suggest orienting your camera so that the ecliptic runs midway between and parallel to the top and bottom edges of your frame, with 3rd-magnitude

CHECKLIST OF PLANETARY CONFIGURATIONS, 1975

DATE	EVENT		ELONG	MAGNITUDES	REMARKS
1975 Jan 6	Saturn	at opposition	180°	-0.2	In Gemini. Visible all night.
20	Mercury	0°.7 N of Venus	E 18°	-0.6, -3.4	{Within 0°.5 of each other on evenings of Jan. 17 & 18.
22	Mercury	1°.1 N of Venus	E 18°	-0.4, -3.4	{Pair sets 1^h23^m after sun Jan. 17.
23	Mercury	greatest elongation	E 19°	-0.3	Favorable. Sets as twilight ends.
Feb 8	Mercury	3°.6 N of Sun	0°		Inferior conjunction.
17	Venus	0°.2 S of Jupiter	E 24°	-3.4, -1.6	Spectacular! Pair sets 2^h after sun.
Mar 6	Mercury	greatest elongation	W 27°	+0.4	Fair. Rises 1^h08^m before sun. Look 16° lower left of Mars.
21	Jupiter	1°.1 S of Sun	0°		Conjunction.
Apr 2	Saturn	at quadrature	E 90°	+0.3	In Gemini. Sets 7^h after sun.
7	Mercury	0°.9 S of Jupiter	W 12°		Not visible.
13	Venus	2°.8 S of Pleiades	E 37°	-3.5	Venus sets 3^h after sun.
18	Mercury	0°.6 S of Sun	0°		Superior conjunction.
21	Venus	7°.2 N of Aldebaran	E 38°	-3.5, +0.9	Venus sets $3\frac{1}{4}^h$ after sun.
May 4	Mercury	2°.1 S of Pleiades	E 16°	-0.7	Mercury sets shortly before twilight ends.
10	Mercury	7°.9 N of Aldebaran	E 20°	-0.1, +0.9	Mercury sets after twilight ends.
16	Mercury	greatest elongation	E 22°	+0.6	Year's best evening apparition. Sets after twilight ends.
24	Venus	2°.7 N of Saturn	E 44°	-3.7, +0.4	Pair sets more than 3^h after sun.
24-25	Moon	total eclipse	180°		Mid-eclipse 1:38 a.m. EDT May 25.
30	Venus	4°.1 S of Pollux	E 44°	-3.8, +1.1	Pair sets more than 3^h after sun.
Jun 10	Mercury	3°.1 S of Sun	0°		Inferior conjunction.
16	Mars	0°.5 S of Jupiter	W 65°	+0.8, -1.9	In Pisces. Pair rises $3\frac{1}{4}^h$ before sun.
18	Venus	greatest elongation	E 45°	-3.9	In Cancer. Sets nearly 3^h after sun.
Jul 4	Mercury	greatest elongation	W 22°	+0.6	Unfavorable. Rises 1^h17^m before sunrise, in bright twilight.
8	Venus	0°.3 S of Regulus	E 43°	-4.1, +1.3	Pair sets just after twilight ends.
15	Saturn	0°.0 S of Sun	0°		Conjunction.
16	Jupiter	at quadrature	W 90°	-2.0	In Pisces. Rises 5^h before sun.
18	Saturn	6°.7 S of Pollux	W 2°		Not visible.
21	Venus	greatest brilliancy	E 39°	-4.2	Sets shortly before twilight ends.
24	Mercury	5°.7 S of Pollux	W 9°	-1.4, +1.1	Difficult. Mercury rises 48^m before sun.
25	Mercury	1°.1 N of Saturn	W 8°		Not visible. Saturn rises 40^m before sun.
Aug 1	Mercury	1°.7 N of Sun	0°		Superior conjunction.
11	Mercury	1°.1 N of Regulus	E 11°		Not visible.
14	Mars	5°.4 S of Pleiades	W 81°	+0.4	Mars rises $4\frac{1}{4}^h$ after sunset.
17	Mercury	8°.2 N of Venus	E 15°		Not visible; Venus sets before sun.
27	Venus	8°.4 S of Sun	0°		Inferior conjunction.
30	Mars	4°.4 N of Aldebaran	W 87°	+0.2, +0.9	Pair rises within $4\frac{1}{2}^h$ after sunset.
Sep 3	Venus	8°.9 S of Regulus	W 11°	-3.5, +1.3	Difficult. Venus rises 38^m before sun, Regulus 50^m.
5	Mars	at quadrature	W 90°	+0.2	In Taurus. Rises 4^h after sunset.
13	Mercury	greatest elongation	E 27°	+0.4	Unfavorable. Sets 48^m after sun.
22	Mercury	1°.5 S of Spica	E 24°	+0.7, +1.0	Difficult. Mercury sets 38^m after sun.
30	Mercury	1°.6 S of Spica	E 16°		Not visible.
Oct 3	Venus	greatest brilliancy	W 40°	-4.3	Spectacular! Rises $3\frac{1}{2}^h$ before sun.
3	Venus	4°.4 S of Regulus	W 40°	-4.3, +1.3	Pair rises $3\frac{1}{2}^h$ before sun.
9	Mercury	1°.9 S of Sun	0°		Inferior conjunction.
13	Jupiter	at opposition	180°	-2.5	In Pisces. Visible all night.
24	Mercury	greatest elongation	W 18°	-0.3	Year's best morning apparition. Rises before twilight begins.
26	Saturn	at quadrature	W 90°	+0.4	In Cancer. Rises 6^h after sunset.
Nov 2	Mercury	4°.0 N of Spica	W 16°	-0.8, +1.0	Mercury rises shortly after twilight begins.
7	Venus	greatest elongation	W 47°	-4.0	In Virgo. Rises nearly 4^h before sun.
18	Moon	total eclipse	180°		Mid-eclipse 5:23 p.m. EST.
28	Mercury	0°.7 S of Sun	0°		Superior conjunction.
30	Mercury	3°.6 N of Antares	E 1°		Not visible.
Dec 1	Venus	4°.2 N of Spica	W 45°	-3.9, +1.0	Venus rises nearly 4^h before sun.
15	Mars	at opposition	180°	-1.6	In Taurus. Visible all night.
1976 Jan 7	Mercury	greatest elongation	E 19°	-0.3	Favorable. Sets just before twilight ends.
9	Venus	6°.5 N of Antares	W 39°	-3.6, +0.9	Venus rises nearly 3^h before sun.

Zeta Tauri midway from left to right but 2°.2 below the center of view. In this way the retrograde loop of Mars, 18° in length, will be neatly centered with plenty of room to spare; my 50mm lens can photograph a field 35° in width.

Observe Jupiter through its synodic period beginning with heliacal risings (emergence into morning twilight) in early April 1975. Unfortunately, during retrograde, Jupiter will appear against the faint background of Pisces. Take a series of photographs showing Jupiter's direct-retrograde-direct sequence from mid-June 1975 to mid-February 1976; center each photograph on 5th-magnitude Zeta Piscium, with the ecliptic running horizontally as in the Mars series. Jupiter retrogrades only 10°, from August 15 to December 10, 1975.

Saturn's next complete cycle begins with heliacal rising in early August 1975 and ends with heliacal setting in early July 1976. Take a series from late August 1975 through late June 1976. Center each photo 1°.4 south of Mu Cancri (about midway between Delta Geminorum and Delta Cancri) to center Saturn's retrograde arc, 7° in extent.

Finally, in taking a series of photographs illustrating planetary motion, avoid times when the moon at or near full would brighten the sky, and avoid dates when the moon would be in the star field. The moon's image would be greatly overexposed in time exposures long enough to record faint background stars. Also, choose times when the planet is at least two hours from rising or setting. The Graphic Time Table would be very useful in planning your photographic program.

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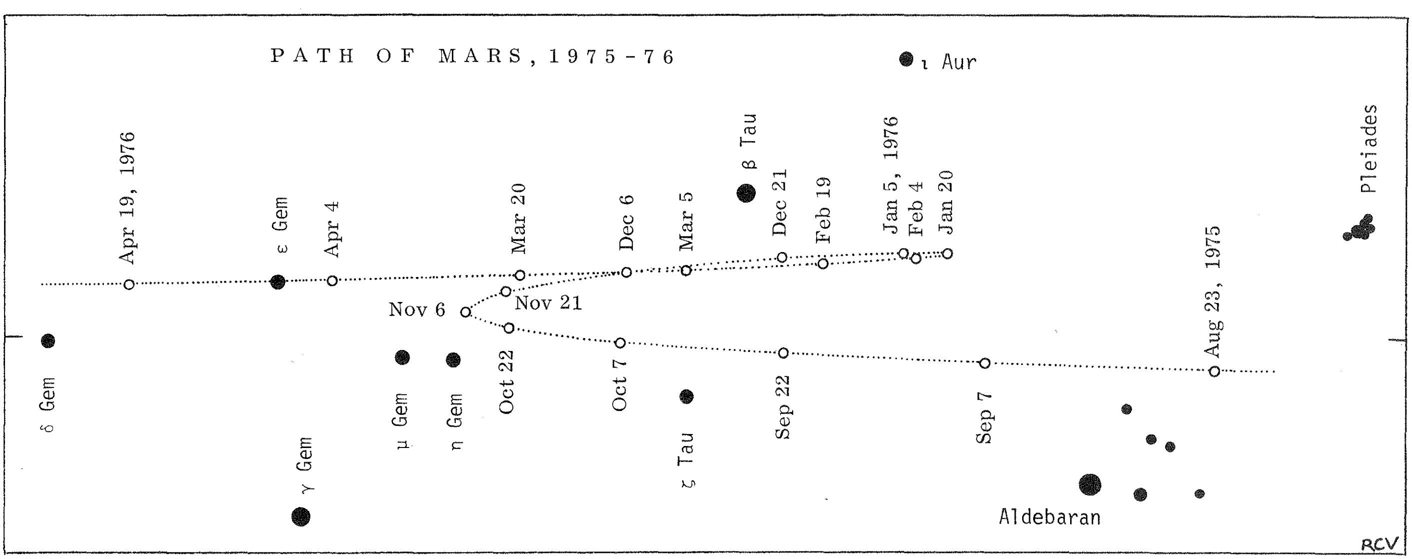
[1] For details of this procedure for setting planets, see THE PLANETARIAN, Volume 1, No. 3 (December 1972), page 84.

[2] Published by the Maryland Academy of Sciences, 119 S. Howard Street, Baltimore, Md. 21201. Also appears annually in the January issue of Sky and Telescope.



Planetarium for the Deaf

by Lionel Daniel, *Vanderbilt Planetarium, Centerport, New York*

A planetarium is primarily visually orientated. It may be fortunate enough to have an elaborate supporting sound system, as is the case at the Vanderbilt Planetarium, but the distinctive characteristics that make it a planetarium are the visual effects. This being the case, a planetarium would seem to be the ideal place to produce shows for the deaf. How would such shows differ from the standard program? What special problems would be encountered and what modifications would be necessary in equipment or procedure? Those of you who have read the September issue (Vol. 1, No. 2) of The Planetarian have been introduced to some of the problems and some of the solutions based on the experience of the Strasenburgh Planetarium. The present article may prove of value by presenting the somewhat parallel experience of another major planetarium.

Experience at the Vanderbilt Planetarium indicates that programs for the deaf may vary little in content and format from the regular programs. Even the musical background is retained. This latter aids the lecturer and technicians as well as those members of the audience who retain some hearing ability. An interesting point in this regard is that even those considered totally deaf can sense the lower frequencies. If the music is to be changed for the deaf program, or if a special program is being disigned for them, this is a point worth considering.

The chief point of divergence between regular shows and programs for the deaf involves use of word slides for the latter. Each slide contains a single word or, at most, a small phrase. This technique enables one to project slides with relatively large lettering that can be quickly interpreted. Word slides enable the audience to understand the visual presentations more fully without giving them a lecture by projection. To have them spend more than a modicum of time reading would detract from the continuity and effectiveness of the presentation.

The word slides help further by preparing the audience for what is about to happen. For example, if a trip to the moon is in the offing, one cannot prepare this audience by narration or by quickening the pace of the music. To simply set the sky in rapid motion without explanation might be unsettling. Instead, a slide is projected with the single word <u>TO</u> on it. After several seconds the slide changes to <u>THE MOON</u>. The audience is now anticipating something, and when the sky begins to move and the moon appears growing larger and larger, they can appreciate the meaning of the effects. This technique of building a sentence by small increments adds to the suspense and gives versatility.

Care is needed in using word slides as labels. The rule here is to start at such a basic level that there is no room for ambiguity. Start with something the audience is likely to be familiar with already. One might start with the <u>BIG DIPPER</u>, moving the green arrow back and forth from the word slide to the star group. After this proceed to the less familiar. Don't start with <u>CASSIOPEIA</u> and have the less knowledgeable members of the audience wondering whether Cassiopeia is a group of stars, a section of the dome, or the name of a green arrow.

When there are two terms to describe the same phenomena, or when one word slide is to be clarified by another, a useful technique is to flash back and forth from one slide to another. For example, alternately flash <u>ECLIPTIC</u> and <u>PATH OF THE PLANETS</u>, or <u>NORTH STAR</u> and <u>POLARIS</u>. In this way vocabulary may be introduced without impeding the presentation.

The program <u>Exploring the Solar System</u> was a specific presentation successfully performed for a deaf audience. The title was our first word slide. A panorama of the sun was brought up, identified by word slide and a brief verbal description was given. Having the lecturer give much of his usual talk during the presentation does not harm the program and assists in preserving continuity and timing.

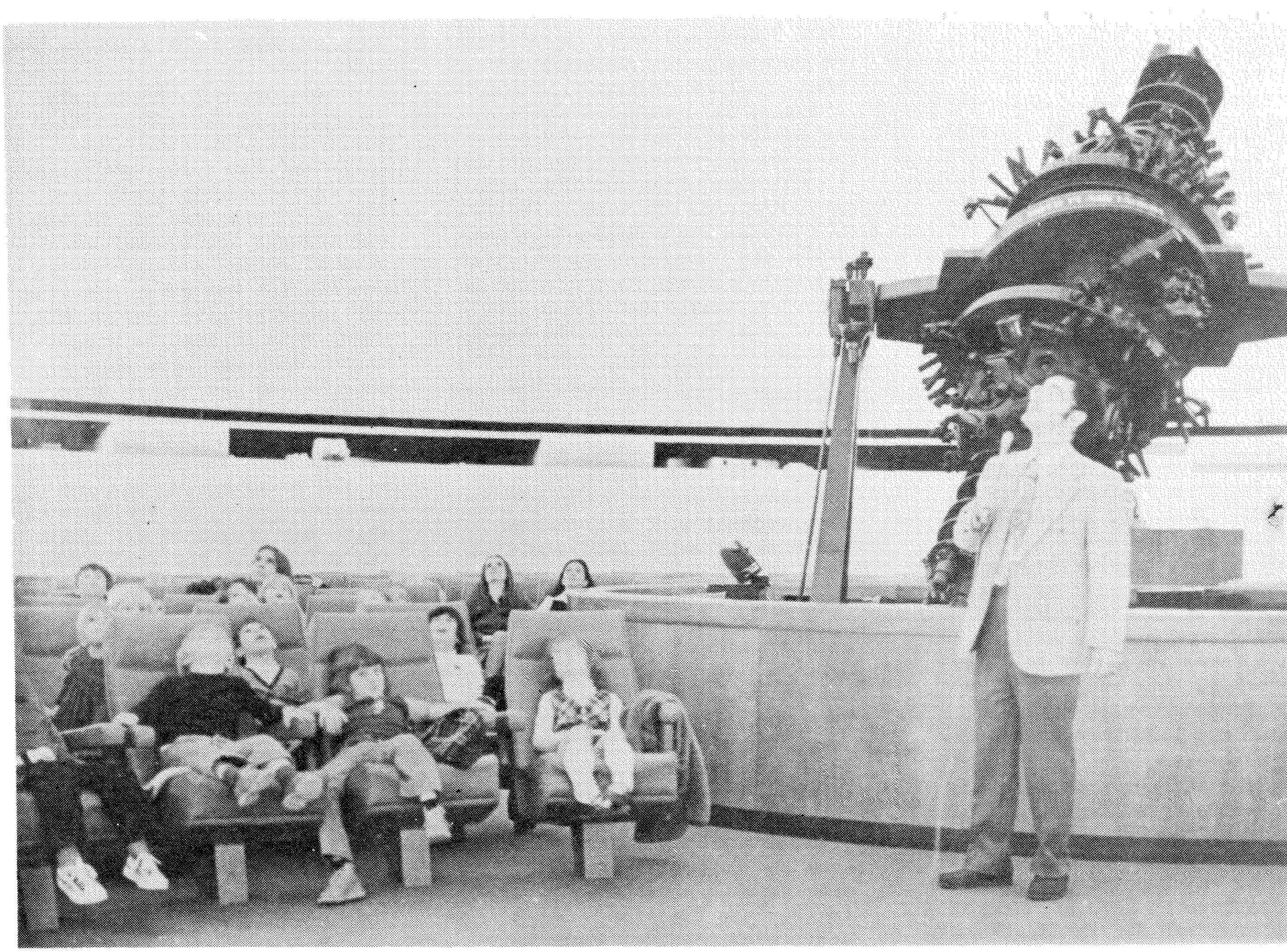
The sun panorama was faded out and a mobile representation of the solar system was projected. <u>THE SOLAR SYSTEM</u> word slide was projected and since the effect and the word slide were not adjoining in this case, the green arrow was moved slowly back and forth twice between the word slide and the effect.

The solar system projection faded leaving a normal daytime sky. The green arrow appeared and moved slowly across the dome to the western sky and the sun, then faded from view as a sunset progressed. No word slide was used and the sole point of the green arrow was to inform the audience the only changes occurring were in the western part of the sky so dure with THE BIG DIPPER, POINTER STARS and POLARIS/THE NORTH STAR, some of the more difficult constellations were introduced.

Following the constellation identification sequence, a space probe appeared among the stars. The word TO appeared for about 15 seconds followed by the words THE PLANETS for another 15 seconds. The probe then appeared to be receding, the sky revolved in simulation of travel through space, and a panorama of the surface of Mercury came up simultaneously with the cessation of motion and the appearance of the word MERCURY. This type of sequence was repeated for each of the naked eye planets in turn. The panoramas were as detailed as possible to lessen the need for word slides. In the future brief data slides may be included, perhaps indicating temperature, presence or lack of atmosphere, and planetary diameter. No more than three items will be used on any one slide.

A RETURN TO EARTH slide was shown after the last planet was visited, and this completed the word slides. The moving stars, the casual appearance of an artificial satellite followed by a view of the earth from space, and sunrise were all self-explanatory.

To recap the salient points

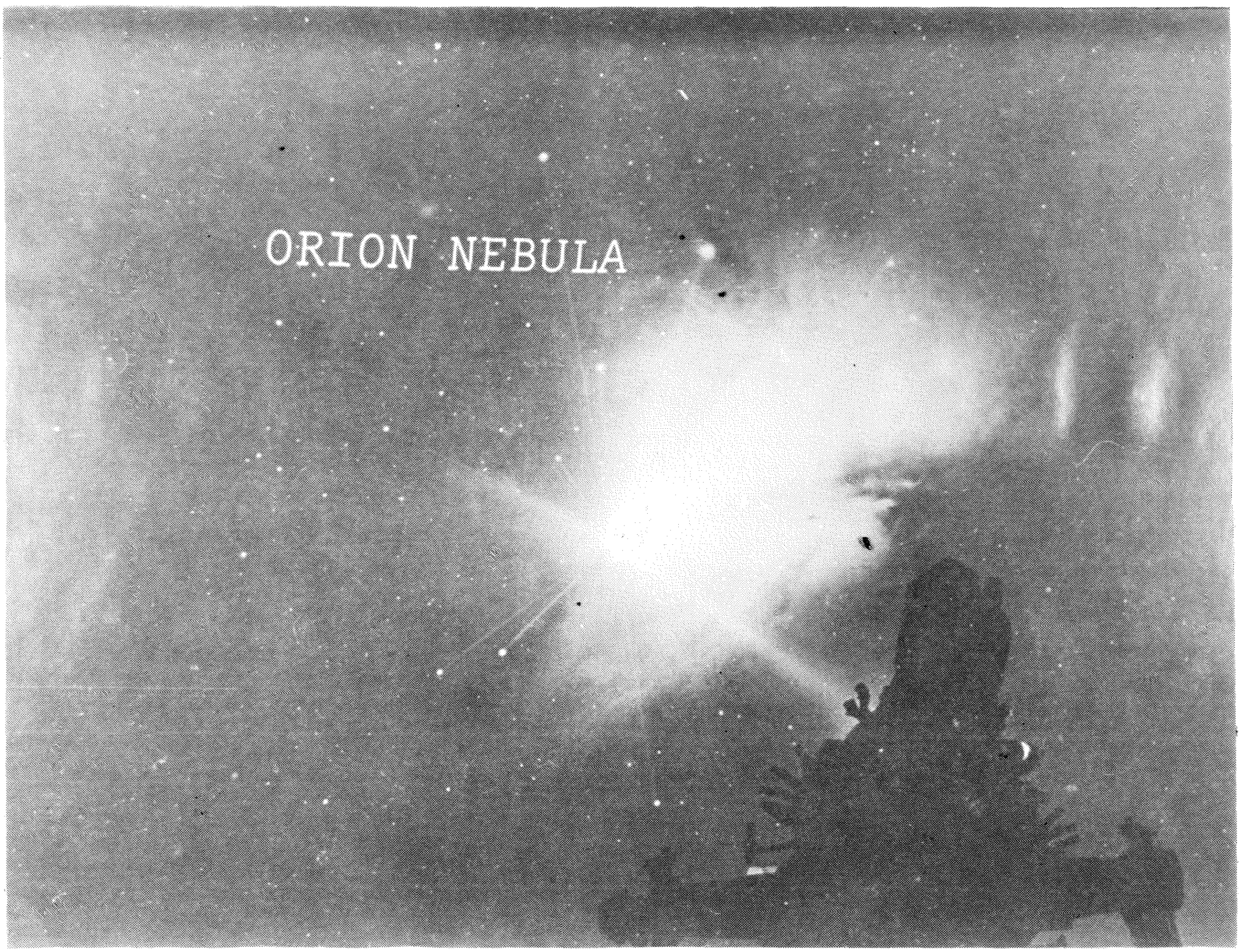


The author giving a visual clue to the children by looking expectantly at the far side of the dome.

there was no point in scanning the rest of the dome. The sunset, fading twilight and the appearance of the stars needed no interpretation.

A display of the Northern Lights appeared, at first without expalnation. After a few moments, a slide appeared reading NORTHERN LIGHTS and alternated with one reading AURORA. The green arrow then moved slowly from the slides to the effect, then the arrow and slides faded leaving the effect to be enjoyed for a few more moments.

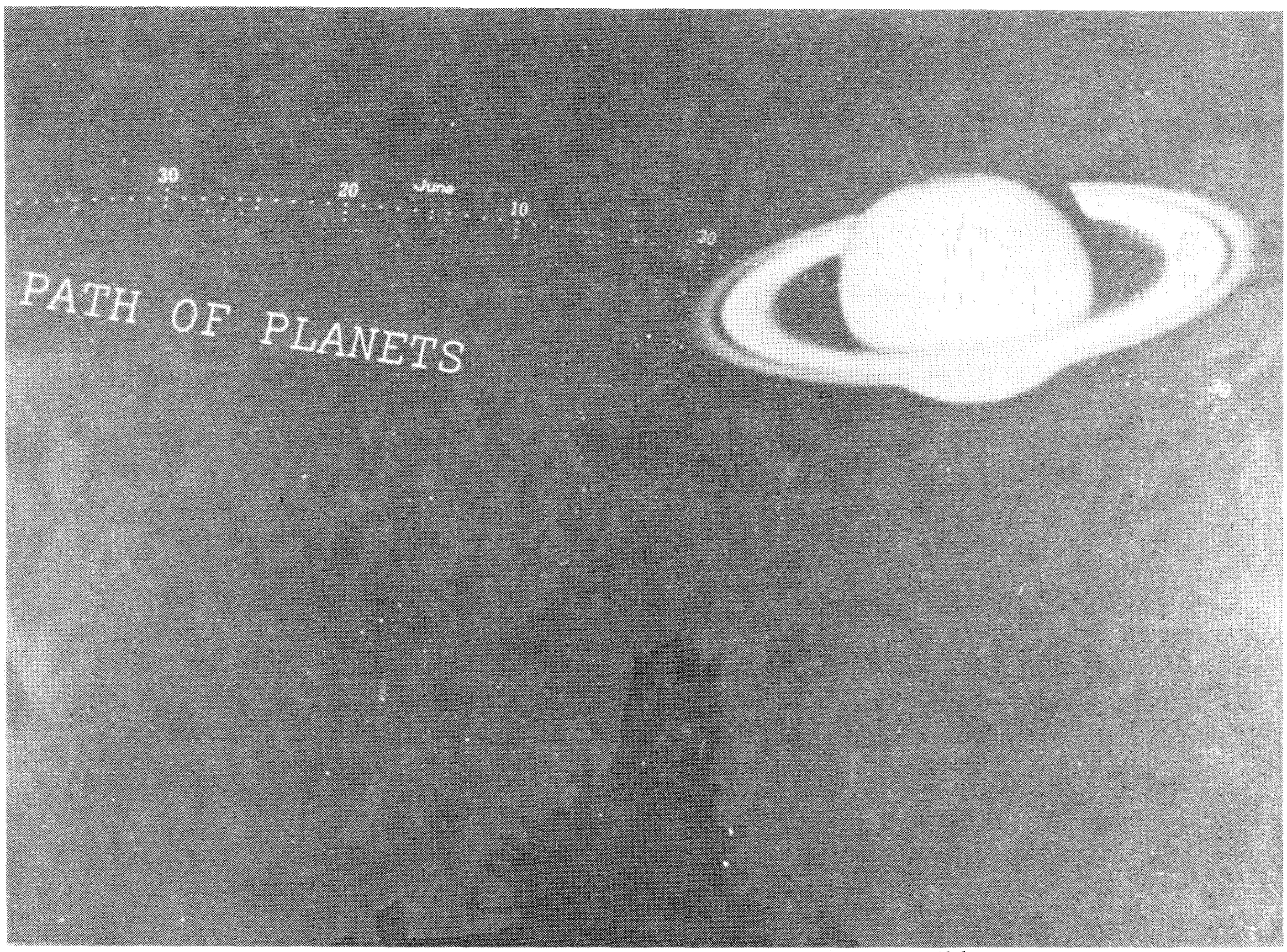
Next, two word slides were alternated: CONSTELLATIONS and STAR PICTURES. A third slide replaced the first two: THE BIG DIPPER, and the green arrow moved slowly from the slide to the star group and traced out the picture. Note that although the word asterism would have been more precise than star picture, it was decided at this point that simplicity was what was needed. A distinction could be made at a later point. After establishing the proce-



A deaf audience demands that you make full use of visual techniques with a minimum of explanation. Here the Orion Nebula is seen expanding out of the constellation, giving its location without words.

of a planetarium for the deaf: Deviate only as much as is absolutely necessary from your ordinary program. After all, your viewers are still ordinary people but with an impediment. Make the word slides brief and with large lettering. A lecture by projection would be at least as boring as any other kind of lecture. Use green arrows when necessary to direct attention, i.e. when the audience is not facing the coming action. It is no more necessary for the audience to follow every detail than it is necessary during a standard presentation.

One interesting footnote: a storm sequence was originally planned for the deaf program. Since it depended heavily on the sound track it was decided to delete it. It was run following the program to see what kind of reception it would get. Judging from the comments and mail received, the visual storm effects combined with the low frequency sound of thunder were the hit of the show.



Word slides should be as brief and simple as possible. They must describe the action without impeding it.

The Third Stage of Planetarium Evolution

by Max L. Ary, *Charlie M. Noble Planetarium, Fort Worth, Texas*

Forty-four years ago, the idea of planetarium education was initiated within this country. On May 5, 1930, the Adler Planetarium in Chicago opened its doors. Since then, planetariums in general and the whole concept of education that was to take place within their doors have radically changed and evolved.

We now find ourselves within the third stage of planetarium evolution -- a stage in which all planetarians will find our own institutions within varying degrees. A stage which all of us need to evaluate and just generally sit back and think about.

The first stage of this evolutionary process led to such institutions as the Adler, the Fels, the Griffith, the Hayden, and the Buhl Planetariums. This was a stage that I would like to call the Mausoleum Era. These planetariums were set up, usually by large foundations, with the main concern being to honor the families that originated the foundation. Families like the Adlers, the Haydens, and the Buhls were immortalized in gigantic buildings of marble, concrete, and precious metals. They were castles complete with statuary, large gardens with reflection pools and fountains, and an architecture of great massiveness and openness. Within them stood huge domes containing some of the most massive and sophisticated optical instruments in the world such as the Zeiss star projector. But, at this point in history, very few people could fully appreciate the educational future of such a center. These were objects of great curiosity for they were new and no one really knew their potential. This was their calling card and their pulling power. All to often the public was drawn to these institutions mainly because of their aesthetic and curiosity-forming ingredients more than the educational value they possessed.

After all, who was really interested in a relatively new science called "Astronomy"? What good was a science based purely on theories and unproven ideas? These mausoleums became much like a world's fair exhibit -- once they had been seen and experienced, the curiosity vanished, and with it went any remaining educational value that these people thought the planetarium contained. This can best be proven through a survey taken by the Hayden Planetarium in New York City during the first ten years of its operation. It was found that only five percent of the people visiting the planetarium during that first decade of operation had visited the planetarium before. This means that only five percent of the combined audience felt that there was something to come back and see again. This may have been the result of the fact that the people of this era (the thirties, forties, and fifties) were scientifically ignorant and could not fully appreciate what a science, or more specifically, an astronomy education center, could give them. Or it may have been the fault of the planetarium itself in not providing a continuous, provocative type of programming for its audience. But in the planetarium's infance in this country this really did not matter, because the institution was doing what it originally set up to do -- that of honoring and showing how great and how community-minded a certain dead philanthropist had been.

This was basically the scene set for most planetariums in this country up until the early 1950's. Slowly, mainly through the efforts of a few dedicated individuals within these large institutions, the tremendous educational potential of a planetarium began to be recognized. But a great problem arose. There were five planetariums in this country to serve approximately 40 million students and 180 million people.

For those living in the smaller cities and rural communities, the planetarium experience would never be a reality. The obvious solution to this growing problem was to install more projectors to meet the demand. This solution, however, presented even more problems. A major Zeiss planetarium installation was truly a million dollar operation. Few communities possessed either the financial means or the enthusiasm for astronomy to provide necessary funds for such an undertaking. Seemingly, the only answer for this problem was to develop a new concept in planetariums -- the small, relatively inexpensive planetarium. This goal was accomplished in 1947 when Armand Spitz introduced the Model A star projector. Shortly therafter, the Models A1 and A2 were introduced, and the planetarium world found itself entering into a whole new stage of evolution.

This second stage is one with which we today can identify. This was the stage that allowed the small planetarium to set its roots within the American educational system. Small cities, towns, and even relatively small schools found that a planetarium was now within their financial grasp. Between 1950 and 1957, over 100 small planetariums set their foundations in the American soil. But still, these small, early institutions possessed the problem that the large planetariums had encountered -- all they really had to offer the public was curiosity. But in the case of these smaller planetariums, curiosity could not support them, since most were located in relatively small population centers. They had to develop more; they had to create more to assure themselves that their attendance and financial stability could be maintained.

In 1957, a great world happening allowed planetariums, more specifically the small planetariums, to go beyond the curiosity stage. It was that year that a tremendous wave of forced enthusiasm quite suddenly engulfed the American people. This was instigated by a feeling of great urgency-- an urgency propagated by an imminent challenge. Man's machines had invaded the solitude of the space environment, and man was soon to follow. On October 4th of that year, the Soviet Union successfully launched the first artificial satellite and surprised the free world with its advanced technology. America was shocked out of its complacency, and a few months later placed its own satellite into orbit. And so, the technological contest had begun. America found itself and its educational program wholly inadequate to meet this challenge.

It was apparent to the nation's legislators and educators that from that time forward, the United States, by accepting the space challenge, must also accept the responsibility of educating its people to the space environment. Astronomy and space science impregnated almost every field of learning, and an understanding of them became essential to the country's well being. It penetrated the nation's history, economics, foreign policy,and all branches of its science and industry. In the schools, the teachers became victims of the times -- totally unprepared to answer the probing questions of the students. Parents were suddenly confronted with the excitement their children found in the drama of the space age, but like their children's teachers, could not nurture the enthusiasm of their inquiring minds. It was this dilemma, forced upon the American people, that brought the modern American planetarium -- and more specifically again the small planetarium -- into its own. In fact, the planetarium represented such a highly potential space education tool, that it was selected by President Eisenhower's Advisory Council as one of six outstanding innovative educational projects of his term of office. It was through this concern of the President and Congress that the NDEA matching funds and Title III grants led to the construction of literally hundreds of new, small planetariums throughout the country.

Everyone was getting into the scene with seemingly every community thinking that they needed a planetarium. Also, of the 700 plus planetariums that had been built by 1970, it would be a fairly safe assumption to say that there were probably 700 plus ways that school administrators, appointed planetarium directors, and foundation boards thought that their facility should be utilized within their own community. In many ways this was good, for it lead to a totally new creative process within the planetarium community -- a process that, at this point, was greatly needed to modernize the educational techniques in planetariums. Also, the small planetariums had begun to fight for their lives to survive. One reason for the tremendous increase in the number of institutions was the idea of planetariums being an"interesting novelty"began to quickly wear off. No longer could a planetarium rely upon the fact that the public was enjoying a sophisticated freak show. Because of the public's interest, it had to become a warehouse of knowledge and open up to become a learning environment.

This brings us to the third stage in planetarium evolution that most readers can identify with -- a stage that in many ways may be the most crucial stage yet encountered, and one that needs to be handled with utmost care to preserve the future of planetarium education This stage encompasses what I would like to call the 2001 Complex or possibly better yet, the MGM Syndrome.

Not all planetariums experience this stage. Those that are set up mainly as planetariums many times do not go through this syndrome -- it is reserved for those of us that are labeled "public planetariums."

This syndrome has been caused basically by the increase in sophistication of audiences. At least with our case in Fort Worth, we find that most people are coming to see more than just a general night sky presentation. What they seem to want every time is a run-off of 2001 - Space Odyssey. This can create a few problems -- especially if you are only allocated thirty, forty,or fifty dollars a month for materials. This brings up a very large question -- should we attempt to compete with other media such as the movie industry? Because of the movie industry producing such shows as Marooned, Silent Running, The Andromeda Strain, and the classic 2001 -- all produced for the big screen -- and those shows produced for television such as Star Trek, Earth II, and Genesis II, audiences are craving a blend of science and reality that makes them feel that they are really (quote) "a part of the space age."

I feel most of us that are trying to create this type of illusion within our shows are achieving it to some degree. But, if we are going to continue this form of production within our institutions, we must very definitely consider some possible problems. First of all, audiences reach a saturation point very rapidly. If you create a "tremendous, slam-bang" show that the audience gets totally turned on to one month, you better be prepared to create an even more "tremendous, slam-bang" show the next month, or you will slowly lose your audience. Once they have experienced a certain level of production, they expect to see at least that level, if not more, in every show. Will this become a never ending pyramid? Who's really to tell? For the sake of most of us, the answer is no. For you can only make so many things out of broken pop bottles, shimmer disks, brute force projectors, and broken mirrors. Everyone has a point where his or her creativity stops. To continue this spiraling pyramid, we are going to have to look forward to seeing a tremendous increase in annual budgets. To accommodate these increases, we will have to guarantee not only a stabilized attendance, but an ever increasing one. In other words, what I am trying to say is that for us to accept the challenge that various visual media seemingly present to us, we will have to, likewise, accept the responsibility of possibly sticking our necks out too far. This is a great responsibility, not only for ourselves, but for the future of the small planetarium.

Already I am seeing programs in which the star projector acts primarily as a background for the rest of the visuals. I am seeing planetariums turning away from that original intention that Armand Spitz had -- that of a simple, discreet, astronomy educational tool. Maybe this is good, for it may be part of continuing to explore a planetarium's potential. But, I think we do need to stop and think, and to plan what we are going to do with this and how far we can take this type of production. We need to think about this not only as individuals but as a group. I am in hopes that in some future conferences,or possibly symposiums that any of us may set up, that this problem can be discussed.

Another thing that I am seeing public planetarium directors do is to become so carried away with the idea of creating a planetarium version of "2001", that they become blind to what they are actually trying to do. In other words, it is like the old saying,"You can't see the forest for the trees." They, many times, have their heads so high up in the clouds they are not seeing what their audiences are really requesting. They are, very simply, prima donnas. I can say this because I, myself, found that I was slipping into this Jehovah complex state. I realized that I was more concerned with the production of a show than with the content. Luckily, I was made aware of this situation before it got too far out of hand. Now, I find myself having my shows, and any other output from my institution, critiqued by fellow staff members, colleagues, and the general public. It has helped tremendously in showing us the path that we in Fort Worth must follow, and has also given us guidelines and a point of reference on which to base future shows.

In closing, I would like to invite all of you, specifically in this case, those of you who man public planetariums, to fully evaluate what you do with them in the future. I think you need to ask yourself a few general questions: (1) Are you giving your public in your own community what they want? (2)What is this thing that the public wants -- is it educational or is it just entertainment? (3) Are you creating for yourself a never ending production pyramid that will eventually produce a quality plateau? (4) In creating your presentations, do you find yourself competing with other planetarium and continue to try to outdo them to the point that it becomes the main purpose of the program?

Remember, in the planetarium field in this country today, it is those of us within the small public planetariums that are keeping creative openness alive. But remember also, that it is our responsibility to insure that this creative process will be maintained in the future.

Letters

In August 1974 I visited both the Munich and Paris planetariums. Munich has a Zeiss IV, their second instrument, installed May 7, 1960, replacing one of the two original Zeiss instruments, installed in Munich May 7, 1925 after having first been exhibited in Jena for about a year. They have a 15 meter dome seating about 250 people. The director since 1970 is Fraulein Lutze, who is also in charge of the Deutsches Museum's physics, astronomy, geology and geophysics exhibits. The halls for these exhibits fill about five kilometers of the 14 kilometers of public exhibit corridors in this immense museum. With such extensive responsibilities and a budget which does not permit hiring an astronomer as a consultant (a volunteer amateur had died about a year before my visit and was not yet replaced), this planetarium is somewhat handicapped. Four shows are scheduled daily at two hour intervals, with an extra show occasionally added. All are totally packed. The shows are given by a rotating staff of four people, rarely by Frl. Lutze.

Paris has one of only five pre-war Zeiss instruments still in use, the 25th of the 27 prewar installations. It was installed in a 20 meter dome seating 350 on June 19, 1937. The current director is Mssr. G. Oudenoy. Two shows are given every day but Monday at 3:00 and 4:30. They rarely draw as many as 200 people. Annual attendance runs about 320,000 people. The shows are given by the director, three part-time people, and by a couple of people from other departments (such as genetics).

Munich shows run twenty minutes. The same show is given for an entire claendar year, so a good part of the Munich and surrounding Bavarian population must see each. The 1974 show was on the causes of the seasons. In Paris the topics are rotated daily, and changed monthly October to June, unchanged but rotated during the three summer months. Thus this summer the topics rotated were "The Northern Polar Night & The Midnight Sun" (Tu & F, 3), "The Planets, Family of the Sun" (Tu, 4:30), "The Sky of France" (W, 3), "The Sun & The Zodiac" (W, 4:30), "The Southern Sky & the Seasons" (Th, Sa, Su, 3:00), "A Little Astronomy" (Th, 4:30), "The Moon and its Eclipses" (F, 4:30), "Galaxies & the Universe" (Sa, 4:30), and "The Summer Sky" (Su, 4:30). Each runs about 35 minutes.

The Munich show pointed out a number of northern constellations (e.g. U Ma, U Mi, Cep, Cas), and then discussed the current positions of the planets, going on to explain annual motion while putting this motion on high speed. The ecliptic, coordinates, and meridian were used. The show concluded with a poor aurora and the Zeiss meteor shower. One slide of clouds at sunset was used to open the show and one slide diagram explaining the seasons was used during the show.

I saw the southern sky show in Paris. It began with an abrupt entry into three minutes of total black while the lecturer explained this was not a movie and how the machine worked. The stars were suddenly turned on, and the lecturer pointed out U Ma, U Mi, Peg, and a few other sights. There was a discussion of annual motion similar to the one in Munich, with the difference that the Parisian Jupiter was out and their coordinates were on the floor. Paris is at 48°N; we were taken to 48°S and shown Cen, Lup, Cru, Pav, Gru, the Magellanic Clouds, and the SCP. The machine returned to Paris for a quick sunrise after a Zeiss meteor shower. This show used two slides, both for explaining seasons.

Neither planetarium had any of the many homemade auxiliaries felt so necessary in the United States. Daily motion and latitude change were both used at much higher speeds than I have ever seen at public shows in the States. The pointer was waved around very quickly in mentioning each of the constellations, with no projections of the figures, although Munich did flash on the constellation names, a Zeiss full sky effect.

The people I met at both planetariums were most friendly, answered all my questions, and gave me much information on local activities. I am particularly grateful to Frl. Lutze, who gave me several hours of her overburdened time.

Thomas Wm. Hamilton

Contact!

by Tom Gates

Several letters concerning the traditional "Christmas Star" program done in just about all planetariums in the western world have come to me asking for clarification on technical points. For reference, the most definitive article I know of on the subject appeared in a 1967 publication by Carl Zeiss, Inc., titled 1967 1 Planetarium International. The article is by Dr. Roy K. Marshall and is titled "Stars of Bethlehem in the Planetarium." A revision by Dr. Marshall is available in the "Planetarium Director's Handbook," Number 10, March 1972, published by Spitz Laboratories, Inc., edited by Michael A. Bennett. (Editor: A forthcoming chapter in the section Principles of Planetarium Operation in THE PLANETARIAN will be devoted to this favorite topic.)

Specific questions regarding the Star of Bethlehem show:

1) "What then is the actual shape of the triangle formed by Mars, Jupiter and Saturn?"

ANSWER - The widely held notion of these three planets tightly compacted (a carry-over from the suggestion of Kepler) and as the points of an equilateral triangle are incorrect. The triangle on February 25th of 6 B.C. was near isosceles with Jupiter 4 degrees from Mars, Mars 4 degrees from Saturn and Saturn 7 degrees from Jupiter. Saturn was at R.A. 23^h36^m, Dec. -5.1 degrees; Jupiter at R.A. 0^h1^m, Dec. -1.2 degrees; Mars at R.A. 23^h46^m, Dec. -2 degrees. The effect was a rather flat isosceles triangle with respect to the 7 degree base line between Jupiter and Saturn. The Sun was only 22 degrees from the center of the triangle, so it was barely visible in the evening twilight, very low on the western horizon.

2) "On what dates did the conjunctions occur?"

ANSWER - Since the magi were most likely astrologers, in that period of history, conjunctions were likely noted in celestial longitude. In celestial longitude the conjunctions occurred on May 27, October 5 and December 1. If you desire also the conjunctions in R.A., they are June 1, September 27 and December 10.

3) "What are the proper sky settings for precession?"

ANSWER - To set the instrument for January 1, 7 B.C., the star Regulus should be located at R.A. $8^h16^m.7$, Dec. $+20°13'.8$. Delta Orionis should be located at R.A. $3^h43^m.2$, Dec. $-3°\ 43'.4$.

4) "What happened to Kohoutek?"

ANSWER - Due to the energy crisis, Kohoutek has been turned down.

"I'm very much interested in the area of planetarium education. As a graduate student in astronomy at the Universiy of Wisconsin, it would be helpful to have an idea of what opportunities exist in the planetarium field for Ph.D's. For example, can I hope to be able to compete successfully for positions which might ordinarily require a M.S. or teaching degree? For what types of positions which might ordinarily require a M.S. or teaching degree? For what types of positions (if any) would a Ph.D. degree be an advantage?"

John E. Davis

ANSWER - In regard to your letter of February 1, the Ph.D. would offer an advantage for some positions and a disadvantage for others. For the most part, it would be an advantage, especially when hiring on with older, larger, more established planetariums which want prestige as a part of their name. Also, a good many school planetariums want someone with the depth in astronomy which a Ph.D. would represent.

However, a good many institutions are so squeezed for budget and also do not attach significance of their planetarium operation, that they purposely hire the least expensive person they can get. A Ph.D. is at a disadvantage in such a situation. From the attitude that prevails here, you are probably just as well off to stay away in the first place. Unfortunately, this attitude is far too prevalent.

As to your ability to compete with such other M.S. or teaching degree holders, I am convinced that individual capability is by far the most desirable quality. A Ph.D.

does not mean you possess the characteristics necessary to run a good planetarium program. Your ability to relate well to people is the single most important quality. A great many people in planetariums have this quality and, unfortunately, poor astronomy backgrounds. On the other hand, a great many people in planetariums have this quality and a good astronomy background. Thus you should first access your people-relating capability. Do you enjoy people? Do you think quickly? Do people respond to you? Do they follow what you are saying or do they have to ask for clarification often? Do you use terminology which is the astronomer's language or do you find it easy to explain astronomy without the "language of astronomers"?

If you do feel you have these people relating qualities, then by all means, I would encourage you to pursue a good astronomy background. In the planetarium field one is involved in a lot of general science and I would caution you in pursuing a Ph.D. in astronomy that you not exclude courses in other disciplines such as geology and history (particularly science history). With this in mind, it is very encouraging to see individuals such as yourself desiring to pursue a Ph.D. in astronomy with planetarium operation as the goal. I feel the field needs more doctorates as far too many administrators regard a planetarium as a novelty rather than a serious pursuit. Vol. 2, No. 2, June 21, 1972 of the Planetarian carries a directory of institutions offering coursework in planetarium education. Abrams Planetarium at Michigan State University has coursework leading to a Ph.D. in science education with emphasis on planetarium usage.

CONTACT! *is our Question-Answer column. There are no holds barred on questions or requests for help, providing they are related to the legitimate purposes of this journal, and the Editor will send a researched reply to every letter sent him even though space may prohibit its being used in the column. So* CONTACT: *Mr. Thomas Gates, Space Science Center, 12345 El Monte Rd., Los Altos Hills, Calif. 94022.*

Radio Astronomy Notes

Conducted by G. L. Verschuur

Few problems in radio astronomy have been studied as long and as closely as the decametric radio bursts from Jupiter. They were discovered nearly 20 years ago by B. Burke and Ken Franklin. What have we learnt in this time about these bursts and what problems still exist?

Jupiter's decametric radio emission (abbreviated to DAM by some, suggesting an expression of frustration by the researcher at trying to explain the emission perhaps) occurs between radio frequencies of a few MHz and 40MHz, the lower cut-off being due to the Earth's ionosphere which prevents radio signals at lower frequencies from reaching us. The upper cut-off seems to be a real effect on Jupiter which allows some of the physical properties in the source region to be determined. The radio signals are burst-like with bursts lasting a few seconds. The bursts sometimes occur in groups lasting minutes and storms of bursts may last for hours. The bursts drift in frequency with time and this property has puzzled researchers for years. The individual bursts are narrow band phenomena covering a few hundred kilohertz and they drift at 20 to 30 MHz per second to lower frequencies during their lifetimes. Some of the bursts cover a wider frequency range (1 to 10MHz) but these show bands of little emission within them which drift in frequency as well. In the late 1960's it was discovered that the burst occurence, and their structure in frequency and time, correlated perfectly with the orbital period of the Jovian satellite Io. The periodicity of the bursts had been found to be $9^h55^m29^s$ and this was called the system III longitude on Jupiter suggesting that some property of Jupiter was rotating in this time. Since then it was found that this period is nearly the time it takes the satellite Io to go around Jupiter, but not quite. It is the orientation between the Earth-Jupiter line with respect to the Io-Jupiter line that goes through a periodicity of this length. For some reason we receive bursts from Jupiter when Io, Jupiter and the Earth are alligned in a particular way. They means that the bursts are beamed from Jupiter in a very narrow cone emission. The energy in the bursts makes Jupiter the second strongest radio source in the sky, at these frequencies, after the sun.

What about the detailed nature of the bursts? First, as we said above, they are beamed. Second, since they are narrow frequency phenomena the region of space in which they originate must have rather uniform properties (and is therefore very small) so that enough power is produced by a coherent mechanism to allow us to pick up the signals at all. Thirdly, the nature of the bursts from one day to the next is so constant that some underlying constancy is present in the emitting region. This is thought to be the moderating influence of Jupiter's magnetic field. In addition the bursts are polarized, suggesting that the magnetic field is present and important. Lastly, the correlation with the relative position of Io is perfect; when one predicts that bursts are expected, they do occur. It should now be a simple matter to explain what is happening.

The first attempts to explain the bursts suggested that they originate in the immediate vicinity of Io. However, from the radio observations it was found that the density of matter around Io would have to be unacceptably large. The emission can not, if fact, originate near Io, which orbits Jupiter at distances way above the Jovian van Allen belts.

A reasonable explanation seems to go as follows. The region of space through which Io passes does contain particles of low density, too low to generate radio waves directly. These particles can pile up just ahead of Io and it is possible for this region of higher density to become unstable, which means that various oscillations are set up within it. These oscillations can generate waves which are capable of travelling through the surrounding low density undisturbed regions around Jupiter (the plasmasphere, as it is called). The waves are known as magneto-hydro-dynamic (MHD) waves because they travel through a fluid containing particles and a magnetic field. They do not generate radio signals. Instead they travel down to Jupiter and reach the Jovian ionosphere where they do trigger radio emission, as follows. Within the ionosphere the electron density is very high and radio signals can be generated in this region provided the electrons can be made to oscillate strongly. At various levels in the ionosphere the electrons have a natural frequency of oscillation which depends on the density of the electrons. As the wave from

Io reaches the level in the ionosphere which has the same natural frequency as the original wave, the electrons all start to oscillate in unison and radio signals are emitted. It is these radio signals that we detect as bursts. The precise reason for the very narrow beam of emission is not clear. It appears that the motions of the electrons in the ionosphere is not simply one in which the electrons are forced to move, and subsequently to spiral about the magnetic fields there, nor are the oscillations completely random, otherwise the emission would radiate in all directions. It appears that another wave motion is generated in the ionosphere whose frequency is close to the frequency at which the electrons would spiral about the magnetic fields in any case (although not radiating appreciable amounts of energy - the point is that these motions are always occuring - only sometimes they are stimulated enormously so that we can detect their radiations). The problem of how so much energy can be radiated in the bursts themselves has not been solved yet, a familiar story in radio astronomy. A mechanism is though up, but the energy is a problem. The MHD waves are continuously radiating from near Io and continuously generating radio waves in the ionosphere of Jupiter. We only see the bursts when we are oriented correctly. The frequency drifts also seem to be directly associated with the narrow beaming mechamism which leads us to pick up signals at different frequencies at slightly different times as the beam sweeps past us. individual bursts are produced because the original oscillations in front of Io can damp themselves out as a result of yet another set of instabilities. After these cancel out the generation of the original MHD wave, the whole process repeats and another burst is generated.

Few problems in radio astronomy have been studied for as long and few are as fascinating as Jupiter's decametric bursts.

It looks as if 1974 is going to be a better year for molecule discoveries that were either 1972 or 1973. The discovery of the presence of complex molecules in interstellar space by means of radio observations of the spectral lines they generate started in earnest back in 1968 with the detection of ammonia (NH_3) and water (H_2O) in clouds of gas and dust between the stars. The year 1969 was a slow year in which only one new molecule, formaldehyde (H_2CO) was discovered and the reason for that was that radio astronomers were not really ready with suitable equipment to pursue the searches for further molecules very quickly. In addition, of course, the largest radio telescopes are scheduled many months ahead of time and then there is a further delay between the time of making the observations and when they are analysed and made public.

What we saw instead was that 1970 appeared as the first vintage year in which some 7 new molecules were discovered, followed by 1971 in which no less than 9 new molecular species were reported. However, this initial spate of results slowed to a trickle with 3 molecular types being found in interstellar space in 1972 and only 3 molecular types being found in 1973. One of these 2 was CH which had of course been known to optical astronomers since the thirties.

This year we have heard about the discovery of at least 4 brand new molecular species in interstellar clouds. The new candidates are Dimethyl Ether ($(CH_3)_2O$), Methylamine (CH_3NH_2), Vinyl Cyanide (H_2C_2HCN) and the Acetylene fragment (CCH). These are some very fancy molecules, with one containing 9 atoms, the largest yet discovered in space. Why is the rate of discoveries picking up again? One reason is that new equipment is becoming available for making more sensitive observations at previously observed wavelengths as well as new equipment being at wavelengths not studied before. Radio astronomers had tended in the past to use equipment at wavelengths within the so-called "protected bands" in the radio spectrum, protected by international agreement. This protection hopefully means that other services, such as radar or communications channels, would not transmit at the wavelengths (or frequencies) at which the radio astronomer is trying to pick up weak radio signals from space. There was never much point for a radio astronomer to try to pick up radio signals from space at frequencies being used by say some television station or some satellite communication channel.

Now however, the radio astronomers are on the trails of many new molecules in space and they have to try and find some of these molecular signals in un-protected bands. Of course, the largest observatories are situated in radio-quiet areas so as to minimize the influence of distant transmitters on earth which would produce interference. And so the search is starting to gather momentum again as new equipment becomes available and as new telescopes are built. We are far from the end of discoveries of new molecular species that are likely to be made. Studies of interstellar molecules are increasingly going to shorter and shorter wavelengths, and now infra-red astronomy has an exciting future ahead of it since many molecules radiate in the infra-red part of the spectrum. These all still remain to be discovered.

Up to May of 1974 some 30 interstellar molecules were known to exist. In addition there are a few unidentified spectral lines known, whose origin is not yet understood. Of the 30 well studied species (including the unknown species, X-ogen) there are no less than 20 organic molecules (molecules that are carbon based). Since all life on this planet is based on the processes of organic chemistry, this bodes well for those who like to speculate on the possible similarities between life elsewhere in the universe and life on our planet. It now appears certain that organic chemistry is universal and occurs in such widely divergent environments as a cold, diffuse, interstellar cloud and on the surface of a planet in the high density atmospheres at much higher temperatures.

A last comment on one of the new molecules that has just been discovered and that is the molecule methylamine. It can react with formic acid (HCOOH) to form glycine, the simplest of the amino acids. Formic acid has allegedly been detected in interstellar clouds as well, although its detection is still controversial. Nevertheless, we appear to be nearing the time when astrochemists might start to say some conclusive things about the formation of amino acids in space, and we might not be too far from actually finding such molecules in the interstellar clouds. Such a discovery would have a radical bearing on our thinking on the evolution of life in the universe. The problem that prevents radio astronomers searching for an amino acid even now is that no one knows to just what wavelength to tune a radio receiver in order to pick up the right signals. The reason for that is that no one has yet been able to do a laboratory experiment of the required nature on the amino acids not has anyone been able to perform the complicated mathematical calculations that would be required to make a theoretical estimate of the characteristic frequency of the simplest amino acids. The time when the first laboratory frequency measurement is made or the first theoretical calculation is done might not be too far away now.

The Stars of Primeval China

by Julius D. W. Staal, F. R. A. S., *Planetarium Department Head*

The astronomy of ancient China differed in many ways from western astronomy. Chinese astronomy was closely connected with government bureaucracy, while among the Greeks, astronomers were philosophers and individuals quite often at loggerheads with government officials. Professor Needham[1] writes that the Chinese astronomer is intimately connected with the sovereign pontificate of the Son of Heaven, which is an official government service and is ritually accommodated within the very walls of the imperial palace.

Chinese astronomy was essentially polar and equatorial, depending on observations of the circumpolar stars, while the Greeks based their astronomy on the ecliptic, depending on heliacal risings and settings of zodiacal constellations.

The latter and the insuperable language difficulties caused a tremendous confusion of ideas which still is not fully satisfactorily solved. The Westerners did not consider feasible an astronomy based on anything else but their own ecliptic-heliacal rise and set system, whereas the modern scholars maintain that the Chinese worked by keying certain circumpolar stars to determinative stars of constellations further down at equatorial level and then watched the upper or lower culminations of these stars by means of a gnomon and clepsydra. This assumes therefore an early knowledge of astronomy and the making and using of astronomical instruments. The question is: "How old is Chinese astronomy?"

The story always starts with the famous commission of the legendary Emperor YAO (2357BC) to the six astronomers Hsi and Ho. The text can be found in the Shu Ching, which is dated from the 8th century B.C. The text[2] says: Therefore HE (i.e. Emperor YAO) commanded Hsi and Ho, respectfully following observations of the vast heavens, to calculate and delineate the movements and aspects of the sun, moon and zodiacal spacings and to hand over respectfully to the people the seasons.

He ordered separately the second brother Hsi to reside at Yu-y in what was called the most resplendent valley and to receive there most respectfully, like a host, the rising sun and to adjust and arrange the works of spring. The day is of average length and the star is NIAO. Therefore, you should be able to determine the middle of spring.

Next he ordered the third brother Hsi to reside in NAN-KIAO and there to regulate the transformations of the summer and to observe most respectfully the extreme limits of the shadow. The day is at its greatest length and the star is HO. Therefore, you should be able to determine exactly the middle of the summer.

He ordered separately the second brother Ho to reside in the west in what was called the dark valley and there to accompany most respectfully the setting sun and to adjust and arrange the complete works of autumn. The night is of average length and the star is HIU. Therefore, you should be able to determine exactly the middle of autumn.

Next he ordered the third brother Ho to reside in the northern region in the so-called somber capital and to adjust and arrange the changes of winter. The day is at its shortest and the star is MIAO. Therefore, you should be able to determine exanctly the middle of winter.

The text obviously tries to convey meridian passages of certain marker stars indicating the seasons. Today these stars no longer have this relation due to the precession of the equinoxes. It seems, therefore, not too difficult a task to compute the positions of these stars relative to the equinoctical and solsticial points by going back in precession. Planetarium directors who have projectors with precession mechanisms will make fascinating discoveries. We shall find that approximately at YAO's epoch (2300 BC) the stars of the Blue Dragon (Scorpio) are at the autumn equinox and the stars of White Tiger (Orion, Pleiades, Aries) at the spring equinox. This is a contradiction in terms because the Blue Dragon is always referred to as the Blue Dragon of spring and in 2300 BC

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*Artwork by the author and Alice Land, Staff Artist, Fernbank Science Center.

[1] T. Needham, Science and Civilization in China, Vol. III, Section 20, p. 171. Cambridge University Press, 1959.

[2] This is the author's translation. Also see SHU CHING, Book of History, edited by Clae Waltham, translated by James Legge, Gateway Edition, Henry Regnery Co., Chicago, pp. 3-7 ("The Canon of Yao").

it was located at the wrong equinox.

This led Gustave Schlegel[3] to the daring assumption that Chinese astronomy must be extremely old. If you care to precess your projector back until the Blue Dragon does coincide with the spring equinox, one will find that the epoch in which this occurred was round about 15,600 B.C. Astronomers and historians could not and would not accept this absurd chronology. But Schlegel used it as the basis for his Uranographie Chinoise which is still the most important reference work on positional astronomy of the Chinese stars and constellations of those days.

Schlegel, with the aid of a star globe equipped with precession mechanisms, tries to prove the commission of the Yao-T'ien, but runs into great difficulties because the text does not mention the exact day and hour of the observations. I have tried to carry out the instructions of the Yao-T'ien with the Zeiss V projector and found that for the epoch of YAO (2300 BC) the following table could be drawn up.

When the sun sets at the:	It is still daylight when:	Allowing 1 hour 15 min. for twilight, we find:
Winter solstice	MIAO (Pleiades) is 16°40' east of meridian	MIAO 1° west of meridian
Vernal equinox	NIAO (or Sing = αHya) 1°29' west of meridian	NIAO 19° west of meridian
Summer solstice	HO (or Sing = β Sco) 18°32' west of meridian	FANG 40° west of meridian
Autumn equinox	HIU (β Aquarii) 6° 45' west of meridian	HIU 25° west of meridian

It will be seen that none of the instructions of the Yao-T'ien yield satisfactory results, nor do the marker stars represent the middle of the respective seasons (or middle of the representative sky animal).

Schlegel has a fascinating theory that once upon a time, way back in 15,600 BC, the marker stars fitted the seasons exactly. This can be easily shown with the Planetarium projector. Schlegel's entire work, called "URANOGRAPHIE CHINOISE" (two volumes) is based on this setting. He does ask himself, however, what might have happened between those early beginnings and the appearance of YAO on the scene? Why had all astronomical information disappeared? He puts forward that a shattering calamity wiped out this early civilization. Schlegel bases this on the ancient writings (e.g. Confucius) where there is mention of four seas. Three of them can be easily be accounted for, namely the Arctic Sea in the north, the Chinese Sea in the east, and the Indian Ocean in the south. But where was the fourth sea? Schlegel believes that possibly the Black Sea, Caspian Sea and Aral Sea may once upon a time have been this fourth sea, and that a gigantic breakthrough of these waters caused the mountainous lowlands between the Himalaya Massive and the Mongolian Massive to be inundated. He bases this on local legends. Apparently the people remember some sort of a flood in ancient times and they have remained nomadic because they still fear the return of the waters.

Schlegel also says that the many lakes are briny and the Gobi desert is a large salt covered wasteland, which all points to an inundation some time long ago. How, otherwise, could salty lakes be on mountaintops? How did the Gobi desert become a salt flat? Schlegel ties this inundation in with the story of the great YU, the master engineer, appointed by Yao, who saved the country by channelling the flood waters to the great rivers. It was this flood that wiped out early astronomical eras and what scraps later came into YAO's possession must have led to the Yao-T'ien commission which obviously would not work on account of precession.

What do I think? Secretly I am a supporter of Schlegel, especially since the discovery of Peking Man (dated 360,000 BC) has thrown light on early habitation of China.

From 360,000 BC until 15,600 BC is a period of 344,000 years,

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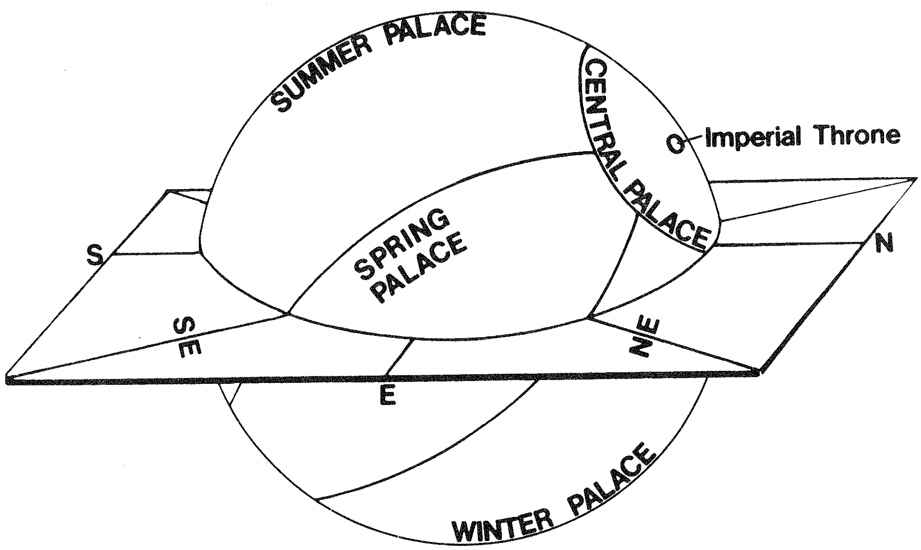
[3]Uranographie Chinoise, Ch'en Wen Publishing Company, Taipey 1967. Gustave Schlegel, born in Oestgeest, Holland in 1840. Died in Leiden 1903. Was in his time a leading sinologist. He studied eastern languages and in 1862 became interpreter in Batavia to the Dutch Government. He obtained his Ph.D. in 1869 in Jena, Germany, his thesis being "Chinese plays and customs:. In 1875 he became professor in the Chinese language in Leiden. Among his works are:

1.A Dutch-Chinese dictionary
2.La loi du parallelisme en style Chinoise.
3. Uranographie Chinoise in 2 volumes, 1875.



a goodly time lapse for a simple agriculturally-based type of astronomy to develop. Heliacal risings and settings with a natural horixon as reference line seems more normal than the rather intricate system of keying determinative stars to circumpolar stars. But who am I to contradict the great minds on this subject?

It is from Schlegel's two books that I have drawn information for the description of the four sky animals of the first division of the Chinese sky. This only scratches the surface. The fascinating part comes when one reads the second division of the sky, the subdivisions of the mentioned sky animals in their twenty eight hsiu, each hsiu having numerous paranatellons which are all linked with some or other ritual or task.

The four sky animals discussed in this article are:
(1) The Blue Dragon of Spring (Xeiss constellation E 31);
(2) The Red Bird of Summer (Zeiss constellation C 49);
(3) The White Tiger of Autumn (Zeiss constellation C 50);
(4) The Black Tortoise of Winter (Zeiss constellation A 47).[4]

The Chinese divided the sky in five sections. The area around the pole star T'IEN-HUANG-TA-Ti is the Central Palace, representing the Government and its officers. The Celestial Emperor sits on his throne in the middle kingdom.

The remainder of the heavens are made up of four sections, The Spring Palace, The Summer Palace, The Autumn Palace and the Winter Palace.

THE BLUE DRAGON

In the Spring Palace lives the Blue Dragon. Sometimes we read azure or even green dragon. The Chinese word for it was TSHANG-LUNG. On our star map it occupies the constellations Spica of Virgo, Libra, Scorpio and Sagittarius. (Zeiss Constellation Box E, No. 31, colored blue.)

To westerners dragons are monsters of evil. Nothing surprised early European travellers in China more than to find that there the same monster was revered as a beneficient animal, taken as a symbol of the Emperor and Imperial power.

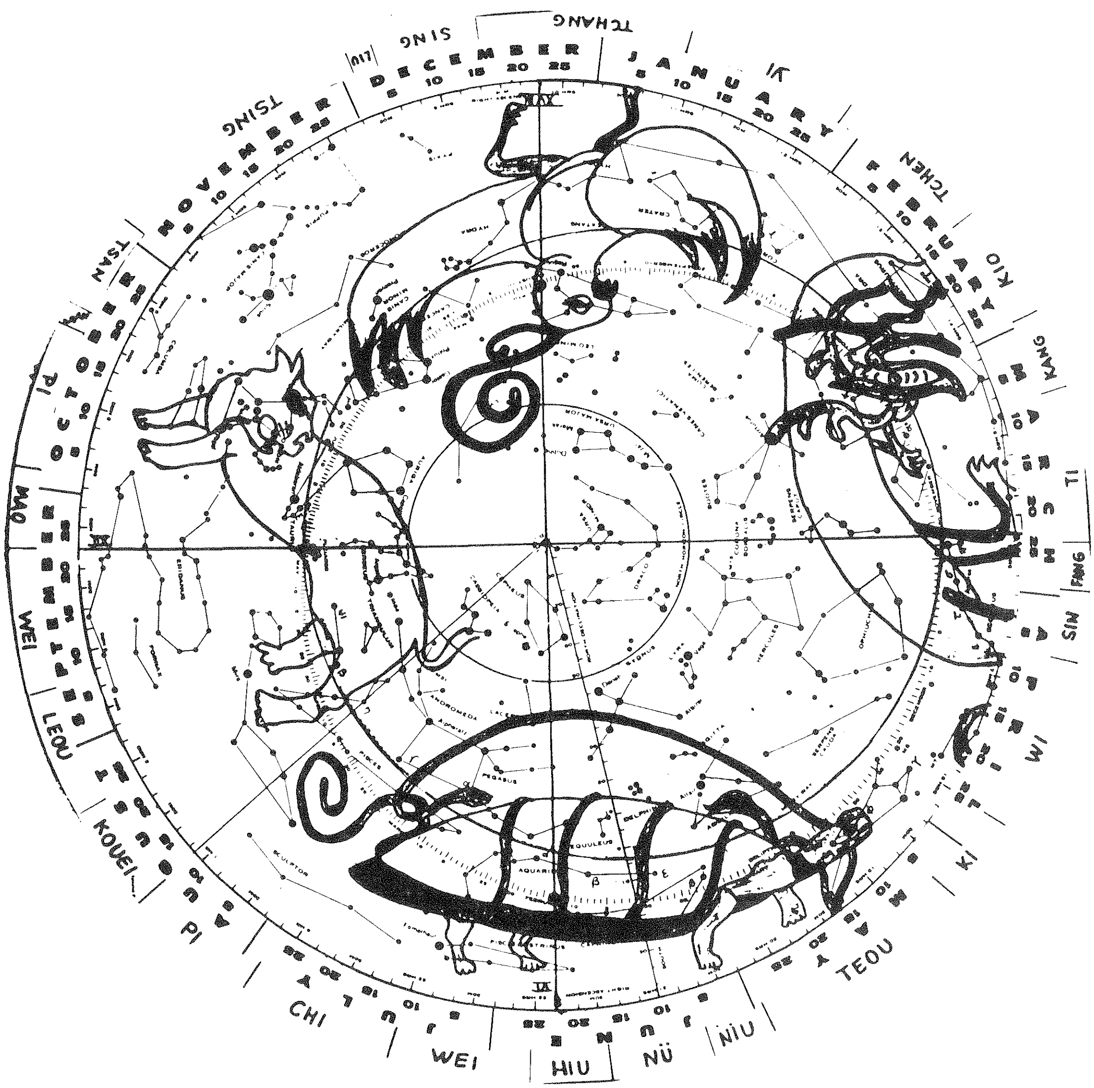
Whether dragons are fabled animals or not, the Chinese believed in them and claim that high in the mountain caves, fossils have been found that can only be those of dragons.[5]

The dragon is always seen closely connected with the watery elements; mud and rain are apparently his favorite habitat. There is a story about a certain FANG-KOUAN, who happened to be in the Nan Mountains, when he suddenly heard a noise like copper bells being beaten by iron lances. He asked some old people what this might be and they told him that it was the song of the dragon and that the rains would soon begin to fall. KOUAN went out to see for himself and there he saw the clouds whirling all over the sky and a heavy rain started to fall. KOUAN listened once more and assured himself that his ears were not deceiving him.

The Chinese thought that the dragons laid their eggs in the earth where they remained for a thousand years before hatching. On the day that they crawled out of their shells floods and inundations occurred everywhere. The Chinese connected these floods with the birth of the dragons. But actually it is the other way around. At that time of the year the rains began to fall

[4] Zeiss constellation outlines described in this paper are obtainable from Carl Zeiss, Inc., 444 Fifth Ave., New York, N.Y. 10018. To the best of our knowledge, this is the only source available, the slides having been designed by the late Dr. Helmut Werner of Carl Zeiss, Oberkochen.

[5] Needham, Science and Civilization in China, Vol. III, Section 23, p. 621.



causing floods and the dragons (probably some type of crocodiles) who had been hibernating in the mud began to wake up, rising out of the mud which started to crack open like egg shells.

Thus came the idea of the birth of the dragon at the spring equinox and the going into hibernation of the dragon at the autumn equinox. So the Blue Dragon became the symbol of the productive force of humidity, of spring when through abundant rains the whole of nature renewed itself and put on a new face. The sun passing into the constellation of the Blue Dragon at the spring equinox became the emblem of springtime and the Blue Dragon itself was symbolically seen as the Sun.

An ancient Chinese dictionary, the CHOUO-WEN says that there were 360 scale animals and that the dragon was the chief one. This meant of course that there were 360 degrees in the sky route of the sun and that the dragon, being the chief one, was the first degree or the starting point of the sun's annual journey through the sky. The dragon being the sovereign sun symbol was placed in the east. Its heliacal rising announced that spring was in the land.

Springtime was the awakening of nature. Man also awakened from his semi-hibernation. He no longer needed to be afraid of attacks from neighboring barbaric tribes. He could start thinking about ploughing and fertilizing his fields. There were preliminary festivals, leading to the Equinox ceremonies. The Imperial Palace also awakened to get ready to receive the new spring sun. New children were born and the Empress, concubines and nurses would be busy in the palaces. The army spruced up and generals inspected their troops.

Finally when the sun reached the Equinox in the shiu (house or mansion) of FANG, the doors of heaven were unlocked to welcome the new spring sun and on earth parallel ceremonies were held to bring offerings to the new spring sun and to do homage to his powerful and invigorating dominance.

The Blue Dragon of spring is subdivided in seven shiu as follows: (1) KIO shiu - the house of the horn, the star Spica; (2) KANG shiu - the house of the neck, the stars μ, ι, κ and λ Virginis; (3) TI shiu - the house of the foundation, the stars α, β, γ, and ι Librae; (4) FANG shiu - the house of the heart, the stars Antares and σ and τ Scorpionis; (6) WI shiu - the house of the tail, the stars ε, μ_1, μ_2, η, θ, ι, κ, λ and υ Scorpionis; and (7) KI shiu - the house of the manuring or winnowing tray, the stars δ, η, ε, and γ Sagittarii.

The seven shiu have between them 33 paranatellons. All these asterisms represent the spring palace. Each paranatellon has a special task or ritual. To give one example, the first paranatellon of the house TI, was called T'IEN-JOU, celestial mild, made up of one single star, namely - Serpentis. The Queen or Empress and concubines did not feed their children themselves, but special nurses were set aside to look after the young ones. The asterism is thus the guardian star over the feeding of the babies and later, when they had grown older and could eat sweets and pastries, it consequently also presided over the delicacies and confectionary in the palace. If the star appeared clear and bright, the weather man would forecast the red morning sky, occasional showers and mild rains of spring. When T'IEN-JOU culminated it was thus time for the imperial nurses to get busy.

THE RED or VERMILLION BIRD

In the summer palace lives the RED BIRD. The Chinese word for it is TCHOU-NIAO. On our star maps it occupies the constellations GEMINI, CANCER, HYDRA, and CORVUS. (Zeiss Constellation Box C, No. 9, colored red.)

The red bird represents the essence of heat. The red[6] bird was the phoenix of China. The blue phoenix was called HO, the red phoenix CHOUN, the yellow phoenix or quail YEN, the white phoenix SOU and the pink phoenix TSO. All these species were combined into one collective name TCHOU-NIAO, Bird of the Sun, or Bird of Summer, red being the color caused by the sun.

There were many descriptions of this bird, but the following may serve as a representative cross section. He had the head and beak of a chicken; a long neck like a serpent's; the feathers overlapped like the scales of a tortoise. The colors ranged from dark green for the head and neck; the inner part of the throat and the beak were purple violet; the wings and the rest of the plumage steel blue; the back part was white; the tail reddish brown; while on his head he carried a crown of green feathers shot with gold. Such a magnificent bird justly deserved the name "King of the Birds" and so he became representative of the king of the solar system....the Sun and consequently the essence of heat.

Other Chinese authors refer to him as the pheasant and also the quail. This is the reason why (when we study the second division of the sky in which each of these great sky animals is subdivided into seven shiu, such names as "Head of the Quail" or "Fiery Heart of the Quail" can be found.

There are apparently two types of quail, the red quail and the white one. The one in question here is the red quail whose habit it is to appear mysteriously on the scene in summer and equally mysteriously disappear again in the autumn. Their arrival announces that the summer is in the land. This indicated that the crops, which were planted in spring (when the Sun moved through the Blue Dragon) were beginning to ripen and mature. The beginning of summer was announced by ancient astronomers when the tail of the Blue Dragon began to fade at heliacal rising (i.e. the sun enters the Black Tortoise). In the evening they then waited for the first appearance of NIAO

[6]The red phoenix of China. This can be found in Schlegel's Uranographie Chinoise, Volume I, Chapter V, page 69-72, La grande constellation estivale TCHOU-NIAO or L'oiseau rouge or le FOUNG est le phenix de la Chine....etc.

or our Alphard (α Hydrae) in the southeast, when the Red Bird began to ascend into the summer night sky, culminating in the south, hence his title "Great Southern Constellation of Summer".

The Red Bird of Summer is subdivided in seven shiu as follows: (1) TSING shiu - House of the well, the stars λ, ζ, ε, ξ, γ, ν, and μ Geminorum; (2) KOUI shiu - House of spirits, the stars δ, σ, η, and θ Cancri; (3) LIEOU shiu - House of the willow, the stars θ, ω, ζ, ε, δ, σ, η, and ρ Hydrae; (4) SING shiu - House of the asterism, the stars ι, τ_1, τ_2, α, 26, and 20 Hydrae; (5) TCHANG shiu - House of the net, the stars ν, o, μ, υ, κ, and λ Hydrae; (6) YI shiu - House of the wing, the stars α, β, γ, ζ, η, δ, ι, κ, ε, and θ Crateris; (7) TCHIN shiu - House of the chariot, the stars β, γ, δ, η, and ε Corvi.

These seven shiu have between them 61 paranatellons. All these asterisms represent the Summer Palace. To give an example, the 18th paranatellon of the House of TSING is T'IEN-LANG, the celestial jackal consisting of one star, namely Sirius. In the month of May the corn was already level high with the surrounding dykes. The jackal loved to hide in the tall corn where he hunted for unsuspecting birds, especially quails and pheasant. At night he went out prowling around farm yards and workers cottages to steal chickens. The kings of China organized hunting parties to get rid of these pests. To follow the spoor was easy because the jackal had already flattened the corn and this would lead the hunters to its lair. These summer hunts were known as MIAO which Schlegel says come from the Chinese character 苗 which was made up of 艹 plants and 田 field, in other words the plants coming out of the field. As the hunts were held in the high standing cornfields, they were also named MIAO.

THE WHITE TIGER

In the Autumn Palace lives the White Tiger. The Chinese call him PAI-HOU. On our star maps he occupies the constellations Andromeda, Aries, Musca Borealis, the Pleiades, Taurus and Orion. The tail end is in Aries, the head and forepaws in Orion. (Zeiss Constellation Box C, No. 50, colored white.)

The Chinese pictured in the autumn sky a huge white tiger constellation. They believed that tigers grew very old, could attain an age of one thousand years, and it was only after his 500th year that he became white. Like the Blue Dragon, the White Tiger was supposed to be a benign and kind animal, who - it was said - never ate living things but only fed on carrion. However, nearly all other Chinese authors agree that the tiger was cruel and ferocious and they called him "King of the Four Footers". Since he was the prince of the mountains, he was also named "King of the Mountains".

He was considered a sun animal. As the chief of all other animals he howled like the rumbling thunder so that all the beasts feared him and trembled at the sound. Wherever he went, the winds followed him.

The reason for having a tiger in the sky is easily understood. The summer is over, and the nearly intollerable heat is followed by a refreshing breeze. But this does not last for very long. Soon they would be followed by autumn thunderstorms which with raging fury would strip the trees and plants of their foliage so they were made to whirl in space, dry up and shrivel away.

The coincidence of the east winds and the appearance of the tiger in the open country side had given rise to the idea that the wind followed the tiger, while in fact the tiger was forced out of the woods through the drying winds and thus actually followed the winds.

The tiger's appearance on the scene served as a reminder for the people that autumn was in the land, so naturally the stars which appeared during the three months of autumn in the western sky were designated as the stars of the White Tiger.

Another reason for placing a deadly tiger in the sky was that to the Chinese the autumn was the period of decay of nature on earth and of the Sun in the Sky. So they saw a tiger symbolically as the killer of nature during autumn.

The White Tiger of autumn is subdivided in seven shiu as follows: (1) KOUI shiu - House of the sandal, the stars η, ζ, ι, ε, δ, π, ν, and μ Andromeda and σ, τ, L, υ, ϕ, χ, and ψ Piscium; (2) LEOU shiu - House of the reapsters, the stars α, β, and γ Arietis; (3) WEI shiu-House of the grainstore, the stars 35, 39, and 41 Arietis; (4) Mao shiu - House of the setting sun, the Pleiades; (5) PY shiu = House of the net, the Hyades; (6) TSOUI shiu - House of the mouth, the head of Orion; (7) TSAN shiu, House of the supreme Army commander, Orion.

These seven shiu have between them 42 paranatellons. All these asterisms represent the Autumn Palace. To give one example, the third paranatellon of the House of LEOU was called T'IEN-CHOUEN, the celestial ship, composed of the stars of Perseus (μ, 48, 89, δ, ψ, α, 128, γ, and η). It lies in the Milky Way or celestial river which is the correct place for a ship or boat.

At the time of our discussion (15,600 BC) this ship sets in the evening at the end of the month of August, beginning September, i.e. at the time of the great inundations caused by torrential rains against which dikes were no positive safe guards. They would often break away, thus flooding the fields. Communications were disrupted, and the only means of conveyance was by boat.

The asterism was thus a reminder to make the boats and canoes ready for the flood season. Chinese astrologers maintained that when this asterism was not visible in the Milky Way, it was a bad omen that the passage of fords and rivers would soon be interrupted and that great floods were due. Schlegel gives an account that he was present at such a flood on 28th August 1859 when he travelled by sampan or canoe through the streets of Emoui, when because of a typhoon the water had risen 22 feet above normal level.

The invention of the ship was apparently lost in the oblivion of remote times in China. However, a broken canoe was found in a pond situated on top of Mount WOU-FANG in TOUNG-HOA. Tradition said that it was the canoe in which emperor YU (of flood control fame after the great inundation) was supposed to have come.

Legend has it that the idea of making boats came to man when he saw leaves fall on the water and float away with the stream of a river without sinking. The asterism presided over crossings, canoes, boats and oars.

THE BLACK TORTOISE

In the winter palace lives the Black Tortoise. The Chinese call him HIOUEN-WOU. On our star maps he occupies Sagittarius (Milk dipper) Capricornus, Aquarius and Pegasus. The head is in Sagittarius and tail end in Pegasus (Zeiss Constellation Box A, No. 47, colored white).

The tortoise has figured in the most ancient antiquity of China and was considered a divine animal through which one sought to discover one's destiny. In the winter the sun reached its lowest point in the ecliptic when for a week or so it lingers without rising or falling much in altitude above the horizon at noon. The tortoise is a slow animal which cannot move unless with excessive tardiness. This therefore represented the tardiness and lingering of the sun very well.

A Chinese fable tells us that to the west of the YOUEN-KIAO mountains lies the lake of stars which is 1000 Li long (one league = 13 1/2 Li). In this lake was a divine tortoise with eight feet and six eyes. On its back it had the image of the northern bushel (Big Dipper) as well as the sun, the moon and the eight regions of the heavens. On its stomach it had the image of five peaks and four canals.

The top part is round and imitates the sky. Underneath it is square, imitating the earth. The lines form constellations.

The tortiose - say the Chinese - follows the revolution of the light of the sun. It turned its head to the east in the morning and to the west in the evening.

The Chinese also knew that tortoises could grow very old which was the origin of the belief that it knew everything and therefore could foretell the future. The tortoise would always be consulted before undertaking any enterprise.

Because the tortoise was a cold and tardy creature, it was adopted as the symbolical animal for the cold, tardy and slow winter sun. As the tortoise buried himself during the winter, it served as a living calendar to indicate the season and the apparent death of the sun.

Very ancient cosmogenies talked about an immense old tortoise, attaining a length of 25 feet. It should have existed before the beginning of the sky and earth. These cosmogenies said that this tortoise was born from the dragon at the moment of the separation of chaos.

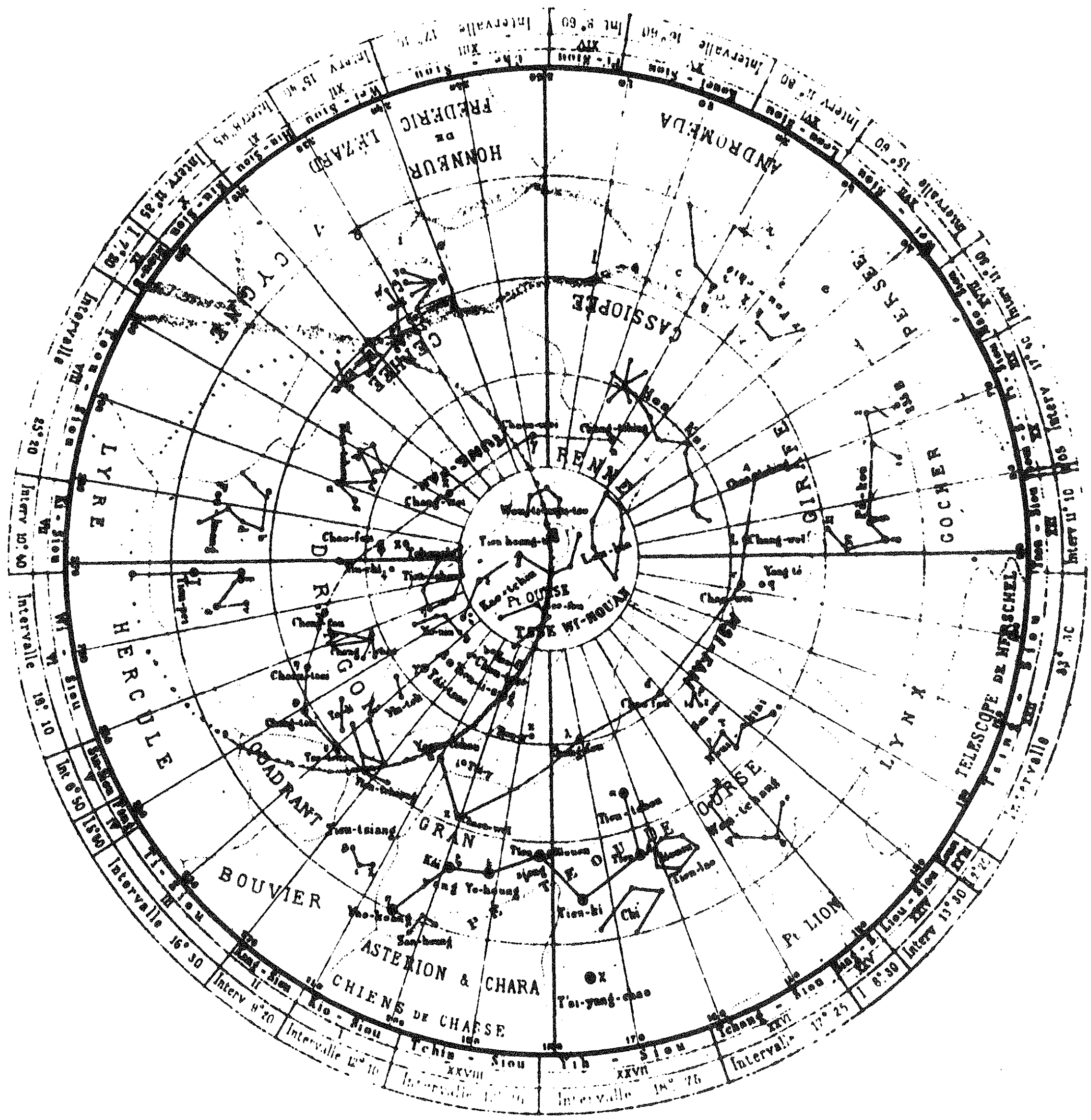
Now it so happens that the tail of the dragon (the house KI) touches the head of the celestial tortoise which was probably the reason for the belief that the tortoise was born from the dragon.

During the long winter's night the tortoise crawls high in the sky sprawling from Sagittarius through Capricornus, Aquarius to Pegasus. Every shiu therefore could be seen easily to culminate as the winter progressed. Each shiu and its paranatellons had a message or ritual to tell.

The Black Tortoise was subdivided into seven shiu as follows: (1) TEOU shiu - House of the bushel, the stars μ, λ, ϕ, σ, τ, and ρSagitarii; (2) NIOU shiu - House of the ox, the stars α, β, ξ, o, π, and ρ Capricorni; (3) NIU shiu-House of the virgin, the stars ν, μ, and ε Aquarii; (4) HIU shiu - House of the funeral hill, the stars β Aqa and α Equulei; (5) WEI shiu - House of the apex, the stars α Aqua and α and β Pegasi; (6) CHI shiu - House of the pyre, the stars α and β Pegasi; (7) PI shiu - House of the wall, the stars α Andromedai and γ Pegasi.

The seven shiu have between them 51 paranatellons. To give one example, the eighth parana-

CARTE DU FUSEAU TSSE-WI-HOUAN



tellon of the house of HIOU was called TCHI-HIU the weaving girl, consisting of α Lyrae (vega), and α and ζ Lyrae. This is the famous girl of the story of the weaving princess with her cowherd lover KIEN-NIOU, the star Altair on the other side of the Milky Way.

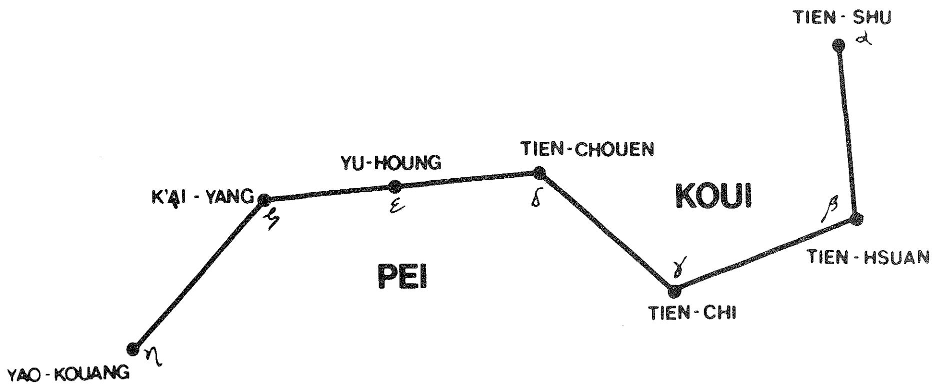
The culmination of the star announced the 10th Chinese month (November). During this month the women, who had all helped with the reaping during harvest time, were now to begin the woman's works. During the long winter nights when there was nothing else to do outside and while the men were out hunting or fighting wars, the women locked themselves in and busied themselves with the weaving of clothing for their husband and children.

This concludes a brief and sketchy description of the four palaces and the four sky animals of the four seasons that reside in them. To complete the picture, one has to imagine the central palace above these four palaces. From here the directives are given by the Celestial Emperor. Schlegel does not mention anything about the Central Palace of the early epoch we have been talking. History he says is silent about this. But in 3000 BC the Chinese were is possession of astronomical instruments, and the peasants wanted to have a natural calendar. The astronomers were aware that the ancient groups no longer corresponded with the periods which they used to indicate. The names were religiously reserved as venerable relics from time gone by. It was, however, necessary for the people to have fixed signs to determine the principle periods of the year, especially the winter solstice (beginning of the year) and the spring equinox. This need gave birth to the naming of new asterisms. I will indicated only a few interesting asterisms of the Central Palace in this article, namely what we know as the Big Dipper, and the Pole star of that period.

Referring to the attached map "Carte de fuseau TSSE-WI-HOUAN, I have indicated the precession circle. Allowing 1° for every 72 years that have passed for recession to shift, we can plot backwards about 70° from our present pole star (T'IEN - HUANG-TA-TI) Polaris to find that the North Celestial Pole in 3000 BC was close to α Draconis.

The Chinese had a name for the area around the Pole star, namely TZU-WEI-YUAN. The purple forbidden enclosure of which the eastern wall TUNG-FAN was made up of the stars ι, δ, ζ, and ϕ Draconis, κ and γ Cephei and 21 Cassiopeiae, and the western wall HSI-FAN of the stars α, κ, and λ Draconis, 24 Ursae Majoris and 43, L, and α Camelopardalis.

The gap between α Draconis and ι Draconis was called TZU-KUNG-MUN, gate of the purple palace and ι Draconis was called YEOU-SHU, right pivot. (On the map another spelling is used, Tso-Tchou and Yeou-Tchou.) The North celestial pole of 3000 BC would have been exactly on the line connecting



PEI – TEOU

Northern Bushel

ι and α and at the point where it intersects the precession circle, very close to α Draconis.

By about 1000 Bc the pole had shifted and Kochab (β Ursae Minoris) now functioned as pole star although it was a good 5° from the precession circle. The Chinese do not see Ursa Minor as we do. They see a string of stars starting with γ Ursae minoris (T'AI-TZU, the crown prince), then the Imperial star himself, β Ursae minoris (T'IEN-TI-HSING), then the star 5 Ursae minoris (SHU-TZU, son of the Imperial concubine), then the star 4 Ursae minoris,(CHENG-FEI, the Imperial concubine) and lastly T'IEN-SHU a small 6th magnitude star close to the precession circle. This must have been the pole star of the late Han period.

<u>THE BIG DIPPER</u>

The asterism is composed of seven stars which correspond to the stars of our dipper but the names are quite different. The dipper itself is known as KOUI, the Chiefs and the handle as Pei or PIAO, while the whole of the dipper is called PEI-TEOU, Northern Bushel.

α	Dubhe	T'IEN-SHU, Celestial Pivot
β	Merak	T'IEN-HSUAN, Celestial template.
γ	Phecda	T'IEN-CHI, Celestial armillary.
δ	Megrez	T'IEN-CHOUEN, Celestial balance.
ε	Alioth	YU-HOUNG, Jade observation tube.
ζ	Mizar	K'AI-YANG, Opener of the heat.
η	Benetnash	YAO-KOUANG, Scintillating brilliant one.

It was also known as TI-TCHE, Emperor's chariot. The Chinese had devised a system whereby they could tell the season by looking at the position of the handle of the dipper at night after sunset. For the epoch of 3000 BC the following holds good:

When in the evening the tail points to the east it is spring.

When in the evening the tail points to the south it is summer.

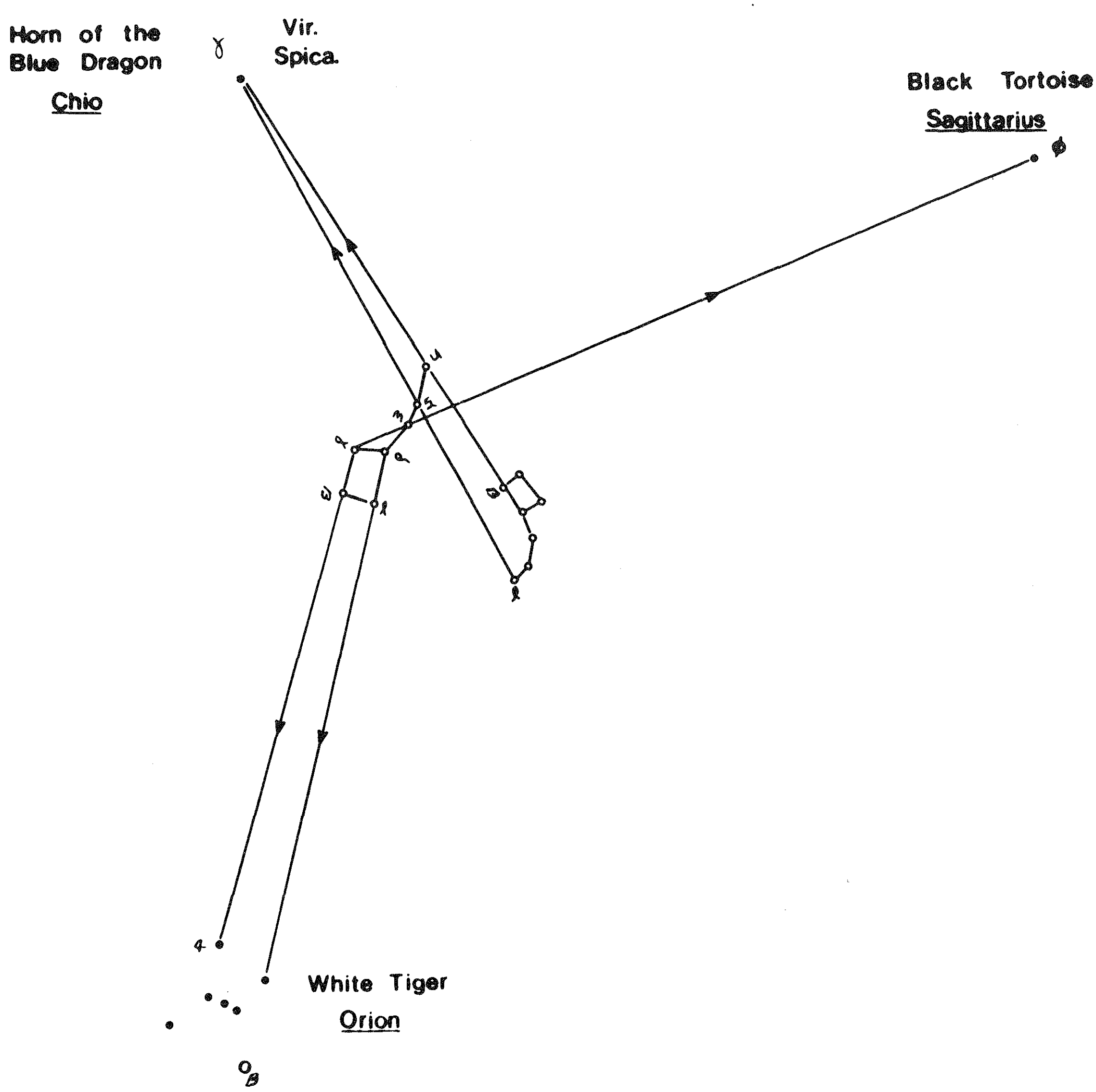
When in the evening the tail points to the west it is autumn.

When in the evening the tail points to the north it is winter.

If one goes deeper into the polar-equatorial system with the determinative stars keyed in to certain circumpolar stars one will find an interesting role being played again by the dipper. I am not going to discuss the system in detail, but this one instance is rather interesting introduction.

Connect Polaris through ζ Ursae Majoris and also Kochab through η Ursae Majoris. Both lines will point to Spica which is KIO, the horn of the Blue Dragon. Extend δ, α and λ,β Ursae Majoris, and both lines will point to Orion, the Head of the White Tiger.

Connect λ and ε Ursae majoris and the line will point to ϕ Sagittarius, a star in the shiu called TEOU of the head of the Black Tortoise. There does not seem to be anything on record for the Red Bird. This is rather odd because a line from Kochab through α Ursae majoris points exactly to Alphard, the heart of the Red Bird.



Andrews and Moore, the Richmond get-'em-up-in-the-morning team at WRNL radio, came up with these goodies one day recently, under the heading of things kids say about science: "The best thing about being in our solar system is night and day"; "It takes the earth 24 hours to roll over once"; "Astronomy is when you look up at the sky and see stars; astrology is when you look up at the sky and see lions and virgins and other spooky creatures".

For those of you who missed it in the February, '73 Reader's Digest:

The main hall of the Hayden Planetarium was filled with youngsters as the lights dimmed and the magnificent star show began. The narrator introduced his talk to the hushed, awed audience by stating that on a clear night one can see 5000 stars in the sky. From the first row came a small voice: "One, two, three....."

The narrator, recovering gamely, said, "Well, most people take our word for it."

- Contributed by Walter C. Ebmeyer

My uncle, a Wisconsin farmer, spent a holiday in Los Angeles, where he paid his first visit to a planetarium. "First you see that sky," he told me enthusiastically,"and all those little houses all around, like we were sittin' in a field in the center of the city lookin' up at the sky. And then it starts gettin' on to twilight so real it beat all get out. And then, by golly, that quarter moon shows. I tell you I never saw the moon more real than that. Then it started gettin' darker and got to real dark, and the stars come out like I've seen 'em a thousand and one times. Well I tell you!" He shook his head, overwhelmed, and fell silent.

"Then what happened?" I asked.

He came out of his bemused wonder and replied, "What happened? Why, I went right to sleep."

- Contributed by Sam Locke

Jane's Corner

BY

Jane P. Geoghegan

Send your "happenings" to Jane Geoghegan, 4100 W. Grace St., Richmond, Va. 23230

Undimmable Spider
by Ken Perkins, Director

Usually animals can be removed from the planetarium dome with the turn of a dimmer knob or at least the flip of a switch. Not so with a spider that appeared on the plaster dome of the planetarium of the Vandalia-Butler City Schools, Vandalia, Ohio.

On a Monday or Tuesday a spider was spotted a meter or so southeast of the Zenith. By Friday it had moved an equal distance north of the zenith and then lingered not too far from the zenith through several programs including a psychadelic light show for a mod English class.

Finally, the spider was removed humanely with an instrument consisting of three long cane fishing poles, two at the lower and one sticking out at the top, all lashed together with masking tape and topped by an inside-out loop of the same sticky masking tape. A light touch was all it took.

For a six meter ride the spider was safely hauled down from the artificial sky. With the loss of only one leg of eight it was carried outside to a better food supply.

September 12, 1973

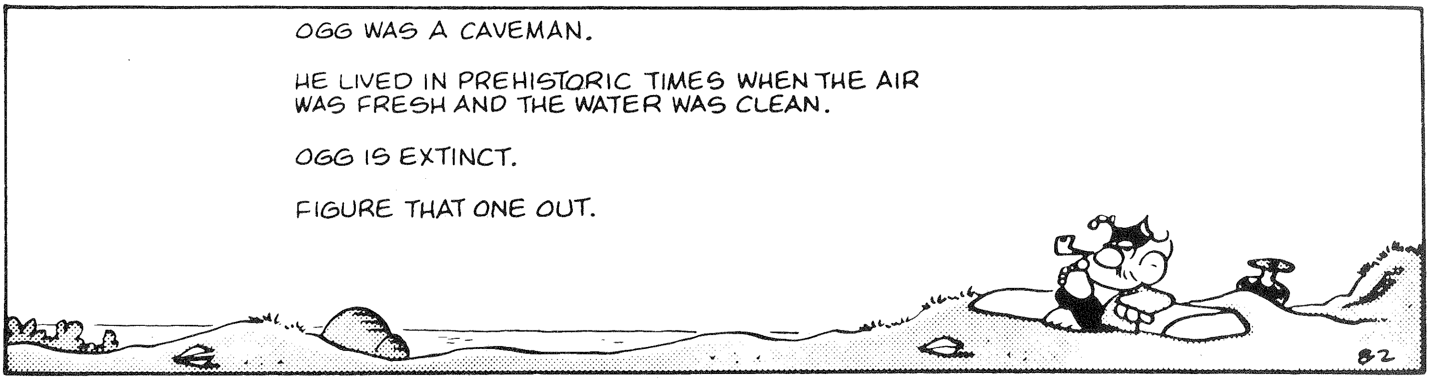
To all PLANETARIAN subscribers:

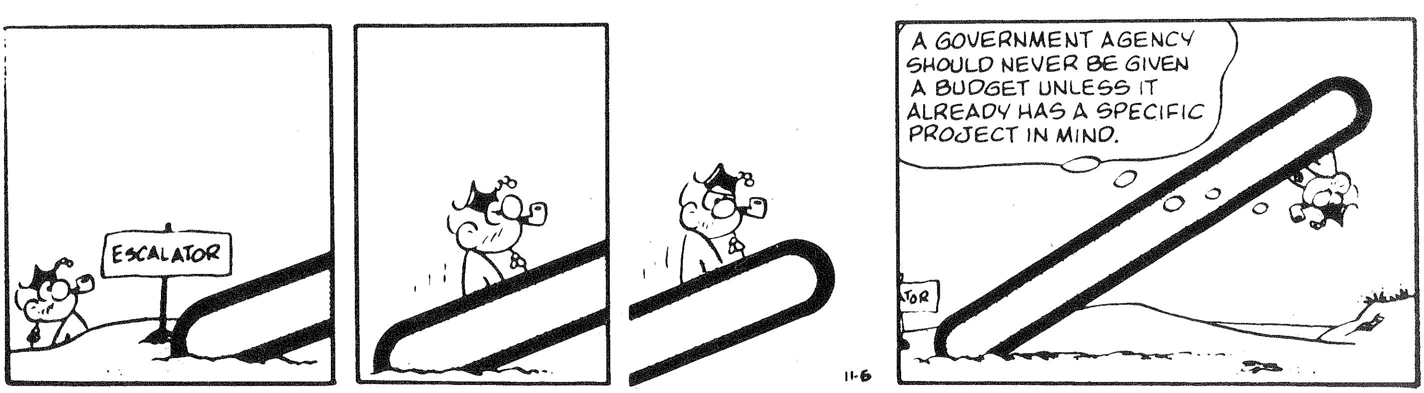
I think the new format is a dirty trick to get me to think of more"stuff" to put on this page. How about helping me out and sending items for <u>your</u> page?

I can't believe that nothing is happening out there in "Fake Sky-Land". Say to yourself 10 times "My page is dying, my page is dying......" There! Don't you feel ashamed? Invest 8 cents in its future.

Jane's Corner is featuring this time several of James Childress's strips, "Conchy", as some of you seem to enjoy him as much as I do. Mr. Childress's home base is the Charlotte (N. C.) News and Observer and his strips also appear in other newspapers around the country; in case you missed them, here goes:

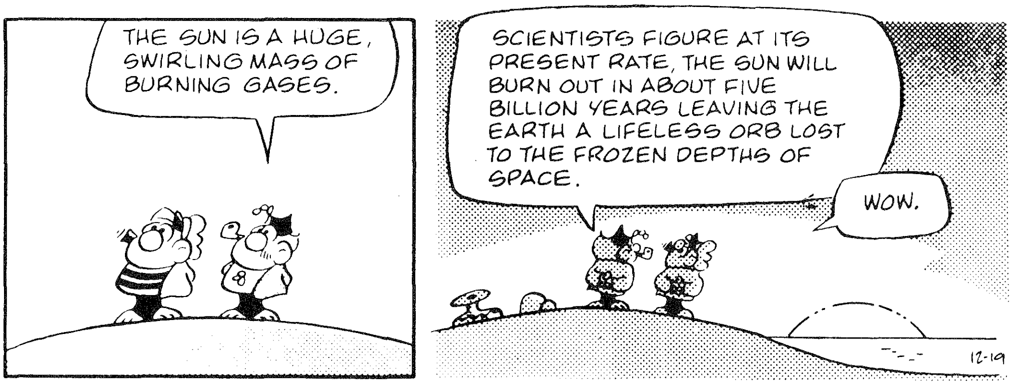
Conchy

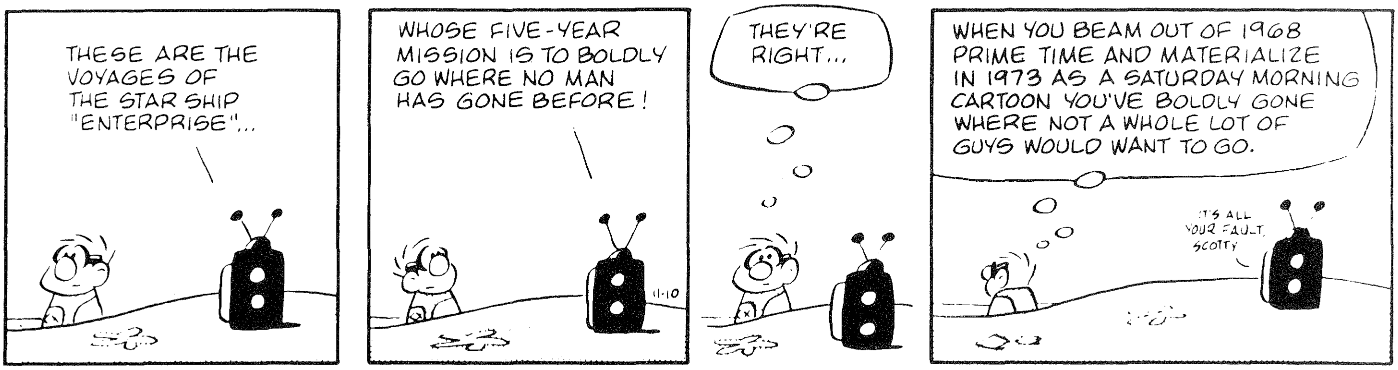


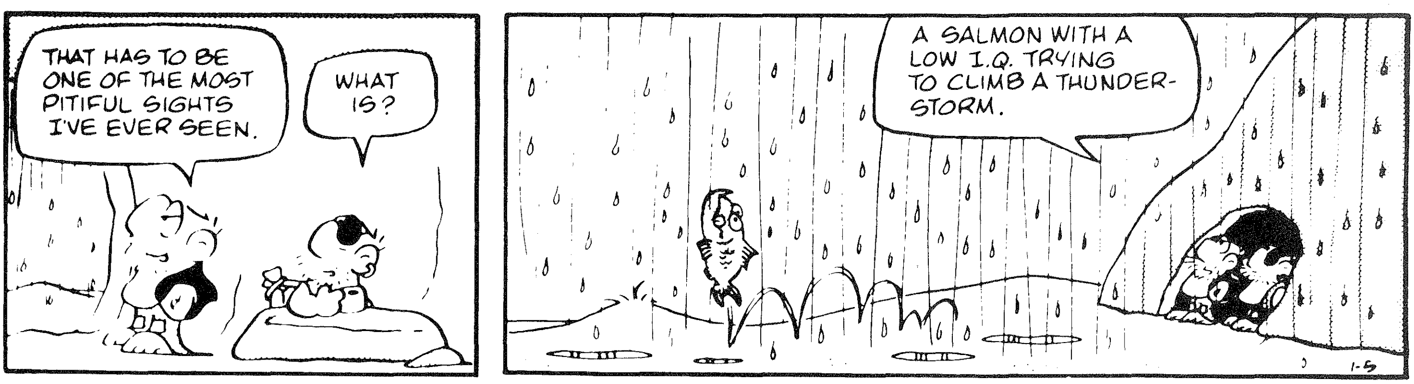


"Conchy" reprinted with permission of James Childress

Conchy

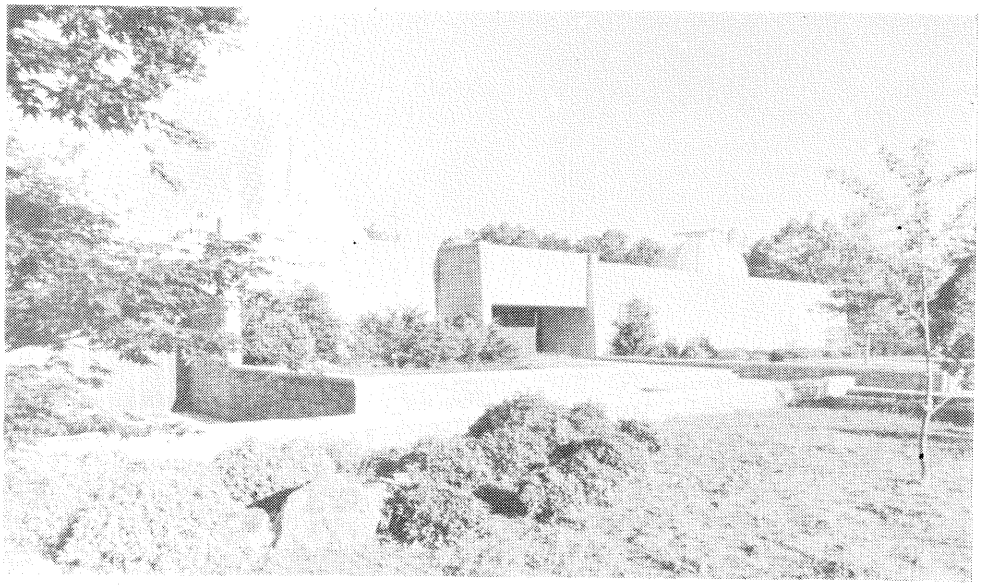






"Conchy" reprinted with permission of James Childress

Planetarium's on Parade



Fernbank Science Center's Planetarium dome, left, and observatory are well-known Atlanta landmarks.

FERNBANK SCIENCE CENTER

THE DEKALB COUNTY SCHOOL SYSTEM, ATLANTA, GEORGIA

by Kay Davis, *Administrative Coordinator, Fernbank Science Center, Atlanta, Georgia*

Owned and operated by the DeKalb County School System, Fernbank Science Center Planetarium is an integral part of one of the most extensive science education resource facilities in the country. The Center's overall emphasis is innovative education in both the life and physical sciences, and nowhere is this more successfully apparent than in the Fernbank Planetarium. Since 1967, the Center and planetarium have provided comprehensive instructional programs for students, teachers and the general public.

Beginning with the second grade, the planetarium instructional format extends to the graduate level, and offers a specifically designed sequence of programs. Included are special education classes for EMR, TMR, deaf and partially sighted students. Public presentations are offered in the evenings and on weekends. In 1974, the planetarium will present ten different programs for the public, including the popular Saturday morning, "Here, There, Everywhere," based on actual astronomical events occurring within the immediate weekend.

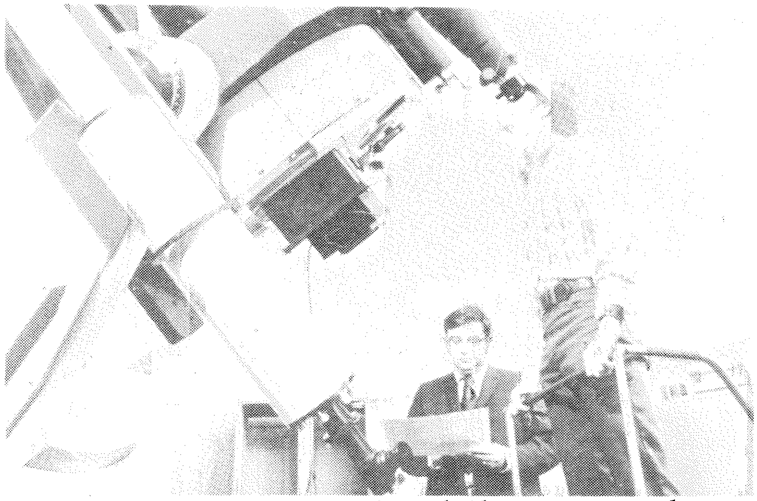
Beneath a 70-foot diameter dome, a Zeiss Mark V projector, with auxiliary projectors and Zeiss horizon system, allows the staff the flexibility needed to conduct the many different kinds of programs carried out year round in the Fernbank planetarium, which seats 500.

At the opposite end of the main Center complex is the Fernbank observatory. The 36-inch reflecting telescope is the largest in the world used by a public school system for general viewing, photography, photometry, spectroscopy, and satellite tracking. Although it is opened to the public on clear Friday evenings, the observatory is primarily a classroom for students of all ages and degrees of accomplishments.

Entrance to the planetarium is through the Center's main exhibit hall, where Fernbank's museum staff has created exhibits and dioramas which cover all aspects of science education. A reference library, meteorology, electron microscope, radiation, chemistry and environmental preparation laboratories, along with classrooms and staff offices are also housed in the main Center. At the rear of the Science Center is Fernbank Forest, a 65-acre relatively undisturbed living laboratory for students and the public.

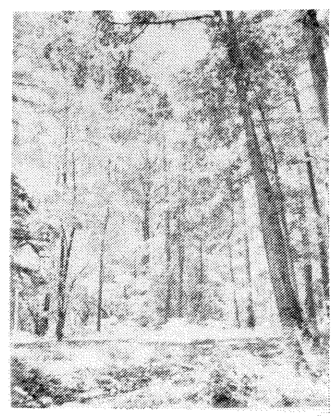
Fernbank Science Center's other major resources include a museum department, horticulture department with greenhouses and gardens, and geological, chemical, physical and computer facilities.

Co-hosting the October, 1974 International Society of Planetarium Educators Conference, the Fernbank planetarium staff extends a hearty welcome to Atlanta and Fernbank Science Center.

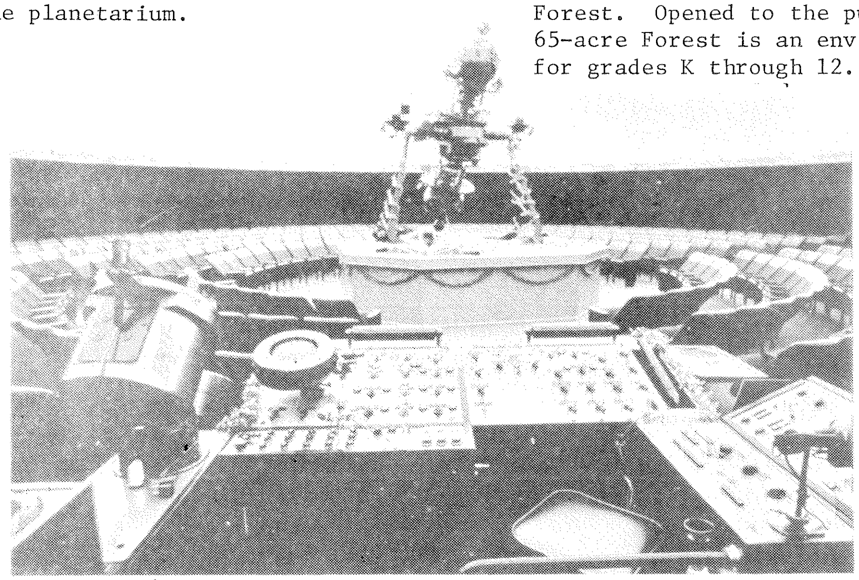


Fernbank's 36-inch reflecting telescope, used in daily astronomy classes, is also part of the Center's "Project Moonwatch," which relays satellite tracking information to the Smithsonian Astrophysical Observatory in Cambridge, Massachusetts. Dr. Ralph Buice, and student Ronnie Lee check calculations.

Staff artist Alyce Land prepares the numerous skylines for the planetarium.



Adjacent to the Center is beautiful Fernbank Forest. Opened to the public year round, the 65-acre Forest is an environmental laboratory for grades K through 12.



The DeKalb County School System's planetarium is the only major planetarium in the U.S. owned and operated by a school system and dedicated to teaching and public enrichment.

Co-Editors: Frank C. Jettner and Von Del Chamberlain. This series was originally conceived as a first-year, graduate level textbook in planetarium education, written by the leading specialists in the field. Installments will appear in each issue of THE PLANETARIAN until completion. It is suggested each installment be removed from the centerfold, punched, and stored in a looseleaf binder for future reference. ISPE and the Co-Editors regret they cannot furnish special binders for this purpose. Questions regarding the text matter may be directed to either Co-Editor or the chapter author.

Editor: It was our sad duty to announce the death of our beloved colleague, Harry E. Crull, Ph.D., on April 25, 1972 at Albany Medical Center. He was survived by his widow Edna; daughters Mrs. Harold Smashey of Olney, Illinois and Mrs. Donald Boger of Nashville, Tennessee; son Harry Jr. of the U.S. Naval Observatory, Washington, D.C.; and seven grandchildren.

At his death, Dr. Crull was Professor of Astronomy & Space Science of the State University of New York at Albany and director of the Henry Hudson Planetarium Project. He was born on February 7, 1909 in Chicago, Illinois and educated in the Maywood, Illinois schools. He then attended the University of Illinois and earned the B.A., M.A., and Ph.D. (1933), majoring in mathematics and astronomy.

Prior to joining the SUNYA faculty in 1965, Prof. Crull served as Prof. of Mathematics and Astronomy and Observatory Director at Park College, Parkville, Missouri (1937-47). He then became the founding Director of the Holcomb Observatory and Planetarium, sometime Director of University College, and Professor and Department Chairman of Mathematics and Astronomy, all at Butler University of Indianapolis, Indiana (1947-65). Rising to the rank of Captain (USNR Ret.), he served as ship's navigation officer and navigation instructor during World War II, and thereafter, he fostered an active teaching interest in Marine Navigation. This culminated in his teaching manual still in use at SUNYA. In his last years he became a pioneer in the popularization of astronomy through television. His course, "Eye On The Universe" was shown many times by the NYS Public Broadcasting System's "University of the Air" and is still used on several campuses in the SUNY system as a one semester descriptive astronomy survey.

Those involved in planetarium education miss the penetrating wit and skill of this gentle man. He was noted as a pioneer and continuing contributor to our rapidly developing discipline, dating back to his first participation as a lecturer at the newly opened Adler Planetarium in Chicago in 1933. He served as Asst. Director of the Griffith Observatory and Planetarium in Los Angeles in 1935-36 and loved to tell stories about his association with Armand Spitz while at the Fels Planetarium in Philadelphia about the same period. His dream to found a school of planetarium education remains with this writer.

We are pleased to here present the last writing of Harry Crull as the fourth chapter of Principles of Planetarium Operation. The chapter gives the kernel of his favorite planetarium lesson but without trying to formalize it into a specific format.

Celestial Navigation

by Harry E. Crull, *State University of New York at Albany*

Celestial navigation can nowhere be taught more efficiently or more easily than in the planetarium. The basic identification of the stars and planets, their motions, most of which are of course merely reflection of terrestrial motions, the change in the aspect of the sky with change of latitude, the astronomical triangle, the concepts of altitude and azimuth, all of which are so easily demonstrated and explained with the planetarium are the bread and butter ideas of celestial navigation.

Navigation is the *art* of finding one's way about on or near the earth's surface. In its rudiments it is a very ancient art and perhaps originated, as did so many of man's early accomplishments, in the Near East. However progress in early navigation was slow, and the methods long remained primitive. We hear persistent myths regarding the prowness of ancient navigators, but such yarns must be taken with more than the proverbial grain of salt. Remember that the incompetent or unlucky navigator is the one that is never heard from again, and the occasional returning early sailor may well have owed his success to luck rather than competence.

(*EDITOR*: In these times it is fun to extend this historical definition to include modern space navigation. But while many ideas do extend along, Dr. Crull thought that mixing orbital mechanics, perturbation theory, and other such notions into his navigation chapter to do a reasonable job was totally out of order. In a future chapter we'll tackle space navigation in its own right.)

Earliest navigation consisted of hugging the shoreline, watching for shoal water or breakers ahead, and beaching the boat at dusk to spend the hours of darkness in the safety of a shore camp. For ages, venturing out of sight of land was virtually suicidal, and only for the last few millenia have navigators boldly (or timidly) sailed the deep blue waters of even such circumscribed inland seas as the Mediterranean.

The basic *modus operandi* of all navigation is the same. One determines his position by measuring objects of known location and deducing where he, the observer, must be for these objects to have their positions as observed relative to him. Illustrations are many even in every day life. How frequently we tell a friend "Turn left at the school house, go two blocks south and five west. My house is the red brick." In its simplest application this is navigation, presuming of course the friend recognizes the school house and knows his directions.

Of course the vital and fundamental point of all of this is that the "known location" of the preceding paragraph is really that. While without doubt most losses at sea result from personnel failure of some sort, a significant minority do result from faulty or inaccurate information of one kind or another. A glance at even 17th and early 18th century charts and comparison with their modern counterparts makes one wonder how navigators recognized their destinations even after safe arrival. Similarly as late as the "age of discovery" ignorance of magnetic variation, correct time and ocean currents, and failure to identify the stars correctly resulted in ship wrecks on inhospitable shores. Today the moon is more accurately mapped than some parts of the earth. Precise navigation must of necessity depend on accurate information.

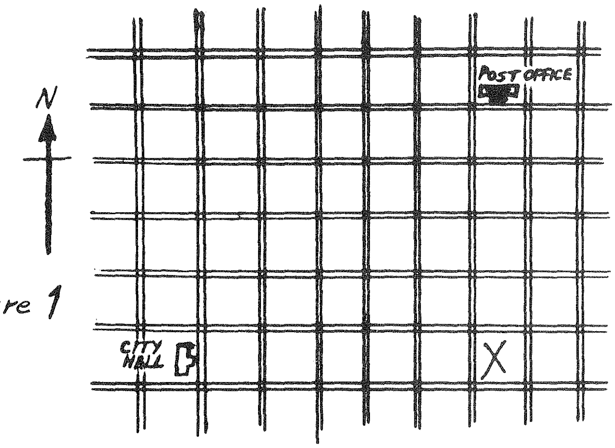


Figure 1

Charts are plane representations of the curved surface of the earth. Projecting any curved surface upon a flat sheet of paper results in distortions, some serious and others not so, but all must be understood. There are a number of such projections, each having a particular useful application or applications to the art of navigation. Here we find it inappropriate to describe these, but simply remark that the earth's surface is successfully (and accurately) represented by this device. Charts are available for purchase from most of the world's governments through appropriate agencies.

PILOTING

The simplest form of navigation is known as piloting. It is basically the same as the practice of the ancient mariners who coasted along within sight of shore and deduced their positions from observations of prominent terrestrial objects, though no longer do we afford the luxury of the overnight bivouac. Piloting has no direct relationship to navigation as it may be explained in the planetarium (*Editor: except with slides)*, but the operator must first understand its principles in order to appreciate and explain celestial navigation by the line of position method in universal usage today.

Suppose you wish to direct a friend to your place of business in a city represented in Figure 1 and you told him that your office was directly south of the post office and directly east of the city hall. Even the most obtuse individual should deduce you were located somewhere in the block marked with an "X".

Now apply the above reasoning to a simulated chart shown in Figure 2.

The navigator of a ship observes a light house directly north of him (i.e. he knows then that he is <u>south</u> of the light house). This information is obtained by comparing the position of the light with directions as indicated by the ship's compass. This one observation does not give uniquely the position of the ship; indeed the ship might be at <u>any</u> point on the <u>half</u> line labeled "LINE #1". This line is called a Line of Position (LOP).

If at or near the same time as the observation in the above paragraph the navigator ascertains that the mountain peak is directly west of his ship, he then knows he is <u>somewhere</u> on line #2. Obviously his ship is at the intersection of the two lines.

This procedure illustrates the line of position method of navigation which is in wide,

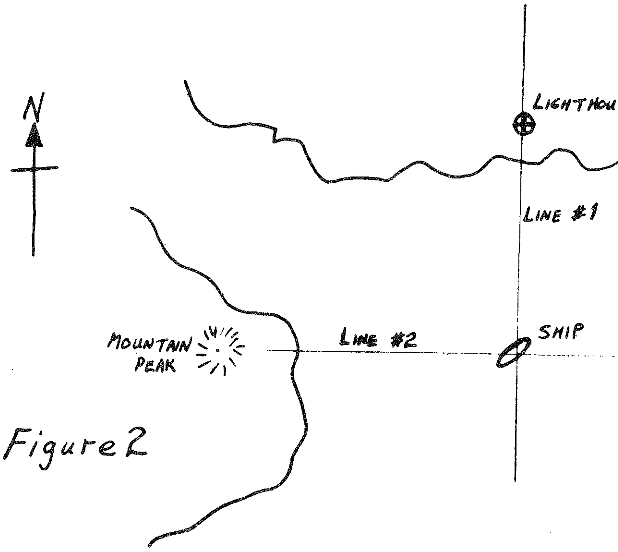


Figure 2

usage today. The same idea is applied to the known positions of the stars, sun, moon and planets for a given instant and their observed places as seen from the ship. Just as the observed places of the light house and mountain peak determined the unique position of the ship in Figure 2, so observations of the celestial objects can reveal our ships position (called a "fix") even when far from land or out of contact with other navigational aids.

"Shooting the Sun"

Probably the oldest and must universally utilized sight is what is called the sun sight at local apparent noon. This is a single sight (altitude measurement) made at the precise instant when the sun is at its highest point for the day. As the sun comes to upper culmination for the day, its altitude is measured with the marine sextant. As can be seen from Figure 3, the observer's latitude results from the simplest of arithmetic.

NPZRQS is the observer's meridian. The earth is represented by the small circle; it and the meridian have the common center O. P^1 is the earth's north pole and P the celestial north pole. The line OQ^1 is the earth's equator and OQ is the celestial equator. Q^1O^1= QZ is the latitude of the ship at O^1. R is the sun and QR is its declination. SR is the sun's observed altitude above the ship's horizon SON at local apparent noon. Obviously then

Q^1O^1= QZ= SZ-SQ= SZ- (SR-QR) or, latitude = 90°-(altitude-declination). If the sun were south of the equator (Q) the formula would be latitude =90°-(altitude + declination).

Obviously the presentation of the above should be carefully worked out in advance or embarassing arithmetic inconsistencies may result.

Two questions of course must be considered in the above process; namely: How is the declination of the sun obtained, and how is its altitude measured? In the planetarium these are easily obtainable from the projectors for the equator-ecliptic (to measure declination) and the meridian (to measure noon day altitude) but certainly the natural sky is not equipped with such conveniences. However other sources are available for the required information.

The American Nautical Almanac gives among many other things the hourly declination of the sun with the necessary interpolative constants from which the declination can be computed for any second during the year. The altitude of a celestial object may be measured by means of the mariner's sextant.

Latitude From the Polestar

Another even simpler sight which can be used to determine latitude is the altitude of the North Celestial Pole. Unfortunately there is no star exactly on the pole but there is one, Polaris, less than a degree from the pole. Small corrections, not in excess of one degree, are tabulated in the Nautical Almanac. These corrections are applied by the navigator to his observed alti-

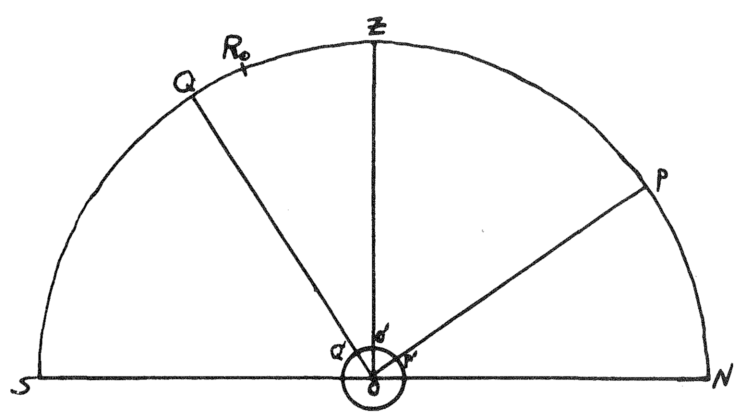


Figure 3

tude of Polaris to give him the exact altitude of the pole. Referring again to Figure 3 we see that since PO$\perp$QO and ZQ$\perp$NO the angles PN (altitude of the pole) and $_1$QZ (latitude of the ship at O^1) are equal.

In the planetarium demonstration the corrections applied to the altitude of Polaris to obtain the altitude of the celestial pole are so small that they may not be visually evident to the audience. The demonstration may be carried out without application of the corrections, but since the Polaris image in the planetarium is usually somewhat removed from the celestial pole marker, the corrections and their purpose should be explained or at least mentioned.

Lines of Position

The two special observations described so far do not at first glance seem to be related to the "Line of Position" method of navigation mentioned earlier, but they are. Line of position navigation simply stated depends upon the certainty by the navigator that his ship is somewhere on a known line on the known line on the surface of the earth. Two or more such lines by their intersection determine the ship's position. In the sun sight at noon and also in the polaris sight the line of position is a parallel of latitude and may be so drawn on the chart or plotting sheet representing the vicinity of the ship. Neither of these sights alone (nor both together) determines the ship's position. At least one other sight is needed.

Both the noon sight and the Polaris sight are made when the observed object is on (or very near) the meridian. Under these conditions only the latitude of the ship is available.

Accurate determination of the ship's position and hence its longitude depends upon knowledge of accurate time. Once a problem of paramount importance, radio communication of time signals on a continuous basis over WWV, CHU and other governmental stations has made accurate time instantaneously available via short wave radio. This plus the availability of precomputed tables of solutions of all possible astronomical triangles in one or one-half degree increments of hour angle, latitude and declination have made line of position navigation simple, straightforward and efficient.

CELESTIAL NAVIGATION

Theoretically at a given instant there is only one point on the surface of the earth from which a specific celestial body has a given altitude and azimuth. If both of these quantities could be accurately measured, the navigator could then determine his position. Altitude of a celestial object can be observed to the nearest tenth of a minute with the marine sextant. This corresponds to 600 feet on the earth's surface. Azimuth, in the other hand, has an error of about one half degree. This is not sufficiently precise to give a dependable position.

Instead of observing the altitude and azimuth of a single body, the navigator obtains measured altitudes only of two or more. From each of these a line of position is calculated and plotted, resulting in a fix.

Given in Figure 4 the altitude h of a star (#1) the LOP is a circle, i.e., the intersection of the spherical surface of the earth with a cylinder. The axis of the cylinder is a line from the center of the earth to the star and its radius is determined by the altitude h. The point S-1 is the sub-stellar point at the instant of observation. The star is in the zenith from S-1. The radius of the cylinder, if measured on the curved surface of the earth, is 90°-h. If it is expressed in minutes of arc, it is equivalent to a radius expressed in nautical miles.

Supposedly, one could locate S-1 on a geographic globe and strike an arc of curved radius equal to 90°-h. This would be desired LOP. Practically,

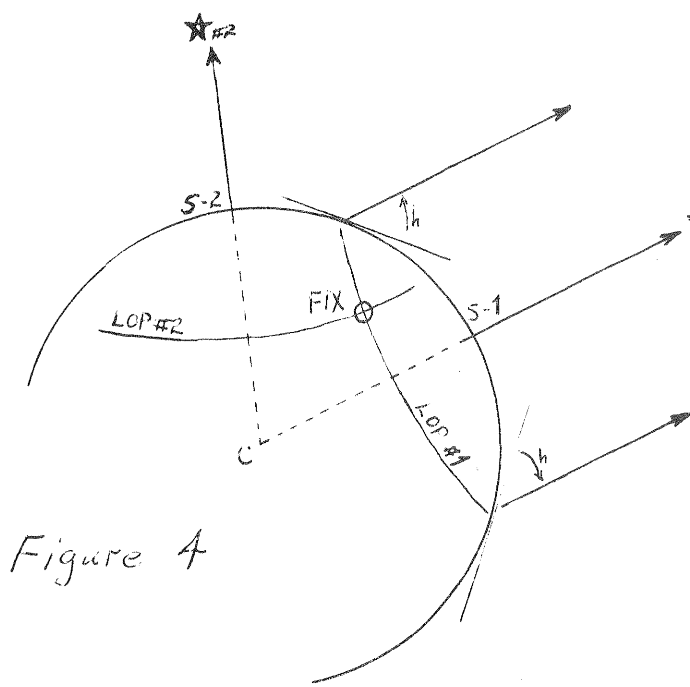


Figure 4

however, a globe big enough to produce any satisfactory degree of precision would be so large as to be impossible to transport.

However, once LOP #1 is determined by whatever method we eventually devise, the ship's position is still unknown. One LOP does not give a unique location; two are necessary. Hence a second star, #2 is observed and LOP #2 is plotted. The resulting interaction is a fix. There are two intersections but they are hundreds or even thousands of miles apart so no ambiguity is involved.

There remains two facets of the problem of practical navigation untouched. These are: first, the problem of coordinate transformation from the equatorial system of the Nautical Almanac to the horizon system of the navigator, and second, the substitution of a chart of a relatively small area of the earth for the impossibly large globe mentioned earlier as a plotting surface. We shall consider these in order.

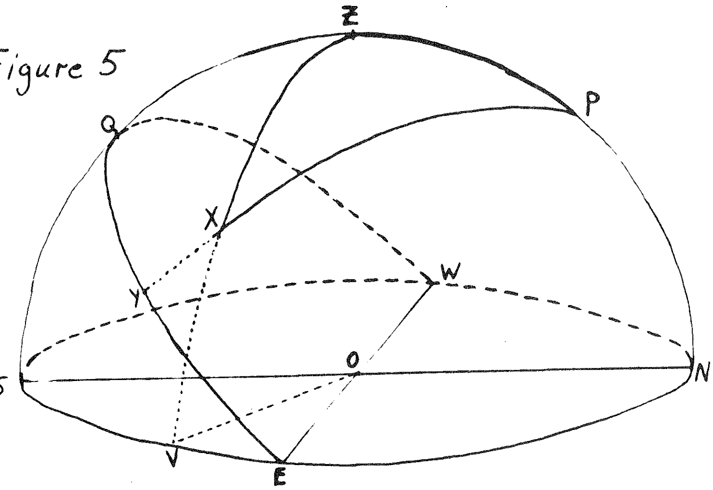
The Astronomical Triangle

Almanacs are necessarily compiled for use anywhere on earth rather than for a particular spot and hence use the equatorial system of coordinates rather than the horizon system. An astronomical triangle projector on the planetarium can represent the transformation from one system to the other.

Referring to Figure 5, NESW is the horizon. P is the north celestial pole. O is the observer on the earth. EQW is the celestial equator. X is the star.

- h=VX=altitude so XZ=co-altitude
- d=YX=declination so XP=co-declination
- ∠XPZ=hour angle (E)=t
- L=PN=latitude so ZP=co-latitude
- Z_n=∠NOV=azimuth

Figure 5



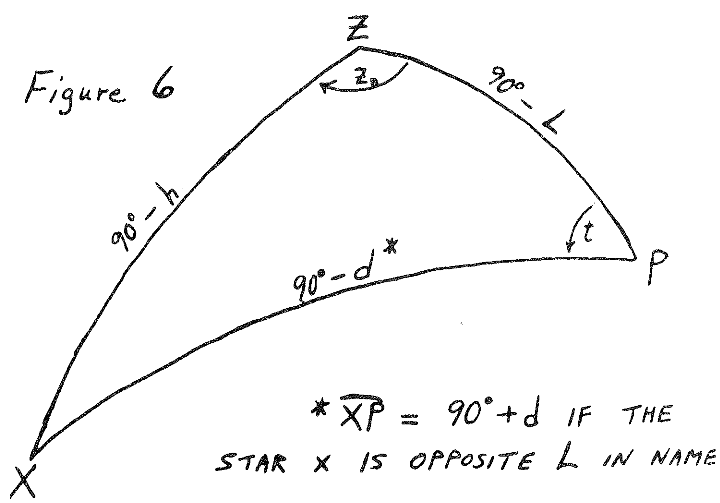
The astronomical triangle is ZPX. Its solution is the basis of all celestial navigation. It can be solved by elementary spherical trigonometry but errors plague the methods long in use so in the 1930's precomputed solutions were provided in tabular form in HO214[2] and subsequently in other tables as well.

Figure 6 isolates the triangle and labels the parts using the conventional letters. The angle PXZ has no particular designation and does not enter the problem.

The known parts of the triangle are

1. t the meridian angle obtained from the Almanac
2. d (or rather 90±d) from the Almanac
3. L the latitude from the known <u>approximate</u> latitude of the ship.

Figure 6



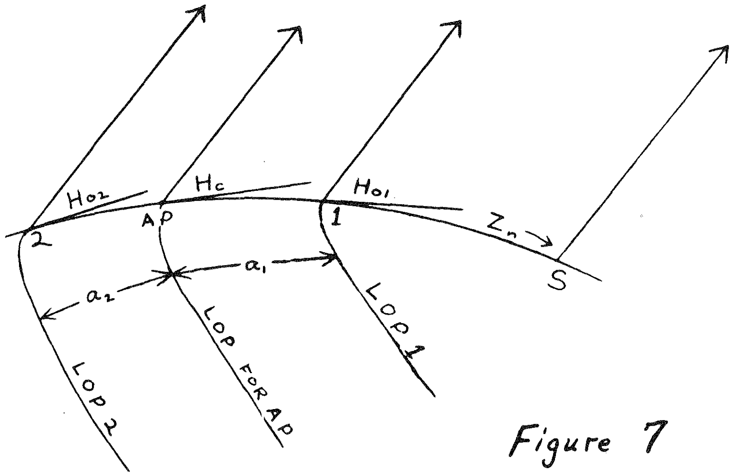


Figure 7

Since two sides and the angle included are known the solution is immediate and Z_n and h are obtained.

One might ask how the latitude and longitude of the ship are known and if they are, why navigation is necessary at all. The answer is that an approximate position (called DR or dead reckoning position) is always plotted forward from the last fix as the best estimate of the ship's position. Navigation is the art of finding the actual position as exactly as possible.

The results of the above described solution are h from 90-h and the angle Z_n, the direction of the substellar point (S-1 in Figure 4). This calculation is carried out at a particular GCT, and simultaneously the actual altitude of the object is measured with the marine sextant. This measurement is appropriately corrected for instrumental and other errors and the corrected result is called the observed altitude and designated H_o. The computed altitude obtained from the astronomical triangle is now designated H_o.

Plotting a Result

We now come to the second part of our problem, viz, how to plot our result on a purely local chart or plotting sheet without striking an arc of radius probably thousands of miles long with its center at the substellar point of the observed object X.

Suppose in Figure 7 the curve is the surface of the earth and S is the substellar point of X. The parallel lines with the arrows are directed to the star X and one may think of them (oppositely directed) as light rays from the star. A.P. is the Assumed Position of the ship obtained from the DR. (It may be the actual DR or a nearby point juduciously chosen to obviate tubular interpolation, H_o the altitude of X and Z_n the direction or azimuth of S from A.P. The latter are computed from terrestrial coordinates of A.P. The LOP for A.P. is perpendicular to Z_n since the LOP is the arc of a circle with radius along Z_n.

If H_o=H_c the LOP is this line; generally this is not true. If H_o>H_o the ship is on a position such as Point #1 toward S; a_1=H_{o1}-H_c. The LOP is drawn on the chart by measuring a_1 nautical miles toward S (in the direction of Z_n) from A.P. and then drawing an LOP perpendicular to a_1. The Plot is shown on Figure 8.

The A.P. is placed on the integral degree of latitude nearest the DR and its longitude is chosen to make t an integral degree thus minimizing interpolation in HØ214. The LOP is drawn as a straight line because a short arc of a circle of thousands of miles radius is closer to a straight line than one could plot the curve.

Had H_o H_c (situation #2 in Figure 7) then a_2=H_c-H_{02} and the direction of a2 is away from S (in direction Z_n+180°).

A complete fix of course requires more objects than one; three is considered a minimum and four is better.

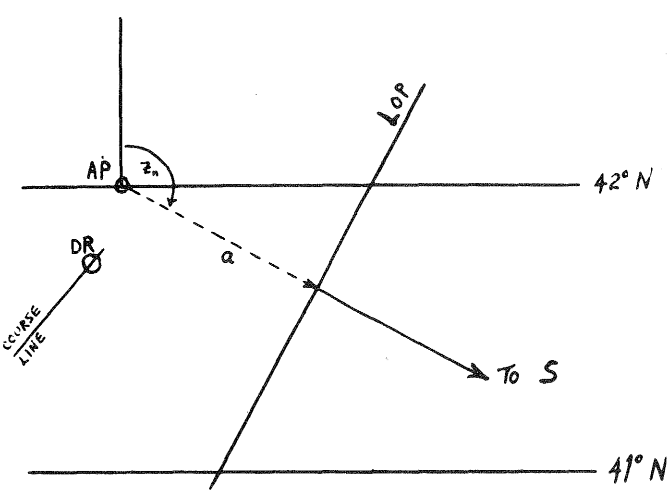


Figure 8

The Technical Side

Conducted by O. Richard Norton, *Flandrau Planetarium, University of Arizona*

Solving the problem of producing zero backgrounds on 35 mm transparencies was covered in the September 1973 issue of THE PLANETARIAN. If you recall, the technique described was effectively used to isolate objects on film with sharp boundaries. To isolate objects with ill-defined boundaries is another story indeed and considerably more challenging. In this issue, I will consider methods of eliminating background around such objects as nebulae, galaxies, and the like.

Since ill-defined objects do not have sharp boundaries, techniques used to produce well-defined overlay masks to eliminate the background cannot be used in the usual way, i.e., laying the mask directly over the object to be opaqued. A sharp mask can be used in another way, however.

Here we take advantage of the projection of the projection lens' ability to focus two objects on two different planes. Obviously, a projection lens only has one focal plane for a given subject to image distance. Only in that plane will the object appear sharply defined on the projection screen. (By stopping down the lens to, say *f*/8 to *f*/16, the lens' depth of field can be increased considerably. If the lens has an internally adjustable iris, it should be used in the wide open position.)

The idea, then, is to place the object (nebula, galaxy, etc.) on the focal plane of the lens and place the kodalith mask made by the technique previously described (*THE PLANETARIAN*, Sept. 1973) at some point forward of the focal plane of the projection lens resulting in an out-of-focus mask, the shape of the object. Since it is necessary to have access to an inch or so along the optical axis of the projector, projectors with enclosed optical systems (e.g., Kodak Carousels, Sawyer, etc.) cannot be used.

Placement of the mask is found by experiment. The projector is set up to project the object over the distance to be used in the program. Then the mask is introduced between the projection lens and object slide and moved along the optical axis until the best effect of background elimination is noted, usually from 1/8" to 1/2" in front of the object slide. Simple cardboard spacers between the mask and object slide and attached to both will hold the mask in the proper location.

You will generally find that the space between the mask and object slide vary, depending upon the focal length or *f*/ ratio of the system. As a rule, the longer the focal length, the greater the space between the two slides since longer focal length lenses (or smaller *f*/ratios) have substantially lesser depths of field.

Incidentally, zoom lenses create special problems with this technique since the focal length of the system is constantly changing. At the greatest zoom, the depth of field is least since the focal length is largest. A synchronized iris usually used to control the image brightness in zoom projectors works against us since it enlarges as the focal length increases, thus decreasing the depth of field of the system with increasing focal length. Usually however, a "happy medium" may be found where the image is acceptable although not perfect at all zoom positions.

If one has the misfortune to have only enclosed optical systems so that there is no readily accessible access to the focal plane or optical axis, a second solution is available. Essentially, the same effect may be obtained by masking the filament image on the front of the projection lens. While projecting the object slide to be masked, place your finger over the edges of the projection lens, making certain to interrupt a portion of the filament image. A darkening of the opposite side of the slide will result (the image has been optically rotated). By placing masking tape over the lens while observing the image, a reasonable opaquing of the image will result. This simple procedure is especially effective when used to fade the linear edges to two adjacent skyline scenes.

In some projection systems it is more effective to interrupt the projected light beam several inches beyond the front element of the projection lens. This is especially true of long focal length systems. In this case an extension tube should be attached to the projection lens barrel and extended beyond the lens to the desired masking point, usually 4" to 6". Here a kodalith mask of the object slide may be used, but the size of the mask will not necessarily be the exact size of the object. This is determined solely by the image size at the point where the mask is introduced, remembering that the image is expanding beyond the projection lens.

These procedures may sound a bit confusing and complicated, especially if you have never had occasion to try them. To this I say, try them! If you have tried the techniques and improved upon them, your editor and the readers would be most grateful to receive your comments for publication.

Co-Editors: Frank C. Jettner and Von Del Chamberlain. This series was originally conceived as a first-year, graduate level textbook in planetarium education, written by the leading specialists in the field. Installments will appear in each issue of THE PLANETARIAN until completion. It is suggested each installment be removed from the centerfold, punched, and stored in a looseleaf binder for future reference. ISPE and the Co-Editors regret they cannot furnish special binders for this purpose. Questions regarding the text matter may be directed to either Co-Editor or the chapter author.

Editor's note: Because 1973 marked the 50th anniversary of the projection planetarium, Prof. Hagar has given us permission to print a chapter in serial form from his forthcoming book, "Planetarium: Window to the Universe." The first section appeared in the Fall 1973 issue and was concerned with models of the night sky. The second section appeared in the winter 1973 issue and dealt with models of the solar system. This section, the last, treats the development of the Zeiss Planetarium. For the purpose of a unified treatment all references previously quoted are given in this issue at the chapter end.

THE HISTORY OF THE PLANETARIUM

by Charles F. Hagar, *Planetarium Institute, San Francisco State University*

The Genesis of the Zeiss Planetarium

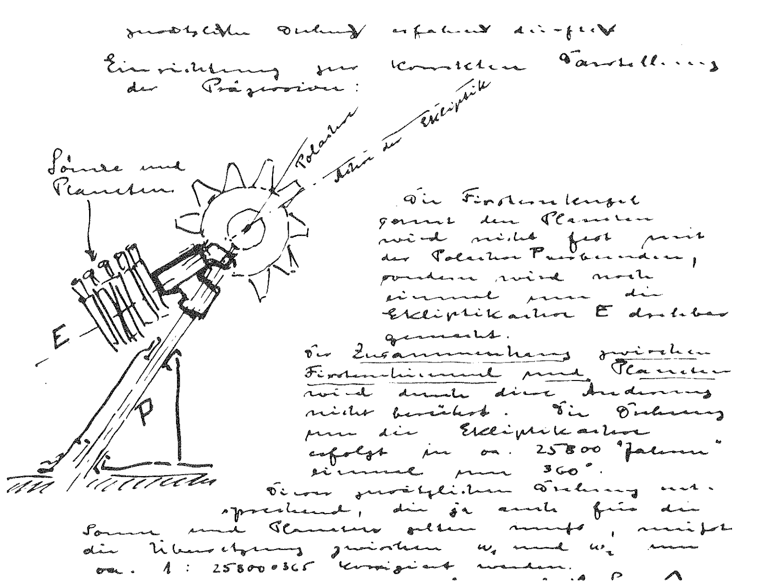
These early attempts by man to reproduce celestial phenomena had certain disadvantages. The hollow globes were not large enough to accommodate many spectators, and the orreries represented the planetary motions from "outside" the solar system rather than as viewed from the earth.* "About the end of the year 1913 the astronomer Max Wolf, of the observatory at Heidelberg, had a discussion with Oskar von Miller, founder and first president of the Deutsches Museum about the possibilities of instructive models for demonstrating the motions of the heavenly bodies. Wolf proposed to show the stars with accelerated motions to a small number of visitors in the midst of a dome of spherical curvature. For this purpose the dome should be constructed of thin plates welded together to a spherical form." (28) It was further proposed that the sphere should have a diameter of about 20 ft, (6 m), and it should rotate to exhibit the diurnal motion of the stars. From this description it is evident that Wolf had in mind something similar to the Atwood Celestial Sphere of the Chicago Academy of Sciences which had recently been inaugurated. It was also envisioned by Wolf that this globe would have mechanisms to exhibit the apparent motions of the sun, moon, and planets greatly speeded up in time to reveal their nature relative to the star background.

Oskar von Miller proposed this project to the Zeiss works at Jena in 1913. Preliminary investigations into this matter were interrupted by World War I. Following the war and after some further investigations which raised considerable difficulties in the construction of the sphere, Walther Bauersfeld of the board of management of the Zeiss works and chief engineer of the firm proposed an entirely new approach in March, 1919:

"The great sphere shall be fixed, its inner white surface shall serve as the projection surface for many small projectors which shall be placed in the center of the sphere. The reciprocal positions and motions of the little projectors shall

* The Copernican planetarium at the Deutsches Museum, through its periscope arrangement on the earth carriage, enabled a spectator to view the planets as seen from earth. The limitation with this method was that only one person could use this vantage point at a time.

Walther Bauersfeld (1879-1959) Director of the Firm of Carl Zeiss Inventor of the Zeiss Planetarium.



The first drawing of the projection planetarium appearing in W. Bauersfeld's manuscript: *Sternprojektion fur das Munchener Museum,* begun on May 5, 1920.

be interconnected by suitable driving gears in such manner that the little images of the heavenly bodies, thrown upon the fixed hemisphere, shall represent the stars visible to the naked eye, in position and in motion, just as we are accustomed to see them in the natural clear sky."

Bauersfeld also relates:

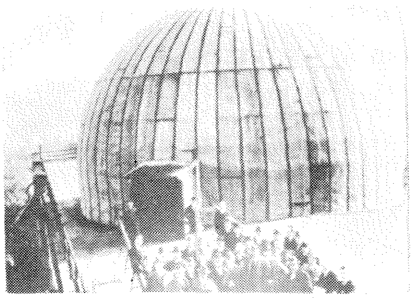
"Some months passed and I was much occupied by many other projects and negotiations and heard nothing about the progress of the Planetarium construction. Until one day I found on my desk a letter addressed to Oskar von Miller from the astronomical department of the firm, which simply declared that after mature consideration it had been impossible to construct the suggested planetarium by optical projection...I cancelled the letter and decided to attend personally to all details of designing the new apparatus. In the beginning I was not sure whether I should be able to master all the problems which would arise during the designing.... But I was fortunate in that no real obstacles hindered me following the proposed method, and at the end the success was much greater than anybody could have imagined." (29)

In early 1920 Bauersfeld began to work out the design details and technical calculations which piled up to some 600 pages (Fig. 15). A large staff of machinists, opticians and electricians were employed for the project which took four years from conception to completion. The long awaited moment arrived in August, 1923, when, for the first time, the artificial sky lit up in a 52.5 ft (16 m) dome which had been built on the roof of the Zeiss factory. In that darkened dome the stars seemed to shine from the depths of space. From the aggregate of lenses, gears, and motors comprising the first planetarium *projector* came a simulation of nature's sky that exceeded the fondest expectations of its designers.

In October, 1923, the instrument was moved to the Deutsches Museum in Munich and mounted temporarily in a 32 ft (9.8 m) dome. After demonstrating its capabilities, the projector was returned to Jena where Walter Villiger, head of the astronomical section of the Zeiss works, gave planetarium demonstrations to thousands of visitors, among them hundreds of school children. During this time the planetarium proved itself as a new and marvelous education medium for astronomy. In May 1925 the planetarium was returned to Munich and permanently installed in the 32 ft (9.8 m) dome at the Deutsches Museum where it was in use until interrupted by World War II. Surviving the air-raids of the war (unfortunately the Copernican ceiling orrery downstairs did not), the planetarium was reinstalled in May 1951 in a 32 ft dome at another location in the building. Finally, the original planetarium instrument or *Model 1,* as it is now called, became a permanent museum exhibit in 1960 when a new Zeiss Model IV projector was installed in a new dome*

A second projector, similar to the first, was built and placed in Dusseldorf in 1926; it was moved to Liegnitz in 1927. Finally it was permanently located at The Hague, Netherlands in a 39 ft (11.8 m) dome on February 20, 1934, where it is presently in operation. This second projector had several improvements over the

The Model I Zeiss projector in the Deutsches Museum, 1925. Note Ursa Major (Big Dipper or Plough) in the middle of the picture; on the left is Arcturus in Bootes.



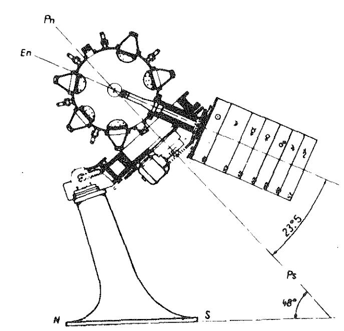
The first planetarium dome in the world, erected on the factory roof of the Zeiss works in Jena, 1923-24.

first including projectors for the meridian, celestial equator and ecliptic. Furthermore, the facility for some latitude adjustment was provided, enabling the sky to be shown between the latitudes of 49° and 68° north. The original Munich instrument operated for a fixed latitude of 48°.

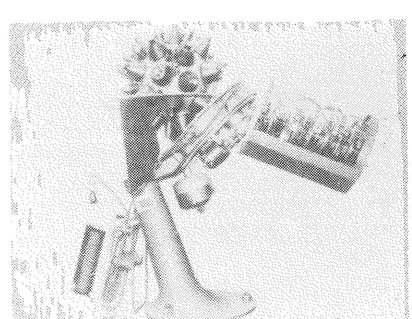
Figures 16-17 illustrate the *Model 1* projector. The star images are projected from the cone-shaped lens supports. A hollow metal sphere 19.7 in. (50 cm) in diameter carries these conical lens supports and has a 200 W lamp in its center to furnish the necessary illumination. This first model projected about 4500 stars from lantern slides which were made by photographing exact drawings of the sky. In later instruments the slides were replaced by thin copper-foil plates which had small holes punched in them to represent the stars. The apparent daily movement of the stars across the sky is reproduced by rotating the instrument about the axis (Pn-Ps) which is parallel to the earth's axis of rotation. Mounted at an angle of 23°.5 to this polar axis is an axis which is perpendicular to the plane of the earth's orbit. This is designated (En-Es). The projectors for the planets, sun, and moon are located in the cage framework. By rotating the projectors in the cage assembly, the apparent motions of the sun, moon and planets are shown by projection upon the dome of the theater.

In 1924 Walter Villiger suggested that the design be modified to make the planetarium capable of showing the sky from *any* latitude. Villiger suggested that the star sphere be divided into two parts, and the two resulting hemispheres - one for the northern sky, and the other for the southern sky - be placed at the ends of the planet-cage assembly. The cage assembly, in turn, was separated so that a horizontal axix could be run through it to provide rotation of the instrument for sky projection from different latitudes. And so in 1924 the design of the Zeiss planetarium became the familiar "dumbbell" appearance of subsequent models.

* It is interesting to note that this first projector has not been retired to dusty obscurity. The star globe is presently on loan to The Institute for the Study of Psychological Reactions of Animals at Seewiesen, Bavaria, where it projects stars on a planetarium dome for the study of bird navigation.



First model of the Zeiss Planetarium.

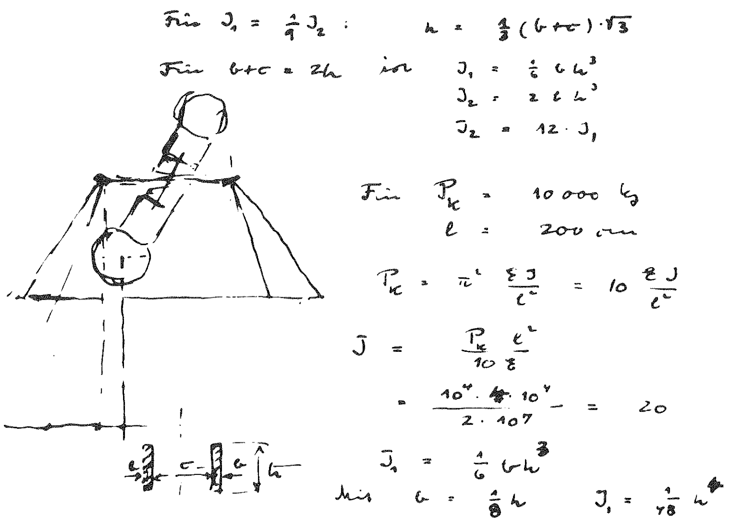


The first Zeiss planetarium projector as provisionally set up in the Deutsches Museum in Munich, 1923.

A section of Bauersfeld's planetarium manuscript is shown in Figure 20 where the dumbbell shape of the *Model II* projector appears for the first time. Bauersfeld calculated the engineering requirements for the structural supports of the new Model II projector.

Twenty-five instruments of this new version (Model II) were manufactured by the Zeiss Works, and the first projector of the new series was placed in Barmen, Germany in May, 1926. Unfortunately it was destroyed during the Second World War. From 1926 to the beginning of the War the 25 Model II projectors were distributed as follows: Germany (11); U.S.A. (5); Italy (2); Japan (2); U.S.S.R. (1); Sweden (1); Belgium (1); France (1) and Austria (1). Of these 11 were destroyed or partially damaged during the war.

The *Model II* instrument (no longer in production) had two star spheres, each 29.5 in. (75 cm) in diameter. A total of 8900 stars projected to magnitude 6.5 through 32 ZEISS TESSAR f/4.5 lenses. Light was furnished by a 1000 W lamp of special filament design. The star plates were of thin copper foil, and the star holes were punched by hand - a process which has presently been superseded by a photo-chemical engraving process of superior quality. The Model II also had two motors for diurnal (daily) motion. These, as well as the three annual-motion motors could be operated separately or in various combinations to yield a variety of speeds both forward in time and reverse. The various possibilities for diurnal motions permitted a



The dumbbell shape of the Model II projector appears for the first time on page 207 of W. Bauersfeld's manuscript. Calculations are for the structural engineering of the support system.

"day" in 4 minutes, 2 minutes, 1.3 minutes and 1 minute. The annual-motion combinations permitted the following possibilities for a "year": 4 minutes, 2 minutes, 1.3 minutes, 7 seconds, and 6 seconds. Current production models (IV and V) offer ranges in diurnal motion from 3 to 24 minutes and in annual motion from 10 seconds to 12 minutes. Production models IVs, Vs, and Vi have motors which provide continuously variable speeds ranging from a "day" anywhere from 30 seconds to 36 minutes, and a "year" from 30 seconds to almost 36 minutes. Variable speed motors are also provided in Models IVs, Vs and VI for continuous variation of the speed of latitude motion (polar altitude) and precession, permitting even more versatility of operation.

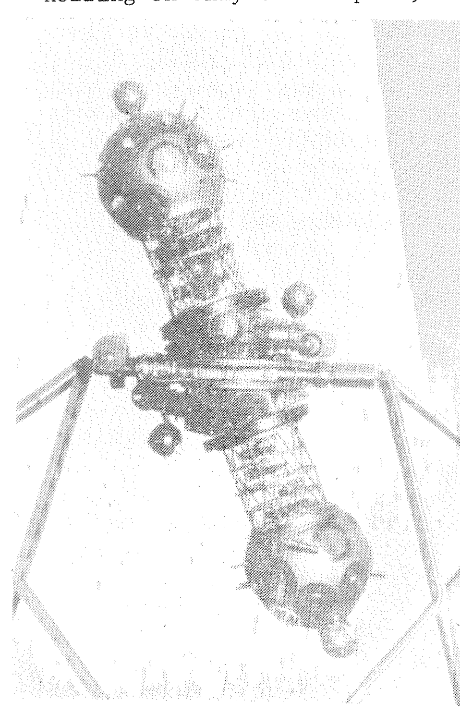
Following the war, the Carl Zeiss factory was relocated in Oberkochen, West Germany by the American Forces. Soon quality optical goods and precision equipment in the Zeiss tradition were once again produced. The planetarium section was able to obtain the remains of a Model II projector. Parts which were missing were duplicated and the entire projector rebuilt and modernized. The completed instrument was sent to Sao Paulo, Brazil, in 1953 to become the first planetarium in the Southern Hemisphere.

Model II projectors which have been subsequently modernized and refurbished by Zeiss, Oberkochen have been re-classified as Model III projectors to distinguish them from models made in Jena prior to the war. Following the Sao Paulo installation, six other Model II projectors have been modernized by Zeiss.

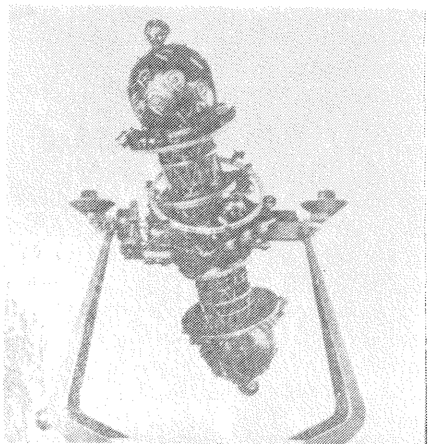
In 1956 Zeiss introduced a new series of projector, the Model IV. The first of these was delivered to Tokyo in early 1957. Subsequent instruments were delivered to Hamburg that same year and to London in early 1958. The new series included various supplementary projectors and technical improvements. Star plates were made by a new photo-chemical process developed by Zeiss. The new plates are scratch-proof and resistant to corrosion. Another improvement was the addition of individual projectors for the 42 brightest stars. These separate projectors are located in the collars of "ruffs" surrounding the base of each star globe. Also attached to the ruffs are projectors for the Milky Way and three variable stars with automatic light modulation for an accurate representation of their light variations-a distinct advantage over the hand-controlled methods of earlier instruments.

Walther Bauersfeld was fully involved in the designing of the new Model IV series. This was to be his last contribution to the planetarium enterprise, however, for on October 28, 1959, death stilled his creative pencil and slide rule. In eulogy before the group gathered at his grave in Heidenheim, Heinz Kuppenbender, of the Board of Directors of Zeiss said, in part:

"Always ready to build bridges to success for others, open to all dynamic forces of life, passionately inclined to the fine arts, never arrogant in success, never reactionarily holding on only to the past, a



Zeiss Model II projector(1926).



Zeiss Model IV (1957)and IVs (1968).

human being of overtowering intellectual greatness with a large heart, so Walther Bauersfeld continues to live in our memory."(30)

In 1959 Zeiss introduced a new and pleasing proportioned support structure for the Model IV (Figure 23). The first instrument so equipped was delivered to the American Museum-Hayden Planetarium, New York City to replace the old Model II projector which had served the metropolitan New York area for almost a quarter of a century. The new projector was unveiled in January 1960. All subsequent Zeiss planetarium projectors have this new support structure which was designed and engineered by Gerhard Schwesinger, Chief Engineer of Zeiss and successor to W. Bauersfeld in planetarium design.

Aware of the constant need for improvement and incorporation of the latest technological advancements, Zeiss engineers began in the early 1960's the development of a new model series.

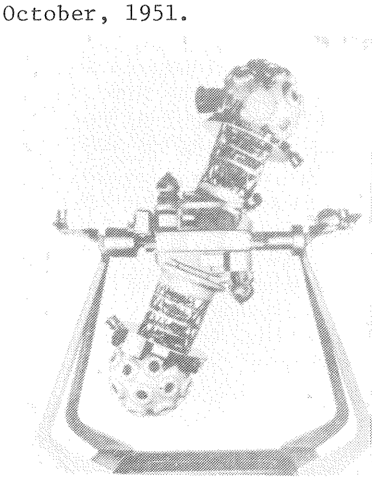
In June 1966 the new Model VI (Figure 25) projector was unveiled at the Zeiss plant in Oberkochen before the Second International Conference of Planetarium Directors. The delegates - representing the major planetariums of the world and each with much experience beneath planetarium domes - were impressed by what they saw. First of all, the stars were even more realistic than previous models. A newly designed high pressure discharge lamp and optical system produced stars which were pointlike, truer in color, and they even "twinkled!" But there was more to come. As the planetarium sun rose, it appeared reddened - as in nature's sky. As the sun climbed higher, the views were treated to a most realistic total solar eclipse. This was followed by demon strations of the zoom capabilities of the newly designed projectors for Jupiter and Saturn. The new moon projector showed a realistic lunar eclipse in addition to changing lunar phases. The planetarium directors were impressed with the silent operation of the Model VI instrument and the flexability of control permitted by the variable speed motors for all the planetarium motions.

The prototype of the Model VI instrument was delivered to Rochester, New York in 1968. The first regular production series of the Model VI was delivered to Chapel Hill, North Carolina in early 1969, and the second to New York City in the fall of the same year. Additional Model VIs were installed in Chicago and Boston in 1970.

Zeiss, Oberkochen also produces Model V and Vs projectors. Model V is basically the Model IV, but with the north cage piece of the Model VI (i.e., eclipse sun and moon projectors, and Saturn zoom). Model Vs, in addition to the features of the V, also has the centerpiece of the Model VI (i.e., variable speed motors and special gearing). Model V and Vs projectors have been installed in: Montreal, Berlin, Atlanta, Winnipeg, and Lucern.

It should be pointed out that there are two firms in Germany which produce planetarium projectors. Carl Zeiss in Oberkochen, West Germany and Jena Optical Works in East Germany (G.D.R.). They share a common history up through World War II. Following the division of Germany into East and West sectors, some personnel of the Zeiss Company were relocated in West Germany by units of the 3rd U.S. Army in 1945.* Some personnel remained in Jena (now in East Germany), and others were relocated in the U.S.S.R. The personnel which moved to the West established the Carl Zeiss Works in Oberkochen. The group that remained in Jena continue to manufacture optical goods under the name of Jena Optics. Following 1945 both companies resumed production of planetariums. The models manufactured by Carl Zeiss Oberkochen have been described in this article. The Jena Optical Works manufactures planetariums based upon the same historical designs of Bauersfeld and Villiger, and also with modern improvements. Their type of instrument, known as the "universal" projector is installed in Vancouver, B.C.; Calgary, Alberta;

* See my article, "Through the Eyes of Zeiss," The Griffith Observer, June, 1961. See also, Max Eastman, "A New Life for Zeiss," Reader's Digest, October, 1951.



Zeiss Model VI projector (1968).

and Toronto, Ontario. In addition Jena Optics have a projector known as the "Spacemaster." Jena-made planetariums are located in various countries.

Other manufacturers of planetarium projectors include the Japan-based optical companies of Goto and Minolta. There are two major Goto installations in the U.S.A.: a "Saturn" projector in St.Louis, Missouri and a "Custom" at Centerport, Long Island. There is a major Minolta instrument (the "MS-15) located at Cupertina, California. Viewlex, Inc. and Spitz Space Systems, Inc. are well known U.S.A.based planetarium manufactures with installations too numerous to list in this article.

Editor's note: In an effort to determine the present status of major planetariums around the world, the Planetarium Institute is currently mailing survey questionnaires to all planetariums with domes 40 ft (12 m) or larger. We hope to print a summary of this worldwide survey in a future issue of THE PLANETARIAN.

PICTURE CREDITS

Figs. 1,2,4,5,12-25, Carl Zeiss, Oberkochen.
Figs. 3,9, Courtesy Museum of the History of Science,Oxford.
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Fig. 7, Courtesy National Archaeological Museum,Athens.
Fig. 8, Courtesy History of Science Museum, Leyden.
Fig. 10, Courtesy The Science Museum, London.
Fig. 11, Courtesy Princeton University Observatory.

FOOTNOTES

1. Edward L.Stevenson, *Terrestrial and Celestial Globes* (new Haven, 1921, I,p.15.

2. Helmut Werner, *From the Aratus Globe to the Zeiss Planetarium* (Stuttgart, 1957),p.16.

3. C.Ptolemy, *Almagest,* Book VIII,Ch.3(paraphrased).

4. Stevenson, *op.cit.*,p.28.

5. "Celestial Globe - 1362/3," *Slide-letter no. 1* (1965), Museum of the History of Science, Oxford.

6. Tyconis Brahe astronomiae instauratae Mechanica. Quoted by Stevenson, *op.cit.*,pp.185-186.

7. *Ibid.*, p.187.

8. *Ibid.*, Vol.II,pp.73-74. Further references on the Gottorp Globe are found in: Werner, *op.cit.*,pp.20-21. Arthur Beer (ed.), *Vistas in Astronomy,* Vol. 9 (Oxford, 1967), pp.67-70 and pp.76-77.

9. Stevenson, *op.cit.*,Vol.II, p. 78.

10. H.C.King, "Development of the Planetarium," *The Journal of the British Astronomical Association,* Vol.70,no.1 (January 1959),36.

11. "The Atwood Celestial Sphere," *Bulletin of the Chicago Academy of Sciences,* Vol.IV,No.2, (May 1913), p. 12.

12 W.J.Beecher, "Academy Completes Star Dome Exhibit," *Museum Activities,* No.10 (April 5, 1960),pp.1-2.

13. Cicero, *De Republica*,Book I, Ch. XIV. Translation by C.W.Keyes.

14. Cicero, *Tusculan Disputations,* Book I, Ch. XXV, 63. Translation by J.E.King.

15. Werner, *op.cit.*,p.19.

16. Derek J. de Solla Price, "An Ancient Greek Computer," *Scientific American,* 200 (June, 1959), 64-65.

17. J.V.Noble and D.J. de Solla Price, "The Water Clock in the Tower of the Winds," *American Journal of Archaeology,* Vol. 72, No.4 (October, 1968), 351. For a more popular account see: D.J. de Solla Price, "The Tower of the Winds," *National Geographic Magazine,* Vol.131,No.4 (April,1967), 586-596.

18. D.J.de Solla Price, "On the Origin of Clockwork, Perpetual Motion Devices and the Compass," *Bulletin 218: Contributions from the Museum of History and Technology,* Paper 6, (Washington, 1959),87-88.

19. C.A.Crommelin, "Planetaria," *Bulletin of the National Association of Watch and Clock Collectors, Inc.*, VII, No.3 (April, 1956), 133 see also: de Solla Price, *op.cit.*,83-86.

20. Werner, *op.cit.*,pp.24-26.

21. H.C.King, 10, p.11.

22. King, *op.cit.*,p.11. *Oeuvers Completes de Christiaan Huygens,* XXI,pp.579 ff. C.A.Crommelin, "Planetaria. A Historical Survey," *Antiquarian Horology,* (March,1955).

23. G.H.Gabb and F.S.Taylor, "An Early Orrery by Thomas Tompion and George Graham," *The Connoisseur,* 122 (September 1948),24-26, 55.

24. H.R.Calvert, *Astronomy: Globes, Orreries and other Models,* A Science Museum illustrated booklet (London,1967) 12. R.T.Gould, "The Original Orrery Restored," *Illustrated London News,* CXCI (December 18, 1937), 1102.

25. King, *op.cit.*, 13.

26. Howard C.Rice,Jr., *The Rittenhouse orrery,*(Princeton,1954).

27. King, *op.cit.*, 14-15.

28. Walther Bauersfeld, "Projection Planetarium and Shell Construction *James Clayton Lecture* delivered at the General Meeting of the Institution of Mechanical Engineers, May 10, 1957, London.

29. *Ibid.*

30. H.Kueppenbender, Zeiss *Werkzeitschrift,* No.35,p.4.

Construction of the Budapest Planetarium is Under Way

by Gyula Schalk, *Urania Observatory, Budapest, Hungary*
Edited by Norman Sperling, *Princeton Day School*

(Editor: Mr. Sperling writes: At long last I can send you the edited version of Gyula Schalk's article on the new Planetarium in Budapest. Some delay has been actively used by Mr. Tibor Fabian, president of Mathematica Corporation here in Princeton, for correspondence in Magyar with Mr. Schalk regarding the many unclear portions of the manuscript. Fabian has sent me a good-English version of Schalk's article, and what I am sending you is my edited version of Fabian's reworking of Schalk. Got that?

The 44th VEB Carl Zeiss Jena Universal Large-Type Planetarium will be installed in Budapest, the capital of Hungary. Construction of the building is under way, and we hope to open by Christmas 1974.

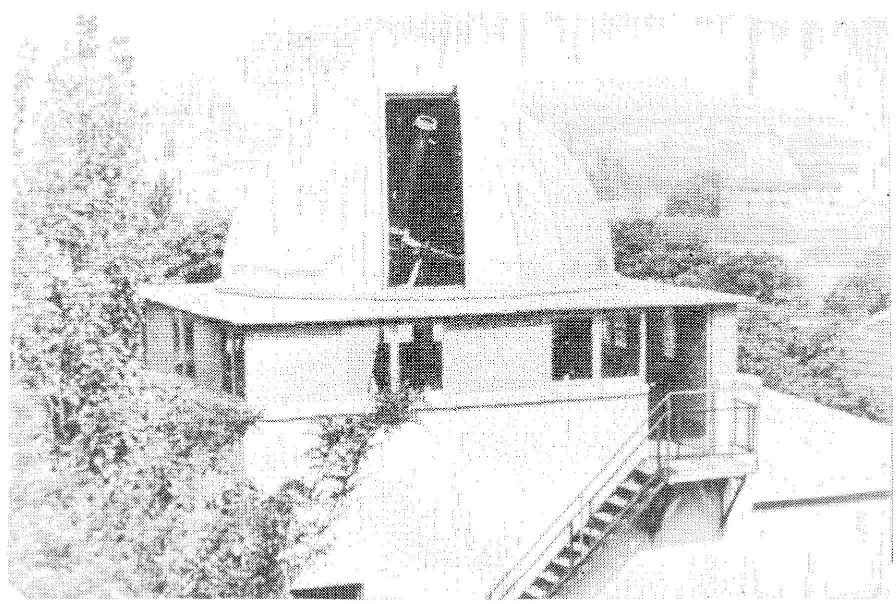
Designing, building and operating a planetarium is new to us, and I would like readers to please examine my ideas and advise me of their experiences.

Location: The Budapest Planetarium will be in the Nepliget, or Peoples' Park, a section of Budapest like New York's Central Park or San Francisco's Golden Gate Park. Except for the concrete outer dome the building will be aluminum and glass to promote rapid construction. Plans to make Nepliget the "Cultural Center" of Budapest in the next few years, in addition to finances, forced the planetarium away from Urania Observatory on the Buda side of the Danube. Located near the geographical center of the city, the Planetarium will be the first important building the tourist sees after arriving at the Airport. It is also on a major subway line. The observatory is 5 km to the west on Mt. Gellert.

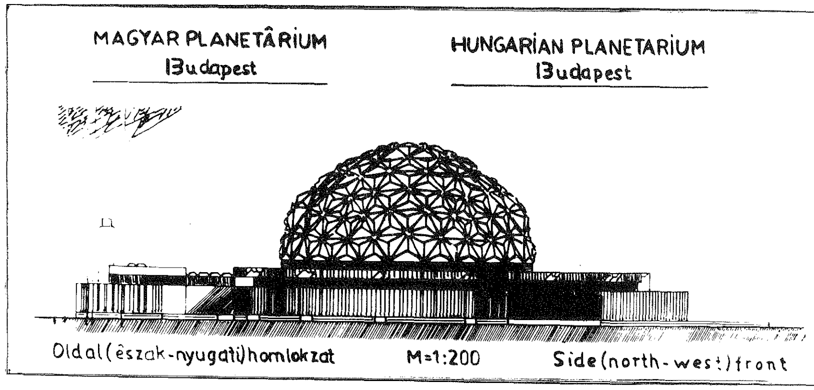
The Plans: The design was by Professor Laszlo Lux, Director, Structural Engineering Institute, Hungarian University of Technical Sciences, and his assistant, Professor Tamas Tanory,with collaboration from five other university institutes. Their work is a remarkable job unprecedented in Hungary. The 26 m outer dome encloses the 23 m projection dome and is in turn girded eccentrically by an exhibition hall accomodating 900. The Planetarium theater itself will hold 500. An administration building is connected to it with offices, libraries, management, TV and radio studios, conference/club room and so on. The connecting unit holds electrical control facilities, laboratories, photo and sound studios, and a cafeteria.

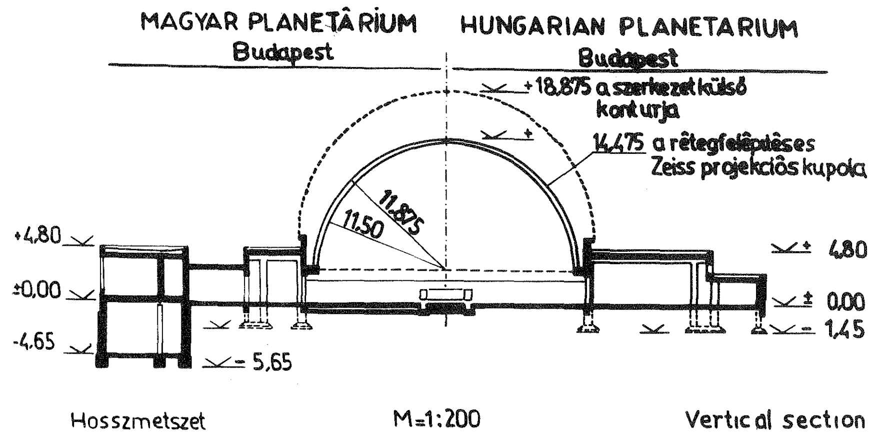
Staff: Urania Observatory, the center of Hungarian astronomy education, operates the planetarium (the Department of Astronomy of the State University very rarely participates in popular lectures). About 2550 to 3000 public lectures are given annually by the Urania staff and the lecturers of the Scientific Educational Society of the country.

As planned, three planetarium staff members visited several major European planetariums. They are: Mr. Aurel Ponori, Director; Mr. Peter Sajo, Chief Engineer; and Gyula Schalk, Program Director. Visiting



The dome of the Urania Observatory. In the background of the dome we can see the panorama of Budapest.(Photo: MTI).





The Urania Observatory in the prenier plan. In the dome is the great refractor of the Observatory with 20 cm lens and 3 meter focus. Hayde refractor. It was built in 1967. (Photo: MTI).

Moscow, Leningrad, Katowice (Chorzow, Poland) and Paris, they have observed the atmosphere as well as the programs of those planetariums.

When the inner projection dome is finished, we will begin designing 50 programs for the planetarium. The "fundamental astronomy" programs will be introductory school lectures. They must be recorded, whether we like it or not, due to our limited staff. Special programs will deal with exobiology, astronomy and astrology, Stonehenge, eclipses, and Old-Hungarian star and constellation names and mythology (see Griffith Observer, June 1973 37, #6). Our 12 different performances each year will take in current astronomical and space-science ventures.

Advertising on radio, TV, in the press, and in planetarium publications, as well as offering special courses for elementary and middle school students and different ones for high school and university students, will all promote planetarium consciousness.

Professor Gyorgy Kulin, Director of Urania Observatory, has made a major effort during the last decade to create our planetarium. It is due to him that the Budapest Planetarium is being built.

Other Programs: Guest lecturers from the University and other scientific institutes will present subjects on the frontiers of astronomy and other physical sciences. The staff will adapt their talks to the planetarium. "Astronomy Week" is a Hungarian tradition. Special lectures will be given in the planetarium that week.

Of course the Hungarian Amateur Astronomers Association will be invited to meet in the planetarium. In addition, I am considering concerts by the State Concert Orchestra under the planetarium dome. I am convinced that such an evening would be an exceptional experience for visitors.

In the future we may attempt complex major programs, like "Astronomy in Nature, in the Arts and in Literature". Invited guests could use the portable stage to demonstrate musical, literary and poetic connections with astronomy. We are also considering the adaptation of science fiction to the planetarium.

Operations: A fundamental objective for us is that the planetarium should operate without interruption every day. We plan for only one or two weeks of down-time, probably at the end of each summer. It is very disappointing to see a sign on a planetarium stating "Closed for the summer." The school year and tourists will determine our operations. To enable each student in the 5000 schools of Hungary to visit the planetarium once during his school career, we will have to give four school lectures each day. These will be at 9, 11, 12 and 2 during the day. Main programs will be at 6 and 8 PM. The 10 AM. or noon performance will be reserved for tourists in the summer.

Because of our geographical location, some lectures will be given in Russian, English, German, Czech, Polish, Rumanian, Italian, and French. We also intend to record a few programs in Esperanto because Hungary's strong tradition maintains that language in living usage and in writing.

The front-side of the Hungarian Small Planetarium in the years of 1960 when it operated in Budapest. (Photo: Schalk).

Attendance: Since about 60,000 attended our small planetarium annually when it operated from 1961-68, we estimate 200,000 to 300,000 annual visitors to our Budapest Planetarium. Most new large planetaria draw over 100,000 yearly, and Toronto drew 200,000 in 14 months.

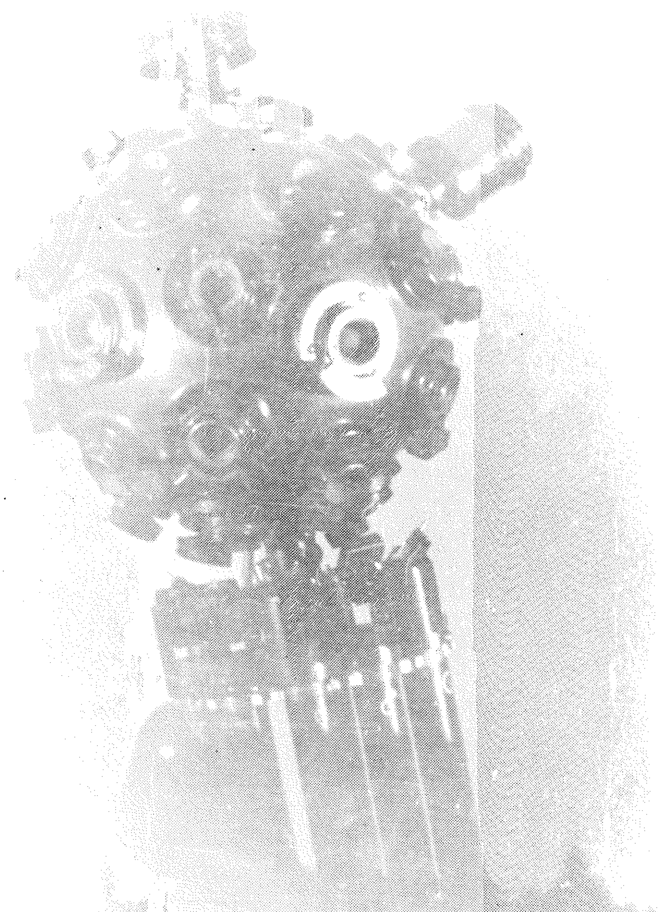
Creating a Following: A large planetarium can exist only in an atmosphere that is conducive to public education, and within that in the spirit of public support that manifests itself as a "Planetarium Following". The public must be familiar with the planetarium. The audience should enter it with the exciting expectation that precedes an excellent performance of the legitimate theater. Since we have never had a major planetarium we have no following as yet. To have an audience with high expectations we must use the media to inform them prior to our opening. Public relations have already started; articles in the newspapers and magazines have described our building, equipment and the whole institution. We are also emphasizing our expected role in public education and school curricula. We are trying to line up on our side educators with no planetarium background.

Presently a book, From the Celestial Globes to Planetariums, by this writer, is being published and should be available about Christmas 1974. Another book, The World of the Telescope", edited by Dr. Dyorgy Kulin, is also at the printer; I have contributed an article on planetariums to it. Finally, we shall open a planetarium column in our popular magazine "Fold Es Eg" (Earth and Sky).

* * * * *

I believe that the planetarium performance compares with the theater performance. The lecturer reminds us of the stage manager or orchestra conductor. He is also the lighting man, property man, and, while at the console, the author. The planetarium play is more far-reaching than the theater because the subject is the stars and heavens. Our mission must be to imprint the mind of the audience with the truth about the stars and the place of man.

This outline of our plans for Budapest Planetarium has been very personal since fewer than 10 Hungarians are involved with planetarium work. As my friends say, "My religion is the Planetarium".



The medium-type Zeiss projection instryment in the Hungarian Small Planetarium under the projection dome. Foreground the fixed star projector and the solar system projector. (Photo: Schalk).

More on the Use of Music...

EDITOR: In the June, 1973 issue at the conclusion of "The Use of Music in the Planetarium" by David M. Solzman, we called for further short papers in this subject area. This section is the response to our call to-date. If you have comments or suggestions on the use of music, please submit them for future publication.

Some Thoughts On Planetarium Show Music

by Tim Clark, *Strasenburgh Planetarium, Rochester NY*

PREFATORY LETTER TO THE EDITOR:

I have asked Tim Clark to set down some of his ideas and comments on planetarium show music in response to the two part article by David Solzman. The result is enclosed with the hope that you will be able to find space for it in a coming issue of THE magazine.

To help the readers, it would be useful to establish Tim's credentials. Tim is a graduate of Rochester's famed Eastman School of Music with a major in composition. He is, to the best of our knowledge, the only "composer in residence" working at any planetarium in the world. His works have been heard by over a quarter of a million visitors at the Strasenburgh Planetarium since Tim joined the staff here in January 1972. In addition, his Strasenburgh-produced sound tracks have been used by many other planetariums across the U.S. and Canada. Tim's original score for *The Last Question* is available on record here and at several leading planetariums elsewhere.

Cordially,

Donald S. Hall, Director
Strasenburgh Planetarium

* * * * * *

Personal taste in music will vary from one person to the next, and so a specific planetarium's "sound" will be shaped by the taste of the person selecting the music. In too many cases, however, selection of suitable show music is left to the last minute. It is all too easy to slap a few pieces by Dvorak or Holst beneath a narration at the last minute. Unless these pieces are shaped to fit the dramatic movement of the show, they will have little more effect than music in an elevator. At one time or another you will probably find use for virtually every type of music in your shows, but it is extremely important to know when to use any particular type.

I have found that under most conditions a well-known piece, such as Beethoven's Symphony #5, tends to make the audience more aware of the music than it ought to be. Classic "hits" seem to conjure up the image of a large symphony orchestra performing in a concert hall rather than heightening the unique drama of a star show.

Given the minimum equipment of two turntables and two tape recorders, you can change the high and low points of the music to fit the dramatic points of the show. Be wary of using a single piece for too long during any one section of the show. Don't be afraid to mix two pieces together or blend the end of a section of one peice into the beginning of another. For example, it is fairly hackneyed these days, unfortunately, to use Gustav Holst's *The Planets* for <u>anything</u>. However, a blending of the end of the Venus movement with Terry Riley's *Poppy Nogood and the Phantom Band* will give you a wispy, mysterious sound, dramatically unlike either of the pieces taken individually.

You will probably discover that more contemporary pieces, especially those written by the same composer, lend themselves better to mixing than do more traditional works. Many planetariums have made wide use of Ligeti's *Atmospheres*, yet have not searched out other pieces by the same composer. *Volumina*, a piece for organ by Ligeti, is similar to *Atmospheres* and lends itself nicely to mixing with other pieces. Penderecki is another composer who deals mostly in "atmospheric" kinds of sounds. His *Flourescences* and many parts of his *Passion According to St. Luke* are useful. Other contemporary composers whose music you might use are: Luciano Berio, Michael Colgrass, Lucas Foss, Charles Ives, Walter Carlos, Toru Takemitsu, Ralph Vaughan Williams, and Iannis Xenakis. In any case don't be afraid to experiment.

I have found that it is better to think of a particular show in terms of dramatic movement, rather than in terms of small segments with no unifying elements. Make a horizontal outline of the various parts of the show. Where are the dramatic high-points? What is the best way, musically, to move into these points? Try to decide ahead of time what kinds of music you want to use throughout the show. When possible, it is even more helpful to choose specific pieces in advance. Doing this facilitates transitions from one section of the show to the next. The final product should be a smooth flow, with abrupt transitions only when they are really needed. This is important no matter what kind of music you are using.

Above all, listen to everything you can get your hands on and try everything that you think may be valid. Go into the theatre and try putting on a short show for yourself with music totally different than the music you are accustomed to using. You will be surprised at the possibilities.

(End)

Music in Omsi's Harry C. Kendal Planetarium

by Dwight Gruber, *Oregon Museum of Science and Industry*

As taped planetarium shows become more and more prevalent, planetariums have increased capability to do spectacular things with sound effects and music. Music programmed thus far by the majority of planetariums has been predominantly classical. This might be for several reasons: the music obviously fits so well in so many places; the musical programmer might be unfamiliar with non-classical material; there is a prevalent attitude that popular music is *trash* and has no place in the planetarium; the idea that, in addition to *teaching* astronomy, we have a duty to expose our audiences (mostly young people) to *good* music.

We have no argument with the first two reasons; the last two we reject. If our primary educational job is to provide an environment where young people can learn about astronomy, then deciding that in addition they should be forced as a captive audience to listen to and appreciate classical music is antagonistic to our purpose. Many young people do not identify with this music, and their consequent rejection of it cannot aid in a positive reaction to the planetarium experience. We do not abandon classical music, but we do make use of the fact that using non-classical music, to which the audience might react positively, can enhance the entire learning experience.

Public shows too can use popular music beneficially. In a balanced presentation, one which is aimed at some semi-mythic median of intelligence, knowledge and interest, whatever that median is decided to be, reliance solely on classical music destroys that balance.

Classical music has been used as background so long that often it is used because it is unobtrusive to the planetarium lecture. We have made the break from the lecture-style planetarium show to the multi-media planetarium production. We therefore place more emphasis on music as a useful dramatic tool and make much greater demands on it. Our prime requirement for a piece of music is that it fit. This extends to the entrance and exit music as well as that in the body of the show. Since the planetarium is a controlled environment, the entrance music should complement the environment of the production. This same consideration applies to exit music.

Rock music, movie scores, and jazz are all non-classical styles that we have found useful in our shows. Movie music seems to be of obvious usefulness, since it is primarily written to augment visual action or set a mood.

Rock music can be more difficult, as much of it is vocal. This sometimes limits its usefulness to filling longer pauses in the narration where the lyrics are appropriate to the topic. We have used vocal music quite successfully as the opening and closing themes of shows (this is actual thematic material rather than entrance and exit music, though it should not be precluded for those uses) and as music for slide montages. On occasion, vocal music can be interspersed with the narration itself and become a primary part of the narration.

Finding music with appropriate lyrics is easier than might be expected. The Moody Blues, for instance, on whose music we rely heavily, has lyrics appropriate to almost any planetarium topic we can think of. Strictly instrumental music is much easier to use, and we find Pink Floyd's music consistently useable. Much good music can also be found as intros and instrumental breaks in vocal music.

We spend a good deal of time just listening to music. Much which is useable can be found in unlikely places, and often, music appears which suggests its own use. We try to use works which are less familiar to general audiences, and we try not to use the same piece of music too often. Occasionally we will review the music for several past shows and place a moritorium on selections we have used frequently.

Our staff and music library is small, and we have no musical director as such; musical suggestions are open to the whole staff. Fortunately, we have many diverse musical interests represented, and we are able to utilize our staffers' own personal, extensive music libraries.

We have no recording facilities and often plan complicated productions. We utilize the services of a professional recording studio and engineer. This allows extreme flexibility when we plan our shows. Although we often try to run our music segments and narration to time, we find that if we really have picked the right piece of music, our results are serendipitous, and the music just falls into place.

The following list is only partial - - some of the music we have used particularly successfully and is annotated, some of the music we look forward to using in the future. The *best* way to find music that will work for you is to listen to everything you can get your hands on, with an open ear ... and an open mind.

* * * * *

Moody Blues .. all LP's. We've used *Higher and Higher* for a rocket launch, *Eternity Road* for a UFO montage, *Dr. Livingstone, I Presume* for an exploring montage; *Processional* makes a dandy evolution of the solar system/evolution of the species. *Thinking is the Best Way to Travel* makes a good closing theme - - it's also a good anti-drug song if you're into that sort of propaganda. Check out all the lyrics on all the records - - most of them are provided with the album.

Pink Floyd .. *Ummegumma, Atom Heart Mother, A Saucerful of Secrets, Dark Side of the Moon.* Pink Floyd are experimentalists. Much of their music is ethereal and makes good back-up for sky shows. There is good music for a countdown sequence in the intro to *Time.*

Deep Purple .. *Book of Taliesyn Shades.* There are some good instrumental intros here. If you are still using *Also Sprach Zarathrustra*, or if you are looking for a different way to use that music, check out the intro to *River Deep, Mountain High.*

Soundtract to *Silent Running* .. see the movie, it's worthwhile. *The Space Fleet* is good for most any spacecraft. We used both the vocal and instrumental *Rejoice the Sun* as opening and closing theme for our sun show.

Soundtrack to *A Clockwork Orange.* This is the Walter Carlos/electronic music/original soundtrack version. The use of the classical material is obvious. We've used *Timesteps* for a lunar landing sequence, a sequence inside Jupiter's atmosphere, and an observatory.

Frank Zappa/Mothers of Invention. Frank Zappa has some good useable jazz out, particularly useful if you use a laser, or for exit music. We used the overture to *200 Motels* as an intro to a show-within-a-show. Zappa/Mothers have a lot of Varese-inspired music. Most of the vocal music is not suited for planetarium use. Remember your open mind? Use it here.

The Beatles .. *Sergeant Pepper* and *Abby Road.* We used *Lucy in the Sky with Diamonds* in a fantasy sequence, but it is also useful as music for an imaginary planet of unusual conditions.

Roger Sessions, Suite from *The Black Maskers.* The last movement is great for the mystery of Mars.

Gustave Mahler, *Symphony #4.* The climax of the third movement makes a fine solar eclipse.

Roy Harris, *Symphony #3.* The section just before the climax is good, ominous, doom-foreboding music. We used it preparatory to destroying the earth in our sun show.

Soundtracks .. *Summer of '42, Romeo and Juliet, Lawrence of Arabia, Ben Hur, Our Man Flint,* and the James Bond movies.

Arthur Brown, *Galactic Zoo Dossier .. Space Plucks, Galactic Zoo, Sunrise, Creation.*

Harry Partch, *Castor and Pollux.*

Three Dog Night, *Live at the Forum,* intro to *Chest Fever.*

Emerson, Lake, and Palmer, all LP's.

Steve Miller band, *Brave New World,* title song.

Iron Butterfly, *Iron Butterfly* theme, "In-a-gadda-da-vida".

David Axelrod, *Songs of Experience.*

Modern Jazz Quartet, all LP's.

(End)

Popular Music and Slides in the Planetarium

by R. John Steiffer, *Thomas Johnson Jr. High School, Lanham, Maryland*

(EDITOR: The author writes that the following paper was presented at the MAPS Convention in Pittsburgh in October, 1973.)

This article and the program it describes would never have been possible without help from the following people: the super students at Thomas Johnson Junior High School last year and this year to whom this program is dedicated; the participants of the 1973 Spitz Space Systems Summer Institute for serving as Guinea Pigs; Paul Boston of the Prince Georges County Public

Schools Planetarium for technical and production advice and help; and Marilyn Cahn, of Delaware Valley Middle School, Milford, PA for the inspiration.

A good way to turn kids on to what you're doing, secondary kids particularly, is to use popular music. As you know, they enjoy good slides too. Therefore if you combine both, it can be really super. Today's music has some really heavy lyrics.

The back to school program at the Thomas Johnson Planetarium used the following this year:

1. John Denver, just playing the guitar, from the "Rocky Mountain High" album. It makes nice quiet music to introduce the program.

2. Carol King, *You Light Up My Life Like Sunrise in the Morning*, from her "Fantasy" album. The slides I use here try to include pictures of students that fit the idea of how kids really do light up a teacher's life. Or, better yet, how people mean something to other people.

3. Bread, *He's a Good Lad*, from the album, "Manna". Obviously the title dictates the use of slides here that show kids in typical school activities - - sports, classroom, and groups. I hope to get across, by showing pictures of kids that have "The Devil in Their Eyes" that there is good in everyone.

   At this point in the planetarium I stop the tape and do 15 to 20 minutes of "backyard astronomy" on the current night sky. Outside the planetarium for a faculty or P.T.S.A. group I go on to the last part of the program.

4. Cat Stevens, *Morning Has Broken*, from the album "Teaser and the Firecat". For this selection, which I refer to as a love poem to a woman, people, and the plants and animals we share this planet with, I tried to use slides of plants and animals and nature that fit the lines of the song. The last two slides set the mood for a woman, people, and if you will, "students". There are a lot of subtle things being **"said"** without being spoken; caged animals vs. free; the beauty of all things in nature; how super sunrise is after watching the beauty of the night sky.

My procedure is as follows: First I write down the words of the song and decide how many slides I want to **use** - - usually one per line or thought. Then I set up 40 or so slides on a slide sorter and see which one best fits a particular line. Here is an example using the first verse of John Denver's *Sunshine*, from the album "Poems, Prayers, and Promises".

Sunshine on my shoulders makes me happy. I wanted to convey the idea of sunshine on my shoulders and beauty. A slide of sunshine on the hills or trees, with a shadow line visible was used here.

Sunshine in my eyes can make me cry. A shot of the sun shining towards you. Sunrise, through the trees, etc.

Sunshine on the water looks so lovely. Obviously the reflection of the sun on water makes a spectacular picture for this line.

Sunshine almost always makes me high. Here I used a slide of sunlight filtering through the trees above, (high) which formed a star image.

After doing this for the entire song, I put the slides into the slide projector, play the song, and see how it looks. Sometimes I'll make a change, usually not. To really make it impressive you should have two slide projectors and a dissolve unit - - it isn't necessary though. You can put the sound track on one channel and "impulses" on the other to change the slides; however, I prefer to control the pace of the slides each time. Since I have a small planetarium it is easy to watch audience reaction and subtle changes are possible.

Many of the planetarium people I know enjoy photography. If you don't, perhaps you know someone who is into it. A few minutes of slides and popular music at the beginning and/or end of your planetarium program will help tremendously to turn the kids onto the rest of the stuff you're into - - you know, Astronomy! And as a fringe benefit, you may get a few other teachers aware of the fact that the planetarium is not just an "Astronomy" room. It can be a very special "Audio-Visual Scene" for Interdisciplinary uses.

(End)

Popular Music Selections for Planetarium Programming

by G. Henry Sultner, *Dallastown PA Area School District*

For those of us who are blessed with a fine sound system in our planetarium, perhaps with several modes of presentation (record, reel tape, 8-track, cassette), I think we would have to agree that this is invaluable in presentations in terms of audience stimulation, student motivation and general atmosphere.

In organizing and directing planetarium programs the question arises frequently "where will I find music and sound effects appropriate to the program I'm working on?" Undoubtedly the first thought is to turn to one of the many sound effects records available commercially, planetarium-lecture soundtracks also available, or to search one's own record library according to his taste or exploit a colleague's.

With an ever-increasing number of school systems and colleges having or having plans for installing a planetarium, larger and larger numbers of student groups are passing through our chambers (and hopefully retaining something of what they learn while there). Just over two years ago, a survey of student audiences began yielding a barrage of musical selections of the popular music variety from the past and which continues to be augmented by new selections from the present - - selections which to student audiences are apropos because of title, theme, sound effects, or musical rendition.

In the following I have attempted to group the selections which have rendered the most positive reactions from student and adult audiences. Each is footnoted so that selections might be located by artist, label, and record number (where available).

Maybe your "thing" is the Age of Aquarius or the Zodiac. Musically, "Aquarius",[1] "Scorpio",[2] "Taurus",[3] and "No Matter What Sign You Are"[4] should enhance the theme. Sound effects of various types and for a wide range of applications are available on the selections "Reflections",[5] "Jungle Fever",[6] "Riders on the Storm",[7] "Raindrops",[8] "Rhythm of the Rain",[9] "In the Rain",[10] "Telestar",[11] "The Fly",[12] "Popcorn",[13] and "Frankenstein".[14]

Some introduction pieces with appeal include the "Overture from Jesus Christ Superstar",[15] "2001: A Space Odyssey",[16] "Out of Limits",[17] "No Matter What Shape",[18] "David's Mood",[19] "Soulful Strut",[20] and "Happy Organ".[21] Some equally appealing closing selections might include "Early in the Morning",[22] "Morning of our Lives",[23] "Here Comes The Sun",[24] "A Beautiful Morning",[25] "Crystal Blue Persuasion",[26] and "A Place in the Sun".[27]

Sandwiched between the opening and closing, a meditative mood of a total lunar or solar eclipse or impressive aurora display could well use "Imagine",[28] or "My Sweet Lord".[29] Seasonally and topically related selections used at the discretion of the individual director might include "Blue Moon",[30] "Bad Moon Rising",[31] "Ebb Tide",[32] "In the Still of the Night",[33] "In the Year 2525",[34] "Theme from a Summer Place",[35] "Our Winter Love",[36] "Autumn of my Life",[37] and "Have You Ever Seen the Rain".[38]

Background, mood music, and filler needs could be extracted from this list: "Because/Theme Without a Name",[39] "So Far Away",[40] "Rinky Dink",[41] "I Want You to Know",[42] "Rain, the Park, and the Other Things",[43] "Joy",[44] "Masterpiece",[45] "Papa Was A Rolling Stone",[46] "Bridge Over Troubled Water",[47] or "Outa Space".[48]

If the ecology movement is the "pitch" at the moment, "What's Going On"[49] and "Mercy, Mercy Me, the Ecology"[50] will work in fine. And if you've never involved your audience (particularly student groups) in "astronaut" exercises, solicit the help of the instructor on the "Moonflight"[51] and "Simon Says"[52] records before your next space flight. This is sure to get the students in "shape" for the journey (get some of that excess physical energy out of their systems before the program begins).

The foregoing may at first glance appear to be little more than an assemblage of trite record titles which happen to match some topics in astronomy and planetarium education which appeal much more with some audio enhancement. If on the other hand the planetarium director is willing to survey young (student) audiences, he will probably find some duplication of selection from the above list, some new and worthwhile suggestions and moreover, probably an overwhelming desire to help locate, organize, and record the many chosen selections. What could be more welcome, particularly to the planetarium director with limited personnel on his staff? The response to the foregoing type of music and sound effects selection and utilization has proven to be overwhelmingly positive in better than 2000 periods of student programming and for slightly better than 11,000 adults at evening programs in this installation. Plans for the immediate future include much of the same type of musical selection and utilization.

* * * * *

REFERENCES:

1. Fifth Dimension, Soul City, #SCR-772
2. Dennis Coffey, Sussex, #SUX-226
3. Dennis Coffey, Sussex, #SUX-233
4. Supremes, Motown, #MOT-1148
5. Supremes, Motown, #MOT-1111
6. Tornadoes, London, #LON-9561
7. The Doors, Elektra, #EKS-45738
8. Dee Clark, Vee-Jay, number not available
9. Cascades, Valiant, #6026
10. Dramatics, Volt, #VOA-4075
11. Tornadoes, London, #LON-9561
12. Chubby Checker, Parkway, #P-830
13. Hot Butter, Musicor, #MUS-1458
14. Edgar Winter Group, Epic, #5-10967
15. Original sound track album
16. Original sound track album; Deodato, CTI records,

#OJ-12 (45 rpm)
17. Marketts, Warner Bros. #5391
18. T-Bones, Liberty, #55836
19. Kingsmen, Wand, #W-157
20. Young-Holt Unlimited, Brunswick, # 55391
21. Dave Cortez, Emit, #E-302
22. Vanity Fare, Page One, #21027
23. Arkade, Dunhill, #45-D-4268
24. Richie Havens, Stormy Forest, #ST-656
25. The Rascals, Atlantic, #45-2493
26. Tommy James, Roulette, #R-7050
27. Stevie Wonder, Tamla, #T-54139
28. John Lennon, Apple, #1840
29. George Harrison, Apple, #2995
30. Marcels, Colpix, #CP-186
31. Creedence Clearwater Revival, Fantasy, #622
32. Righteous Brothers, Phillies, #130
33. Santo & Johnny, Canadian-American, #CA-164
34. Zager & Evans, RCA, #74-0174
35. Percy Faith, Columbia, #4-41490; Ventures, Liberty, #56115
36. Bill Pursell, Columbia, number not available
37. Bobby Goldsboro, United Artists, number not available
38. Creedence Clearwater Revival, Fantasy #655
39. Dave Clark Five, Epic, #5-9704
40. Hank Jacobs, Sue, #795
41. Dave Cortez, Chess, #U-452
42. New Colony Six, Mercury, #72961
43. The Cowsills, MGM, #K13810
44. Apollo 100, Mega, #615-0050
45. Temptations, Gordy, #G-7126F
46. Temptations, Gordy, #G-7121F
47. Simon & Garfunkel, Columbia, #4-45079
48. Billy Preston, A & M, #AM-1320
49. Marvin Gaye, Tamla, #T-54201
50. Marvin Gaye, Tamla, #T-54207
51. Vic Venus, Buddah, #BDA-118
52. 1910 Fruitgum Company, Buddah, #BDA-24

(End)

Music of the Asteroids

by June LoGuirato, *National Capital Astronomers*

Most medieval scholars knew about the music of the spheres, but few modern astronomers have heard about the music of the asteroids. The history of the asteroids - those miniature worlds which move primarily between the orbits of Mars and Jupiter - is not discussed in elementary astronomy texts; consequently, planetarium educators don't realize that over forty asteroids bear musical names. [1,2,3]

A program devoted to music commemorated in the asteroids can begin with an invocation to the ancient Muses. These nine goddesses of music and poetry are honored collectively (Asteroid number 600 is named Musa.) and separately (18 Melpomene, 22 Kalliope, 23 Thalia, 27 Euterpe, 30 Urania, 33 Polyhymnia, 62 Erato, 81 Terpsichore, plus 84 Klio). [4,5,6,7]

The siren's songs (1009 Sirene) may be temporarily fascinating but they pale in comparison to the golden lyre of Apollo, ancient god of poetry and music. Astronomically Apollo (1932 HA Apollo) is an unusual "earth-grazing" planetoid. [8]

Classical musicians also appear among the solar system's minor planets. The compositions of Wolfgang Amadeus Mozart (1034 Mozartia) and Johann Sebastian Bach (1482 Sebastiana) can be enjoyed while asteroids, ranging in size from large mountains to dust grains, move slowly across a star field. Works by the Czech composer Karel Bendl (734 Benda) and the Russian composer Modest Mussorgsky (1059 Mussorgskia) can enliven the bleak features of an asteroid landscape. [9 10 11]

Some asteroid discoverers, particularly Max Wolf and his staff at the University of Heidelberg, were music buffs. A ballet (815 Coppelia) and an overture (540 Rosamunde) are found in the asteroid belt, but opera were preferred. While following the flight path of Pioneer 11 through this belt of irregular rock-like debris,[12] a planetarium audience can enjoy selections from Verdi's *Aïda* (861 Aïda), Bizet's *Carmen* (558 Carmen) or Beethoven's *Fidelio* (524 Fidelio).

It is difficult to determine how many asteroids were named after operatic characters. Participants in the Trojan War are recalled in both the opera houses and the tiny planetoids. Astronomically, the Trojan asteroids move in the same orbit as Jupiter. [13]

Several ancient deities honored among the small worlds - many only a mile or two in diameter - also appear in musical compositions like Wagner's *The Ring of the Nibelungs*. Operatic characters found among the miniature planets include: Papagena (471 Papagena) and Pamina (539 Pamina) from Mozart's *The Magic Flute*; Dalila (560 Delila) from Saint-Saens' *Samson and Delilah*; Violetta (557 Violetta) from Verdi's *La Traviata*; and Isolde (211 Isolda) from Wagner's *Tristan and Isolde*.[14 15]

When considering a program on music of the asteroids, remember that many planetariums have included the minor planets in their programs on the vagabonds in space.[16] Commercial slides on the planetoids are available;[17] however, a planetarium educator can produce his own.[18] Classical music,[19 20] films,[21] and artwork[22] can be selected with the aid of standard guides.

REFERENCES:

1. Willy Ley, Watchers of the Skies (New York: The Viking Press, 1963). Chapter 13 contains important historical material.

2. Günter Roth, The System of Minor Planets (London: Faber and Faber Ltd., 1962). Contains a wealth of historical, observational, and physical data plus asteroid photos.

3. To receive a free copy of high quality tracking charts for currently observable asteroids, send a stamped, self-addressed envelope to: Dr. J.U. Gunter, "Tonight's Asteroids", 1411 North Mangum St., Durham NC 27701, U.S.A.

4. Frederick Pilcher and Jean Meeus, Tables of Minor Planets (Jacksonville, IL: Frederick Pilcher, Illinois College). These tables contain orbital and physical data on all asteroids mentioned here.

5. Characters in ancient mythology or in classic opera and their namesakes among the minor planets may have slightly different spellings. The final authority for the spelling of asteroid names is: Paul Herget, The Names of the Minor Planets (Cincinnati, Ohio: Minor Planet Center, University of Cincinnati Observatory, 1955 and 1968).

6. Bulfinch's Mythology (New York: Random House, Inc.). Standard reference on mythology.

7. Edith Hamilton, Mythology (New York: The New American Library, 1964). Another standard reference on mythology.

8. Brian Marsden, "The Recovery of Apollo", *Sky and Telescope* 46 (September 1973), 155-8. Up-to-date information on "earth-grazing" asteroids including photos.

9. Eric Blom, ed., Grove's Dictionary of Music and Musicians (New York: St. Martin's Press, Inc., 1955, 5th edition). This nine volume set includes extensive bibliographic information plus comprehensive lists of the works of individual composers.

10. The World of Music - an Illustrated Encyclopedia (New York: Abradale Press, 1963). Four volume set including numerous photos.

11. Oscar Thompson, ed., The International Cyclopedia of Music and Musicians (New York: Dodd, Mead & Co., 1964, 9th edition).

12. Tom Gehrels, "The Flyby of Jupiter", *Sky and Telescope* 47 (February 1974), 76.

13. Patrick Moore, The New Guide to the Planets (New York: W.W. Norton & Co., Inc., 1974), 125-6. Chapter 10 includes numerous asteroid drawings.

14. Earl of Harewood, ed., Kobbé's Complete Opera Book (New York: G.P. Putnam's Sons, 1969). Includes lists of characters in well-known operas.

15. David Ewen, The New Encyclopedia of the Opera (New York: Hill and Wang, 1971).

16. Both Morehead Planetarium, Chapel Hill, North Carolina, and McLaughlin Planetarium, Toronto, Ontario, Canada, have presented "Vagabonds in Space".

17. Richard Berendzen and David DeVorkin, "Resource Letter EMAA-1: Educational Materials in Astronomy and Astrophysics", *American Journal of Physics* 41 (June, 1973), 786-7. Lists observatories and firms selling astronomical slides.

18. Hugh Rice, "Miniature Worlds", *The Sky* 1 (August, 1937) 3-5, 21 plus "Miniature Worlds, Part II", *The Sky* 1 (October 1937) 5-7,19. Contains numerous photos and drawings including landscape of Eros. See also *references* 2, 8, and 13.

19. Herbert Russcol, Guide to Low-Priced Classical Records (New York: Hart Publ. Co., Inc.. 1969). Reviews over 1000 compositions by over 300 classical composers.

20. Records in Review (New York: Charles Scribner's Sons, 1973). Eighteenth annual collection of record reviews from *High Fidelity*.

21. Berendzen and DeVorkin, *op. cit.*, p. 788, items 47 and 58.

22. Encyclopedia of World Art (New York: McGraw-Hill Book Co., 1968). Fifteen volumes including photos of paintings and sculpture concerning ancient deities.

(END)

Astronomy Education Resourses

conducted by George Reed, *West Chester State College (PA)*

The Center for UFO Studies

Lord Kelvin once said that until you can measure what you are speaking about, your knowledge is meager, unsatisfactory and certainly not advanced to the stage of science. Of course that doesn't apply to the UFO. There is no reason why anyone would want to apply the methods of science to the phenomena of the UFO. The UFO is a subject for the weirdos, or at least so I felt.

During 1973, I had the opportunity to listen to Dr. J. Allen Hynek, a reputable astronomer and Chairman of the Astronomy Department at Northwestern University, talk about the UFO, a subject he has been intimately involved with for over 20 years. His lectures were given aboard the Canberra during the June 1973 African eclipse cruise. My interest and curiosity were aroused to the point that upon returning, I read Hynek's book The UFO Experience - A Scientific Inquiry.

This book consists of a straightforward, unsensational treatment of the phenomena of the UFO. It is rather lengthily defined as "the reported perception of an object or light seen in the sky or upon the land, the appearance, trajectory and general dynamic and luminescent behavior of which do not suggest a logical, conventional explanation, and which is not only mystifying to the original percipient but remains unidentified after close scrutiny of all available evidence by persons who are technically capable of making a common sense identification, if one is possible".

The book reviews the histories of the United States Air Force projects "Sign", "Grudge", and "Blue Book". These projects are criticized in terms of their handling of data and their insufficient investigations of reports. Hynek feels that any often assumed to be the "probable" explanation, and that solutions were considered more valuable than mysteries. He is equally critical of the Condon Report from the University of Colorado and his fellow scientists. Many scientists express contempt and ridicule toward UFO investigations without ever investigating the content of such reports. The situation reminds one of the attitude of the Aristotelians toward Galileo's telescopic discoveries. Other scientists are convinced that the entire UFO scene is the result of a psychological phenomenon. Some scientists however are believers.

The unexplained UFO reports from around the world are broken down by Hynek into six categories. These categories, which are rated according to the "strangeness" of the observation, have resulted from definite patterns that have appeared after a study of hundreds of UFO reports. The examples given to illustrate the prototype of each category were made by two or more reliable observers. The categories include nocturnal lights, daylight disks, radar-visual observations, and three different types of close encounters.

Hynek has now organized an interested interdisciplinary force under the framework of the Center for UFO Studies. It was established in order that affirmative scientific action can be directed toward the discovery of the essential nature of the UFO phenomenon. The objectives of the Center include the pursuit of a rigorous study and analysis of the phenomenon, the operation of a clearing house to receive UFO reports, and as a source of reliable information about the UFO phenomenon. These last two activities will be of particular concern to the planetarium community.

The school and museum planetarium often present programs

dealing with the UFO phenomenon. The Center for UFO Studies will be able to supply accurate information for those programs. The planetarium in return can encourage people who have observed something mysterious to report it to the Center.

Persons or organizations interested in supporting the serious scientific work of the Center for UFO Studies can volunteer their technical facilities or make tax-deductible contributions to the Center for UFO Studies, P.O. Box 11, Northfield, Illinois 60093, U.S.A.

(Executive Editor: We are aware that some of the views expressed by Editor Reed on Prof. Hynek and the Center for UFO Studies will be considered controversial by numerous members of the scientific community. All interested persons are invited to respond to Letters to the Editor. *Letters of substance will be published as a special section in a future issue of THE PLANETARIAN.)*

Astronomy Through Practical Investigations

Astronomy Through Practical Investigations consists of 15 individually bound "investigations". The investigation booklets were developed for the community college, non-science major astronomy or physical science student. They are well-written and can be used with beginning students at the secondary school level as well as the college level. The investigations are adaptable to formal laboratory situations as well as for use as individual self-study supplemental material. Each booklet is question-oriented. The questions are clear, probing, and logical in their order. The basic concepts of each investigation are developed in a logical fashion with a minimum use of words. The "cook book" style has been avoided. Answering the questions the metric system and the conversions to the English system. The metric system is then used exclusively in Investigation #2, "Drawing the Solar System to Scale" and throughout the rest of the series. The investigations dealing with comets, meteor phenomena, and lunar geology are heavily dependent upon the student's interpretation of photographs. The booklet concerned with asteroids centers around the student's interpretation of the light curve produced by a rotating rectangular-shaped asteroid. Three of the investigations form a good physics sequence dealing with refraction, reflection, and telescopes.

Several of the booklets are of special interest. Some aspects of observational astronomy are dealt with in the "Phases of the Moon", "Horizon System", "Equatorial System", "Sidereal Time", and "The Planetary Configurations" booklets. The latter booklets are especially adaptable to planetarium activities. The constellation booklet provides a good academic treatment of constellations and can be used as a supplement to or in conjunction with a planetarium program.

The authors, G. Lomaga, W. Smiley, and R. Warasila are teachers at Suffolk County Community College in Selden, New York. The entire set of 15 investigations cost $4.50 (U.S.A.) They are available for 30¢ each in sets of more than 9 and 35¢ each in sets of 9 or less. The booklets can be purchased from L.S.W. Associates, P.O. Box 82, Mattituck, New York 11952.

The Evolution of Radio Astronomy

Reviewed by Joseph W. Erkes, Ph.D.
Director of Fullam Radio Observatory, State Univ. of New York at Albany and Dudley Observatory

written by J.S. Hey, is an account of the people, ideas, and events surrounding the developmental discoveries made through its use. The author, an active radio astronomer since the 1940's, writes with authority about his contemporaries and their work.

The first three chapters in the book are a chronological history of the early development of radio astronomy, beginning with the first unsuccessful attempts to detect extra-terrestrial radio radiation by Edison, Lodge, and others, and ending with the discovery in the early 1950's of the 21 cm hydrogen line and the first identifications of radio sources.

Chapter Four deals with the establishment of the modern radio observatories and relates among other stories of the fascinating tale of the construction of the Jodrell Bank 250 foot telescope and the problems, financial and otherwise (including a possible jail term) faced by its director, Sir Bernard Lovell.

In the last four chapters, Hey departs from a strictly chronological development and instead follows the development of radio astronomy as a tool in understanding the Solar System, our galaxy, and extragalactic objects.

In general the book is very readable and contains much historical information not readily available before. It also contains one of the few up-to-date (1971) summaries of our present state of knowledge of radio astronomy. On the other hand, the book is not without some minor flaws. The author, in covering a great deal of information in 214 pages, is understandably rather brief in some of his descriptions occasionally. In particular, some technical descriptions are quite abbreviated, and he uses radio astronomical jargon freely. Perhaps in recognition of this, the book does contain a glossary of radio astronomical terms.

For those interested in the history of radio astronomy, or in learning more about radio astronomy in general, or for those who want to learn the "why" of the phenomenal growth of this branch of astronomy, this book makes for very enjoyable, profitable reading.

(EDITOR: The Evolution of Radio Astronomy is available for $10.00, pre-paid only, from Watson Academic Publications, Inc., 156 Fifth Avenue, New York, NY 10010.

UNDER ROOF, DOME, AND SKY

Reviewed by Gerry Muhl

Two teachers were overheard discussing the national accreditation of their school during a break at a recent planetarium conference. Both felt the accrediting agent's comments were useful in that they pointed up the strengths and also the weaknesses of the institution. While listening to the introduction for the next speaker, I began musing over the question of who evaluates or accredits the planetarium? A few weeks later my question began to be answered when the book Under Roof, Dome, and Sky appeared on my desk.

Various regional associations of planetarium educators have seen the need and taken it upon themselves to decide the merit of what they are doing "under the dome". In the introduction John Richardson, then President of the Middle Atlantic Planetarium Society, sums up the problem by noting,

> "In the past decade there has been a tremendous influx of planetariums into our educational society. With the aid of NDEA funds, many of these instruments found their way into local school systems across the country. Unfortunately, a lack of trained personnel and a dearth of established lesson plans existed, and many of the new instruments were not used to their fullest potential."

This new book, long overdue, attempts to help fill the void mentioned by Richardson. Funded by a grant from the National Science Foundation to the Middle Atlantic Planetarium Society (MAPS) and the University of Maryland, Under Roof, Dome, and Sky is the work of over 45 classroom and planetarium educators.

The book contains 45 student-centered activities for the planetarium and appropriate pre- and post-visit classroom activities. The main thrust is toward the Secondary Grades, though 13 Elementary and Intermediate activities are also spaced throughout the volume. Most activities seem to be graded properly, though in the author's words, some "grey zones" exist where certain activities might be used in the upper intermediate grades as well as in the Secondary grades.

Each activity is prefaced by two or more behavioral objectives making the evaluation of each particular experience an integral part of the lesson. The authors seem to assume students will be able to make multiple visits to the planetarium in completing projects, though for some activities one visit might be enough. In three of four instances however, the planetarium instructor's lesson plan calls for the switching on of some sort of geocentric earth projector. Remembering back to a small college planetarium I once worked with, I was always in doubt if my college classes could upon one visit to the star theatre make the mental gymnastics necessary to fully understand the subtleties of such a projection. Perhaps, at least in these instances, two visits should be spelled out.

One minor shortcoming of Under Roof, Dome, and Sky is the omission of certain books and teacher manuals from the bibliography. The introduction states that the editorial committee had a familiarity with a number of modern curriculum projects - one among them the Elementary Science Study (ESS) materials. Nowhere in the book however, is mention made of any of the various ESS units related to astronomy. Of particular assistance to the classroom teacher in preparing his class for the planetarium experience would have been the ESS unit "Daytime Astronomy" with the activities on page 100 (Sunrise, Sunset and the Seasons) and page 130 (What's Your Local Time). The ESS Pendulums unit would have gone well with page 145 (Earth's Rotation); "Where is the Moon" with page 213 (The Moon at Sunrise and Sunset); and the unit "Peas and Particles" would have helped the classroom teacher with page 243 (Learning Estimation Technique).

Unfortunately, one of the weakest areas of the book was that dealing with student classroom preparation for the activities dealing with lunar observations. Perhaps this would remedy itself if the planetarium instructor could have the luxury of also being able to work with the students first in the classroom. Time limitations being as they are, it would seem wise to assist the teacher by a more comprehensive development of pre-visit activities. For example, students are asked to record their observations of the Moon and Sun at sunset but are offered no way qualitatively to judge by how much the Moon has changed its daily position in relation to the Sun (nt. Neely, The Stars by Clock and Fist). Students are given no method for finding accurate direction and thus work with the assumption that the sun always sets in the "western" sky. Students are given models of the earth-moon system and asked to memorize phase names rather than having them attempt to create their own models on the basis of their own observation. Student-centered activities, as the name implies, should have the *student* at the center of the discovery.

The last two chapters (Mathematics and Measurement and Motions of the Planets) appear most clearly labored over and well thought out. These activities are well-written, though

I would question one statement on the collection of micrometeorites from the runoff water from house tops after a rain shower. Although this may theoretically be done, I feel that greater description of the technique involved would be useful.

Under Roof, Dome, and Sky should prove to be a useful book in any planetarium library. Crammed with ideas, it most certainly will be the catalyst to spark many planetarium lessons to come.

(EDITOR: Under Roof, Dome, and Sky is still available for $7.00, pre-paid only, from John Richardson, MAPS Past-President, c/o Red Lion Road, Huntingdon Valley, PA 19006.)

Other Books

Reviewed by George Reed

From the Black Hole to the Infinite Universe, by Donald Goldsmith and Donald Levy, published by Holden-Day Inc, San Francisco.

Who likes to read academic astronomy books that have elements of science fiction, sex, humor, drugs, and the women's liberation movement? Almost everyone. Unfortunately this book has only a brief and trite science fiction story. The nuclear and astrophysics sections are well-written. The illustrations are interesting. The idea is good, but the auhtors "didn't get it all together".

Modern Astronomy, by Ludwig Oster, published by Holden-Day, Inc., San Francisco.

This text was designed for a one or two semester college general astronomy course. The content, while consistent with other similar texts, is more condensed and broken down into more chapters. The text has diagrams that are superior to those found in other texts.