In This Issue

THE MILKY WAY: SOME NEW FINDINGS .............. Bart Bok 4
SPIRIT MASTER BOOKS: LET THE TEACHER BEWARE .... Roger Grossenbacher 9
MARS: THE 2014 A.D. COLONIES: AN AV PRESENTATION ........ Clair J. and Everett Q. Carr 21

FEATURES

The President’s Message ......................... James A. Hooks 2
The Editor’s Corner .............................. David Hoffman 3
Letters and Announcements ..................... 3
Focus on Education ............................... Jeanne E. Bishop 7
Sky Notes ........................................... Jack Dunn 10
Planetarium Usage for Secondary Students ........ Gerald Mallon 11
Script Section .................................... Ronald N. Hartman 12
(T’The Near Frontier” by Carolyn Sumners)
Trouble Shooting: A One-Shot Advice Column for Planetarians .... George Reed 23
What’s New ....................................... James Brown 24
Creative Corner ................................... David Aguilar 24

Computer Corner
(“Preparing Astronomy Programs: A Basic Approach” by Carl J. Wenning) ............... Dan Spence 26
Special Programs for Special People ............... Rita Fairman 30
Jane’s Corner ...................................... Jane P. Geohegan 31

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THE PRESIDENT'S MESSAGE

We, in the profession of Astronomy, are called Planetarians. We work with a science that is sublime and beautiful. It is noble, elevating and consoling, and to some, it may even be divine. Yet, it does give us wings to soar through the Cosmos. Now let your thoughts have wings so that they may dream of the pleasing, that they may extend from the here to there and everywhere, in all directions. Look to every corner of the heavens and let your thoughts be free. Dream of the perfect and ideal. This, you deserve!

I, your retiring President, feel that without life and without thoughts, the Wilkin would just simply be an empty chamber.

I think it has been diversified thinking and freedom of imagination that have shaped and created this complex world we now live in. These have, and will create the good life, if based on sound judgment, combined with the ingredients of understanding and knowledge. If this world is to survive, its people must be aware of who, what, and where they are as they move through the time zone of life.

In our life we deal with our everyday problems. Many appear to be insurmountable and others overwhelming. Yet, as each day passes, new problems seem to flourish before us, and on and on we go. Our goal is life, and it is life that develops the cognitive process of thought. If we did not have thoughts to conquer our problems and thoughts to perceive to some degree the boundless Cosmos, where would the universe exist?

It is my hope that the International Planetarium Society will continue to exemplify truth, honesty, and foresight, based upon a knowledge with freedom of thought. Then, the day will come when it will have status, power, and authority, and it will be known to society at large that Planetaria are making a worthwhile contribution to the surrounding communities. And Planetarians, themselves, will continue to meet a special need.

If history holds true, and the world’s society continues into more complexity, and Planetarians continue on their present course, the future will be brighter for their profession, a profession that I feel so much a part of. It was in 1970 that the International Planetarium Society was established, and I have been with it since that time. I was first on the Constitutional Committee, and now in 1980 I am bowing out as its President. As your President I have at all times felt deeply grateful and highly honored to hold that elected office. It has been the individuals that make up this great organization that have made it so. It is not disheartening to step down, because I can see a great future ahead for the International Planetarium Society.

In 1981, your President will be Mr. William Peters. He has my enthusiastic support. The Executive Council that he will work with includes some of the finest people I know. They are a dedicated group. There will be an additional member of the Council from the great nation of Mexico. The Association of Mexican Planetarians is now an affiliate of the International Planetarium Society. We welcome them!

You, the membership, will, hopefully, by 1981 change Article II of our Constitution. This will be another advancement. You will have elected new individuals to hold these honorable offices, and these I believe will be the best.

The last two years as President have gone by so swiftly, but so much has happened. There have been many, many accomplishments due to the multitude of highly capable and professional individuals that have participated and given of their tireless efforts. The accomplishments and those individuals that made them happen are too numerous to mention, and there have been the inevitable failures.

The past four years, as President Elect and President, is best described by Jack Horkheimer in one of his programs:

“Attitude—your disposition, feelings, manner towards people and things, as changing as the colors and forms in a child’s kaleidoscope. Man can be blessed by his attitudes or cursed by them. They can carry him to the heights of the best within him, or plunge him to the depths of his most horrifying capabilities.”

Yes, I was blessed with understanding friends and was elevated to the heights by devoted professional Planetarians. And at times, I could see from the top of the mast landfalls beyond the horizons. Yes, my attitudes, disposition, manner, and feelings toward our elected officials in Washington have changed, because of promises not kept—correspondences not answered, time schedules not adhered to. They put on a good show. I was plunged to the depths by unkept words and lack of action, one way or the other. Perhaps time will replace or erase distrusting feelings and negative thoughts. It would be wonderful and profitable to circumvent mistakes in the future, as I have plowed through the mistakes of the past. Yet, my underlying philosophy has not been shaken. Hopefully, it never will be.

As your President, I now say farewell to you, the members of this great Society. I wish each of you a pleasant life with clear and positive free thinking for the future.

James A. Hooks
President
International Planetarium Society
LETTERS TO THE EDITOR

★ Dear Editor:

An information packet on Mars, including unique 3-D views of the red planet, is now available from the Astronomical Society of the Pacific, a worldwide, nonprofit educational organization. The packet includes a complete map of Mars, assembled by the U.S. Geological Survey from Mariner 9 photographs; a set of 3-D views (together with 3-D glasses) of the Martian surface, taken by the Viking landers; an information sheet on what we have learned about our planetary neighbor and a bibliography of further nontechnical readings and information sources. These materials are part of a series of information packets being made available by the Society. Other topics in the series have included black holes, debunking pseudo-science, and an introduction to astronomy. Copies of the Mars packet can be obtained by sending $1 (for postage and handling) to:

A.S.P.
ATTN: Mars Packet
1290 - 24th Avenue
San Francisco, CA 94122

★ Dear Editor:

Instructional materials for teaching astronomy or for preparing teachers to teach astronomy are continuously being developed. Knowledge and dissemination of these materials are very limited. Recently a project has been established to promote development, research and exchange of astronomy education materials. The Dissemination of Astronomy Education Materials Project has been designed to inform school and non-school educators of the existence of these materials, and to provide an opportunity to contribute to the dissemination network and exchange process. Astronomy education materials such as the following are being solicited: locally developed curricula, instructional modules, lab and field activities, assessment instruments, slide and video tape presentations, films, games, simulations, planetarium lessons and labs, computer simulations, and descriptions of instructional strategies which will help provide principal components of an activity oriented astronomy curriculum. Guidelines for the submission of materials have been established as follows:

1. Materials must be easily used at other facilities without major investments and modifications.
2. Developers of materials must be willing to disseminate materials at no cost.
3. Each potential submission to the network must be accompanied by the materials survey form with all items completed.
4. One complementary copy of all materials must be submitted with the survey form to establish a clearing-house for the astronomy education materials. Materials not used will be returned.

In the spring of 1981, an Astronomy Materials Resource Guide will be published which will provide listings describing all submitted materials and how they can be obtained. All persons submitting at least one entry will receive one copy sent free of charge. Otherwise, the Resource Guide will be available for a projected cost of $4.

Future plans call for yearly updating and continuation of this Astronomy Resource Material Dissemination Network through an annual survey. Publication of updated Resource Guides in late spring should help educators plan for the following school year, or for summer activities. For further information and submission survey forms, contact:

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EDITOR’S CORNER

It was with much regret that I accepted the resignation of Herb Schwartz as Feature Editor in charge of Creative Corner. Outside pressures forced him to do so. The Planetarian owes Herb a great deal. However, you will be happy to know that David Aguilar is going to conduct Creative Corner beginning with this issue. Dave is best qualified to take over this vital column since he is the Editor of the Special Effects I.P.S. report which is soon to be published. Tell him about your favorite projector or ask him to solve your technical problem.

Three new features are being added with this issue: Computer Corner will be conducted by Dan Spence; Special People by Rita Fairman; and Planetarium Usage for Secondary Students by Gerald Mallon. Read their introductory remarks and, if you can, get involved.

There is much to read and see in this issue, so let me get off the page. Enjoy!

Dave Hoffman
Editor
THE MILKY WAY: SOME NEW FINDINGS
Dr. Bart Bok
University of Arizona
Tucson, Arizona

Editor's Note: As planetarians we are astronomy educators and popularizers, so it behooves us to be aware of newly made discoveries and expanded theories. Many of our programs will have to be updated or rewritten altogether. For those of you who have done programs on the Milky Way, or are contemplating doing one, the following remarks, made by Dr. Bart Bok of the University of Arizona on the occasion of the joint conference of the Astronomical Society of the Pacific, the Western Amateur Astronomers, and the Association of Lunar and Planetary Observers in July of 1980, will prove to be of great value. They are here printed with Dr. Bok's kind permission.

Tonight I have a very interesting assignment. The time has come for me to revise the book "The Milky Way" without the help of my wife, Priscilla. This is a sad thing for me to do, even though I have many friends to help me with it. I miss Priscilla very much. I decided that I might as well do a real good job on preparing the material for the Fifth Edition, so I took the time to think hard about it. Being retired, I have the time to read and to do other things that I never had enough time to do before. I travel quite a bit, meeting and talking with other astronomers from all over the world. I have been thinking very carefully about how our ideas about the Milky Way are changing.

When the book was first written it was written for young people principally, as well as for amateur astronomers. Later on it became sort of a source book for physicists who needed information in a hurry about astronomical research into the Milky Way. We found we had to write and rewrite the book every ten to fifteen years or so. Fifteen years seemed like a good norm. But when in 1978 I began to look at the edition that came out in 1973, I noted that so much has happened and is happening in Milky Way research that it just is not possible to wait fifteen years anymore. The book is very quickly getting out of date. I therefore decided, and thank heavens Harvard University Press agreed with me, to rewrite parts of the book.

I have just completed the text, so this is the ideal time for me to tell you about the bigger and better Milky Way. I want to stress the places where things have changed. And they have changed in a variety of places! For example, our estimates about the mass and size of the Milky Way System have increased a great deal. The mass has increased four or five fold; some say it may go as high as ten fold. The estimate of the size of the Milky Way System has increased by a factor of at least three, and this may possibly be a factor of five, or even eight!

Furthermore, our knowledge of the center of the Milky Way has changed quite a lot and improved dramatically. We now have infra-red, x-ray and radio astronomy to help in our studies. All of these together are telling us completely new things about the Milky Way System. We have been getting especially fine results from spectroscopy of the infra-red region.

In my retirement I find that I have the time to attend many astronomical symposia all around the world. I got to meet many people and heard many new ideas in Australia, India, Holland and England. These people come to Milky Way research from different disciplines in radio and optical areas. I have been so impressed with their findings that I have been thinking very hard about the overall picture of our Milky Way galaxy. In some areas research is doing very well and is making rapid progress; in others, not so well. The thing that is most interesting to me is not only to see how we think the Milky Way is constructed, but how, over the years, the emphasis of the research is changing.

Take for example the problem of star clusters. It is amazing to see how all sorts of ideas about globular clusters have come into their own. It was not too long that we had good distances for only a few globular clusters. Now we have them for 78 out of a total of 131 globular clusters; all of these have been studied in a variety of ways.

The field of research that I consider the saddest, in a way, is that of the spiral structure of our galaxy. I was a great spiral structure enthusiast until just about the time that Priscilla died. Toward the end of her life, she did her best to discourage me. She told me that it was becoming far from being a fertile field for future research. I took her advice and turned to star formation. I am not sorry.

Before I go any further, let me tell you about what we know about the mass and size of our galaxy. This mass and size affair is a serious business. You don’t increase the mass of your home galaxy by a factor of 3 or 4, maybe as high as 10, without giving it a little thought. Do the new developments throw out all our old thinking about the spiral galaxy? No. Not in the least. It just means that in mass and size we have just found a very large halo or corona (that's a good name for it) surrounding our familiar galaxy.

We have long been aware of the fact that our galaxy is shaped like a disc. The disc is thin and houses the young stars as well as the gas and dust. You and I and the sun and earth live right in the central plane of that disc. The central plane of the disc is outlined in the night sky as the hazy of the Milky Way. We can see it as a great circle in the sky. We know, too, that it is not a ring system like Saturn’s, but is much more than that. It has great depth. Some of the stars that form the Milky Way are 100 light years away; others, 1,000; others, 10,000. We have also known for years, thanks to Harlow Shapely, who, from 1918 to 1922, busied himself with the problem that we are not in the center of the galaxy, but rather in the central plane, far out in the outskirts. As a matter of fact we are about 26,000 light years from the center. That center, as you know, lies in the direction of the great Sagittarius star cloud, best seen from 30° southern latitude where it is seen to pass directly overhead. One look at it is obvious that the center lies in that direction, for that is where the mightiest star clouds are. Ours is a flat-shaped galaxy, known to have a galactic nucleus; in the outer parts we find a spiral shaped structure rotating about the center. Our sun moves with a speed of about 220 kilometers per second, completing one orbit of the center in 200 million years.

This system has long been thought to possess a thin outer halo. But the halo’s size relatively unknown because it is so difficult to explore that halo. That halo goes a little farther...
out than the luminous disc. I should mention that the disc system has a radius of 50,000 light years. Beyond that, perhaps another 10 to 12,000 light years, is the outer part of the halo. Its shape is like a spheroidal blob, made up mostly of very old stars. They must be old, because of the way we visualize the origins of stars in the universe. Blobs of gas were the first objects to form after the Big Bang. The earliest star formation started within them. The oldest globular star clusters, therefore, originated during that particular time - about 15 billion years ago. The mass that remained began to settle toward the central plane of the rotating disc. That is where star formation is now taking place.

Maarten Schmidt, Director of the Hale Observatories, set up a model to describe our galaxy. In that model he predicted how the rotation would vary with distance from the center. Already 7 or 8 years ago we had good information about variations in rotational velocity with distance from the center up to the position of the sun. But we had very little rotation data about the velocities of stars, nebulae, and clusters outside these limits. Schmidt said that this did not matter. The total mass of the galaxy in the disc is about 140 billion solar masses. In the halo we don’t know how much matter there is, but it was expected to be less. He predicted, therefore, that the rate of rotation would drop off the farther one goes from the center.

Three interesting new ideas were recently developed about the Milky Way. The first was put forth by some theorists who believe that the Milky Way contains more mass than we previously had imagined. The first theorist to think seriously about this, enough to stick his neck out, was an Estonian by the name of Einasto. He decided that there was something wrong. Most of the Milky Way astronomers, including myself, say that the sun moves at the rate of 220 kilometers per second around the center of the galaxy. But others, such as Alan Sandage, say that the sun moves at 300 kilometers per second. They base their belief on observations of other nearby galaxies in the Local Group such as Messier 51 and the Andromeda galaxy. The controversy is still going on. If the sun is really moving at 220 kilometers per second, then results of observations of the Andromeda galaxy show that it is approaching us at 80 kilometers per second and that seems just plain silly. We just do not have enough mass in our galaxy to attract Andromeda like that. Einasto said: “Suppose that the Andromeda Galaxy moves at 300 kilometers per second, and that our sun and its neighbors move at only 220 kilometers per second with respect to the center of our galaxy. That would mean that our galaxy and Andromeda attract each other.” Einasto said that the mass of our galaxy must be 10 times greater than we think it is in order to do this.

In the meantime, other things began to happen. Lynden Bell of England was the first to come forth with the idea that in our own galaxy there is an instability. And, he said, our galactic disc can only remain stable if it is enveloped in a huge bowl of soup of some sort that gives it gravitational stability. Ostriker and other astronomers at Princeton echoed that idea. In the beginning Ostriker and Einasto didn’t know each other. They worked independently. Then two or three things happened. Vera Rubin and others from the Carnegie Institution in Washington analyzed the rotation of other galaxies. They found a very peculiar thing. They had expected that beyond the most luminous parts of each galaxy the speed of rotation would drop off. This would be analogous to Jupiter moving slower than Mars, and Uranus moving slower than Jupiter, all according to Keplerian laws. Much to their surprise this was not the case. These galaxies would get up to speeds of, say, 250 kilometers per second, and stay there. In some cases rotation in the outer parts would get up to 300! Well Einasto said, “Take a look at my galactic model. It will also go up to a limit of 300 kilometers per second.” Scientists started to do some checking. Fortunately they had state-of-the-art tools with which to work - especially better spectrographs that gave better values in the radial velocities in the faint outer parts. And what they found out was that as you go far out from the center, the rotation does not slow down at all. The flat rotation curve, predicted by theory for mass in galaxies was borne out by observation.

Then came the observations that clinched it all! These were made by Hartwick and Sargent. They, as well as others, studied the Palomar Schmidt plates and discovered some outlying globular clusters. The two astronomers found eleven globular clusters with distances ranging beyond 20,000 parsecs - some as far out as 100,000 parsecs. That’s about 300,000 light years! When they determined the rotational velocities the flat curve of rotation continued to the limit. All the new pieces of information were coming in and fitting together very nicely. Einasto did an analysis and found that dwarf galaxies, seven known up to 200,000 parsecs, were doing the same sort of thing. Therefore, now it looks like we are going to have to figuratively blow up our galaxy by a factor of 3, increasing its radius from 20,000 to 60,000 parsecs, possibly farther out than that. The minimum mass, measured out to 60,000 parsecs, is about 750 to 800 billion solar masses. This minimum mass is about three or four times the mass that Schmidt assigned to the traditional halo. Our galaxy might even go out to 150 or even 200,000 parsecs. If that is the case, then the mass would be ten times greater than that assigned to it now.

The halo and beyond must be considered. To me it is a beautiful thing, like a lovely story, that just when you think that everything is fixed and everybody agrees, along come a few observers and all the preconceived ideas have to be thrown out of the window. When I started working on rewriting “The Milky Way,” I was skeptical about the increase in mass and size estimated for our galaxy. But I soon saw that all the evidence, like pieces of a jig saw puzzle, fits together.

We live in a galaxy which is pretty big. How big is it? The distance from the sun to the center of the galaxy used to be thought of as 33,000 light years. We have reduced that quite a bit and now think it is more on the order of 26,000 light years distant. The diameter of the galaxy used to be listed as 100,000 light years. Now we think that the radius is 200,000 light years across. That means the minimum diameter of the Milky Way galaxy is at least 400,000 light years across, and might well be even three times larger than this. We believe that the old halo blends into a corona extending at least three times farther out than the original limit of the halo.

We are led to believe that all the old globular clusters and several small dwarf galaxies are part of the outer part of the Milky Way system. They are right within it, like the suburbs of a large metropolitan area so to speak. And we are also aware of another interesting thing. The Clouds of Magellan, the Large Cloud and the Small Cloud, do not behave like the rest of the family. The rest of the family is very old, but the Magellanic Clouds are full of signs of youth. How they fit into the scheme of things I do not know. However, they are components of our bigger and better galaxy.

What other kinds of objects exist within this huge outer corona between the clusters and small galaxies? Most likely very old stars, half dead by now having used up a great deal of their nuclear energy. The surviving stars are so faint that we cannot observe them from the surface of the earth. What we are actually able to see are those eleven globular clusters and the seven dwarf galaxies. They are just the tip of the iceberg, because underneath are all those old stars we cannot see.
Now there is a fertile field for active research! It is quite possible that a telescope placed in earth orbit may detect some of these objects.

Let me consider now the Magellanic Clouds and the Andromeda Galaxy.

The Magellanic Clouds are about 180,000 light years away from the center of the galaxy. According to the new theory, this places them well within the limits of the Milky Way galaxy. Remember, we have boosted our size to 400 or 500 thousand light years in diameter. And we have boosted the mass of our galaxy as well. The increase in mass of our galaxy explains why it can gravitationally influence the Andromeda Galaxy, two million light years away. Our current theory about the mass and size of the Milky Way system nicely accounts for the 80 kilometer per second motion, which is in reality the relative speed between the two. By the way, if this is so, we suddenly find ourselves comparable in size and mass to the Andromeda Galaxy. All of you, rm certain, have seen pictures of the Andromeda Galaxy. Our galaxy probably looks to them more or less like theirs does to us. We are no longer the little galaxy we thought we were. We are of a pretty good size. However, we are nowhere near the size of the huge elliptical galaxies, but we certainly don't have to apologize any more when we compare our galaxy to other spiral galaxies.

As for the Magellanic Clouds, they have proved to be more peculiar than I thought. They must have been recently formed, in one way or another, for there is very little old material within them.

Now let us consider the center of the galaxy. Here I am not an expert, but I have done my homework. You can also do your homework on this subject. The best article on this, authored by Tom Geballe and Eric Chaisson, can be found in the July 1979 issue of *Scientific American* magazine. Another article, as I write this, is appearing in *Astronomy*, along with beautiful illustrations.

Let us see what happens near the center of our galaxy. My friends who wrote the *Astronomy* article, do this in six steps. Let us see how they do it. We will start from a distance of 300,000 light years and approach the center by going ten times closer with each step. From this distance we can see the spiral structure quite clearly. In one of the spiral arms, 26,000 light years form the center, is the position of the sun and the earth. Let's take the next step, ten times smaller, 30,000 light years from the center. Here we can see that at 15,000 light years surrounding the center is a dark ring of carbon monoxide clouds. These are the huge molecular clouds that we are just beginning to learn about. They float in the Milky Way and have masses ranging from 100,000 to one million solar masses. If we take the next step, ten times closer than the previous one, then at 3,000 light years from the center we find another ring of carbon monoxide clouds. There is also a large number of emission nebulae. We don't know yet what stars make them shine. When we go ten times closer to the center of the galaxy, within 300 light years from it, a very peculiar thing happens. There is a region of ionized hydrogen. Ten times closer, at 30 light years, we are getting closer to the center of the galaxy's nucleus, and here we find a huge gas cloud with a temperature of 5,000°. As emission nebulae go, this is cool. But, the cloud has two interesting properties. The first is that it is rotating rapidly around the center. This might offer evidence of a mighty explosion which took place in the center of the galaxy in the not too distant cosmological past, probably like the similar explosions we observe happening in other galaxies. Ten times closer, at 3 light years, we can really see what is going on in the center. There is probably a black hole.

Now that we have been to the center of the galaxy, I want you to be especially aware of two things: 1.) the Milky Way is larger and more massive than we generally thought before; and, 2.) we are just beginning to learn more and more about its center. We are learning so fast that I'll probably have to rewrite several chapters in "The Milky Way" five years from now.

And now we come to the sad part: the spiral structure. Our ideas up to 1973 seemed pretty firmly established. What is wrong with these ideas now? We said that the spiral structure contained the youngest and the brightest stars. But, when you consider the Cepheid variable stars, they refuse to cooperate. Nobody knows why. When Dr. Roberta Humphreys draws the spiral arms of our galaxy to incorporate these variables, she finds that she has to draw them wider and wider until the spiral structure itself is almost lost. The study of the spiral structure of our galaxy has been hit by the law of diminishing returns. For example, we used to say that the 21 centimeter radiation outlined spiral structure beautifully. It still outlines it, but the word "beautifully" had better be dropped. This is because, if velocity distributions are taken into account, the outline of the spiral arms is almost lost. I have, by now, become a skeptic on spiral structure. For example, the simple density wave theory does not take into account that there are shock waves present in the interstellar gas clouds, which makes the gas pile up. If star formation takes place before the shock, during the shock, or after the shock, different velocities are predicted. For all these reasons it is very difficult, to say the least, to infer from the spiral structure of our galaxy, how and where the stars are formed. Furthermore, if we try to determine distances inside our own galaxy, there is an uncertainty factor of 10%. Ten percent of 10,000 light years is 1,000. That's not too bad. But, when you go out to 100,000 light years, 10% is 10,000! When you try to study the gaps between the spiral arms the whole thing becomes a mess.

What is the picture concerning our neighbor galaxies? The 4 meter (Very Large Array) telescopes show their spiral structures beautifully at all wavelengths and research is going very well. The spiral structures are laid out right before our eyes. In the outer galaxies you can actually see what is going on because the whole thing is right there before you on a photograph. When we get the space telescope, we'll get to see them even better. The radio telescopes have been improving, too. In our galaxy their results leave a lot to be desired. Results have been a little better for the outer galaxies. When the Large Array opens officially in October of this year, it will have a resolution of two seconds of arc. That resolution will be sufficient to detect, radio-wise, any spiral structure out there. But, I think it is now safe to say that the great days of the study of the spiral structure of our galaxy are over. Nevertheless, great days are coming for the study, by radio and optical instruments, of the spiral structure of the galaxies beyond our Milky Way system.

As I pointed out right at the beginning, my wife Priscilla saw this coming. About three weeks before she died she admonished me to get out of spiral structure research. I told you already that I took her advice and I am so glad that I did. The main thrust of my current research is in star formation, and I am able to report that it is coming along quite well.
DISCIPLINE IN THE PLANETARIUM

Orderly conduct during planetarium lessons is a necessity for meeting all types of objectives, including those which involve enjoyment and appreciation of the subject matter. If a student throws an eraser or paper wad, if another laughs inappropriately a number of times, or if a majority chatter disinterestedly while you are trying to explain or demonstrate learning of lesson topics is greatly reduced. Depending on our individual psychological thresholds for frustration in these situations, or our previously set standards for continuing a lesson, we react differently. In this article, we'll explore a) conditions and groups which often produce disruptions, b) practices which are effectively used to correct disruptions when they occur, c) and practices which can reduce disruptions.

A number of planetarium educators report that they can spot potential trouble by the manner in which a group enters the planetarium. If they are laughing and talking or in haphazard order, difficulties within a presentation can be expected. Large groups which include students separated in age by more than one grade level frequently will produce disruptions. Some teachers with laissez faire standards, as indicated by their dress and bearing, impart their values to their students—with the result that an entire group of undisciplined “mimics” are delivered to the planetarium. Fortunately, this type of teacher is an uncommon species; but when one visits with a class, we need to be able to handle the circumstance.

It seems, from a limited number of accounts, that junior high and middle school grades have been responsible for the most disruption in planetariums. Many compassionate planetarians hasten to add that “It’s just their nature at that age.”

It’s true that students in 7th, 8th, and 9th grades do have very special (and different) outlooks on the world and learning. The Denver Public Schools Teacher’s Guide to School Studies has extracted the following bits of wisdom concerning the unique natures of junior high students, which are found elsewhere in books about the psychology of the adolescent:

THE SEVENTH GRADER—This student is reaching the end of time when rote memory for facts, events, people, and numbers functions more effectively than it will at any later period. He/she enjoys adding to a store of information. He places faith in information, because he is not called upon to think deeply or abstractly. He needs a stimulating learning environment to bridge the gap between learning through acquiring information and learning through independent thinking. He craves new and interesting learning experiences but treasures the tried-and-true ground of “right answers.” The seventh grader fails to give proper consideration to the right and wrong behavior. He acts now and realizes later the outcomes of his conduct. He is loyal to the codes of his gang or group.

He will sacrifice adult approval rather than lose prestige with his peers. At this time, when his physical growth and mental and emotional reactions are threatening his security, he finds comfort and assurance in being as much like others in dress, talk, and behavior, as possible.

THE EIGHTH GRADER—This student age is more varied in physical and mental development than any other grade level. In this grade there are little boys and young giants, little girls and mature women. Personal appearance is very important, and hair combing becomes excessive. The “obnoxious eighth grader that ought to be put in deep freeze” is common faculty talk, and PTA meetings are filled with anxious questions concerning when “this stage” will end. Substitute teachers will be scolded and promptly burned at the stake unless careful preparations are made for the unusual situation. The eighth grader is less impressed with formal school than the seventh grader, and much less willing to accept it. “What good will it do me?” is a favorite alibi. He is concerned with himself and his own problems and everything is judged in terms of immediate self-advantage. Teaching must be in context with interests and problems or in some way must help the student see value in what is presented to him. The eighth grader is frequently emotionally unstable. He is critical and argumentative. He speaks loudly and confidently about everything, priding himself in being critical of building administrators. The eighth grade leader is deeply conscious of his social role and popularity and he will destroy his image with teachers to maintain peer approval. Eighth graders are convinced that no adult understands their conversation or their shared secrets. In learning capability, the eighth grader is able to organize and to classify material with skill. Now he is willing to examine evidence. He needs to be treated with respect; teachers must handle student opinion with tact. But the eighth grader still needs to be told many things rather than always be thrown upon his own judgement and personal resources.

THE NINTH GRADER—The ninth grader sees himself more objectively than the seventh or eighth grader. He wants to have his opinions considered by adults and to have opportunities to make decisions. A genuine exchange of opinion is welcomed. He sees himself more objectively. He is interested in a broader world of current happenings and developments. But like the eighth grader, he feels perfectly competent to discuss any of these matters without proper background and set people “right.” The ninth grader likes to teach teachers about his world, in his terms, and does well at it. The ninth grade leader monopolizes discussions if given a chance. The ninth
grader is not so dependent upon the influence of his group or class. We are able to deal with him on a more personal basis. The group and group code are no great barrier between students and teacher. The ninth grader sometimes lacks for a point of view opposite his own. He is beginning to think of school in terms of his own special interests and future plans. Deep abstractions in problem-solving situations are still difficult for him.

My own research with junior high students has revealed that a majority are incapable of mastering completely (they are unable to integrate an Earth-based perspective and an in-space perspective) for such commonly taught concepts as the seasons, planet positions and motions, and lunar phases. The problem is correlated with their immature spatial ability, a further characteristic of students at this time which must be recognized by planetarium teachers. Disruptions may occur due to lack of comprehension.

Another type of group which gives almost universal discipline problems is Boy Scouts. Although Scouts usually come for an educational experience, often in connection with fulfilling some requirements for the Astronomy Merit Badge, there is often a high level of talking out, laughter, and mumbled discussion.

How do planetarians correct disruptions? Most who have shared their techniques report sequences of action, each step a little more drastic than the former. Commonly students are warned in the dark, then the lights are turned up and a stricter voice is used to force students into line, and, as a last resort, the program is terminated. A number of planetariums use the "logical appeal" approach, that is explanation of why the talking or other disruptions are unacceptable and an asking for more careful self-discipline. Sometimes this works and sometimes it doesn't. For young children, two devices are noteworthy. Sandy Hallock explains that his trained planetarium arrow "hides because it is afraid of noise." This helps prevent noise and stop it when it occurs. Martha Schaefer tells children of the trained lights, "The lights come on if children are noisy, so be sure to be quiet."

Some planetarians report that lowering the level of voice when lecturing sometimes produces good results. Others use short pauses. Bob Victor sometimes just stops talking until it is perfectly quiet.

Phyllis Pituaga gives groups "choices" when there are disruptions. She asks the group to decide whether the program should continue or not, but of course, if it does, all must be quiet. The group usually decides to go on, and all have a stake in making a quiet learning situation since they are democratically committed.

To elicit cooperation from Boy Scouts, Sandy Hallock dons his cub scout cap and asks, "Now, are you reflecting the Boy Scout code and values?" A short discussion relating behavior to scouting solves the immediate problem.

In schools with planetariums, where students from the same school or immediately adjacent schools are visiting, a last resort is to send or the students back to their classrooms. There a talk concerning behavior and possible future visits can be given immediately. Frequently this can help behavior of junior high students in future visits.

If individual is causing disruptions, they should be dealt with quietly and with as little effect on the rest of the group as possible. Some planetarians walk over and stand by one or two students or speak to them. Some planetarians walk over and stand by one or two students or speak to them when they are disruptive. At Adler Planetarium, when very large groups are within the chamber, a planetarium "guard" circulates to spot potential disruptions by individuals. Sometimes it becomes necessary to have individual students leave the planetarium with a teacher or guard.

Prevention of discipline problems is the aspect of the subject which seems most worthy of our attention.

Gail Bouslog, Sheldon Schaefer, and Tom Torsen point out the value of an extended period (approximately 10 minutes) of seating, settling, and orientation while the lights are up. Gail, who sees only students within one district, requires lists of student names ahead of time. She prepares seating charts, and she calls out students by name if there is a discipline problem. If this can be done, it is very helpful. Not knowing student names is one of the major differences in discipline situation between a school classroom and a planetarium classroom, and students take advantage of anonymity in the darkness. Gail also greets each student at the door with eye-to-eye contact, so students feel they are known by the planetarium teacher. The extended period for orientation, when names cannot be learned or seats assigned, also allows familiarity to develop. Students feel recognized, and disruptions which would occur if they felt anonymous do not happen. In some districts, such as mine, the planetarium teacher visits student classrooms in most grades before the first planetarium visit of the year. Familiarity and a sense of being known by the teacher is developed, so that disruptions are minimized.

Bob Andress has found that he can practically eliminate disruptions by inveterate trouble-makers in high school classes in his high-school located planetarium by telling them before a program starts, "You will be sent back to the classroom with a writing assignment you must complete if you disturb the program. On the other hand, you can go to sleep in here and make no trouble and have no writing assignment." Bob knows-and the student is smart enough to figure out-the best deal all around. There are no disruptions from these students in his planetarium.

Dave Sanford finds that not lowering the lights to full darkness until complete control is established provides an important "set" for the entire program. Sometimes the lights should never be lowered completely. Very young students feel more secure if a low level of illumination with some blue sky is present throughout the program.

Dave Sanford also notes that a planetarium educator builds an understanding with teachers on expectations for their students as a result of a period of planetarium use. The better the communication with visiting teachers, the less likely general discipline problems will occur. A list of standards should be known to visiting teachers or group leaders. They should appear prominently in planetarium guides and teacher curriculum guides related to the planetarium. Scott Stobbelaar, in the Shiras Planetarium brochure, notes: "Students are to walk down into the planetarium as an organized group. The teacher(s) are in charge of the group and talking should be kept to a minimum during the show."

Bob Allen, in the Visitor's Guide to School and Private Programs of the University of Wisconsin-La Crosse-Planetarium, notes, "Food and drink are not allowed in the planetarium. It is considered a classroom...Visitors are also asked to refrain from smoking." Dorthy Angeloff also notes that food is explicitly excluded from the planetarium, and all teachers are notified of this. (After all food can mean noise during the program, pieces of food thrown into projectors, and wrappers and crumbs littering the floor.-all types of problems.)

David Parker says that continuous involvement, solving problems, and participatory activity greatly reduce disinterest that leads to disruptions. Although participatory activities make some noise inevitable, this noise is constructive rather than destructive to the purposes of the planetarium visit. David notes that planetarian listening and observing can prevent ill-chosen words by the planetarian of individual or
a lack of comprehension or key problems with perception, and further teaching instead of discipline action. This procedure may correct, as well as prevent, disruptions.

Science educator and researcher Mary Budd Rowe (See Science, Silence, and Sanctions, Science and Children, March, 1969) describes the value of “wait time”-time before the teacher speaks after a student has spoken--in learning situations. Her research has shown that if you can prolong your teacher “wait time” to 5 seconds, the length of appropriate student responses increases. When teacher wait time is short, students tend to give very short, less interested answers or say, “I don’t know.” Time for student reflection gives not only longer student answers, but much more creative ones.

Dr. Rowe’s studies have shown. Thus planetarium teachers may gain a great deal in learning with better discipline as a fringe benefit if better opportunities for student thinking and activity concerning the lesson (wait time and participatory procedures described by Alan Friedman, et. al. in the IPS Special Report No. 10, Planetarium Educator’s Workshop Guide) are provided. The junior high grades, particularly, improve in achievement and behavior, if opportunities for guided involvement are an integral part of learning experiences.

Finally, it is encouraging to learn from those who contributed ideas for this article, that disruptions are not a major problem in planetarium education for most facilities. This is a tribute to planetarians, because attentive and nondisruptive students are an indication that lessons are being well-received.

Contributing planetarians

Robert Allen
Dorothy Angeloff
Robert Andress
Marilyn Bacynski
Gail Bouslog
Ray Bullock
Larry Ciuplik
Sandy Hallock
Jon Marshall
David Parker
Phyllis Pitluga
David Sandford
Martha Schaefer
Scott Stobelaar
Tom Torson
Robert Victor

SPIRIT MASTER BOOKS - LET THE TEACHER BEWARE

Roger Grossenbacher
Peters Planetarium
Lancaster, Ohio 43130

How does the elementary or high school teacher go about getting reliable, up-to-date information on astronomy and space science? A privileged few can call upon that fountain of knowledge, their local planetarium director. But what about the majority of teachers who labor in unenlightened school systems? The teacher can do several things. He can do nothing, since many elementary teachers are still afraid of science.

Buying a duplicating master or transparancy book is a simple way for a teacher to obtain a bundle of useful information, easily disseminated to students. Or so it would seem. I have carefully checked the material available from Hayes and Millikan publications. I urge you to write a grumbling letter to one or both companies to clean up their act. Their addresses are:

Hayes School Publishing Co.
321 Pennwood Ave.
Wilkinsburg, PA 15221

Millikan Publishing Co.
1100 Research Blvd.
St. Louis, MO 63132

These books typically have over a dozen spirit masters and from 5 to 15 pages of condensed “explanatory text” to accompany the masters. More expensive books may also include a dozen transparencies, sometimes in realistic colors. What does the teacher get when he or she spends from $3 to $8 on an astronomy master book? The answer is: lots of bad information! The avalanche of new discoveries in the 70’s can quickly make the best astronomy book out-of-date, but there is no excuse for the mis-information found in the four books I purchased. A quick perusal at the bookstore was not enough to detect the serious errors they contain.

Certain errors might be of no great consequence as far as what a teacher might wish to teach his students. It is a surprise, however, to read that Ptolemy (not Hipparchus) divided the visible stars into six groups, but it probably won’t stunt a kid’s growth. Some teachers have enough trouble with English and spelling without encountering words such as “spectrum”. One reads about the “processional” motion of the Earth’s axis. Comets are described as “gravel bags”. We learn that much of our knowledge of Pluto is “speculatory” - check your dictionary for that one! The last straw is when one reads about the “Haden” Planetarium in New York!

Every year students recite scientific nonsense to us, things they’ve picked up from TV or Lord-knows-where. It’s a real shock to see this nonsense in print for all to read. One ditto master tells us that Jupiter’s gravitational attraction comes not only from its size but also from its rapid rotation. Amazing! One could go on and on, citing poorly labelled star maps or unrecognizable constellations or bibliography references on the planets dating back to 1958. Numerical errors abound. A table which is supposed to enable students to plot an H-R diagram has 5 errors in it. Poor Antares is reduced to absolute magnitude -2.6 and to a luminosity of 4.4 x 10^3 solar units!

There are sins of omission as well. One finds no mention of black holes, pulsars or quasars in a book on stars dated 1972. On a positive note, most of the transparencies provided in the Millikan books “The Sun’s Family” and “The Universe” are carefully done and generally useful.

In conclusion, we might recall the immortal words of W.S. Gilbert: “Isn’t your life extremely flat when you’ve nothing whatever to grumble at?” Remember also that lots of teachers are getting lots of astronomical misinformation from Hayes and Millikan publications. I urge you to write a politely grumbling letter to one or both companies urging them to clean up their act. Their addresses are:
As promised, we are going to take a closer look at “Fresh Aire,” the original concept of composer/creator Chip Davis that was born in the early '70s when Chip was working in the classical form. He noticed that there seemed to be a gulf between those who like rock and those who liked classical. Devotees of one seemed to have a prejudice against the other. Chip felt that there could be a meeting of these worlds. He created music which used harpsichord, piano, lute, oboe, recorder, and strings. Yet it also uses synthesizers and sound effects. One term which has been applied to this music is “18th century Rock 'n Roll.”

The Mannheim Steamroller has appeared several times with symphony orchestra backing to recreate “Fresh Aire” within a concert setting. The creation of “Fresh Aire” itself is entirely a studio process. Multi-track recording is used so that each element can be controlled for optimum effect. A 24 track recorder runs at 30 inches per second. From this tape, the sound is mixed down to two stereo tracks (going through DBX noise reduction). Much of the flavor of the resulting sound is especially tailored through control of ambient sound and sound effects. Therefore, it is impossible to play “Fresh Aire” live. When the Steamroller goes touring (as they will next spring) there is a large crew backing the five people you see on stage. This crew is needed to control the synchronization of the complex visual and aural elements of their show.

The three albums released so far represent a progress from “spring” through “summer” and then “fall.” The upcoming Fresh Aire IV will represent perhaps the most difficult season to not be finished and ready for sale before next fall. Chip’s great attention to detail and quest for quality means that these albums are not just thrown together overnight.

American Gramaphone albums cost more. Their list prices are $11.98 and $12.98. The higher cost comes from a number of factors, but you expect to pay more for a quality product. Their records are not only pressed on high quality vinyl, they are also master cut at the Sound Recorders studio in Omaha. When most albums are pressed, the master disc is cut from a master tape at the pressing plant. Certain parts of the signal are compressed or limited in making the disc so that it can be played on your average J. C. Penney’s portable phonograph. This means some of the sound quality and its dynamics are lost. American Gramaphone does not make these compromises. Instead, the disc is cut with painstaking attention to detail and clarity. So—it costs more to produce.

Why do all this? It seems that there are a growing number of listeners who can hear the difference. And more and more people are purchasing better quality sound equipment. My intentions in this column are to show you that there are people who still care about producing a quality product, and to show you a bit of the process of how this is achieved.

Next time I want to take up the subject of mixing your own soundtracks. Just a preliminary remark: A few years ago, I produced a slide/tape show and an article about music use in the planetarium. The article was printed in the Planetarian. In an attempt at humor, I included what I called the “Planetarium Top Ten.” These were the most overused pieces in many planetarium shows. Unfortunately, I think some people took me seriously and believed that this was a “magic list” of “planetarium music.” Well—sorry to disappoint you—but there just isn’t any such animal in existence. There is no guaranteed set of music which will work in every situation, in every planetarium show. In the past, I have recommended albums in this column and I shall continue to do so. But these are only suggestions of music you should audition. This situation dictates what is usable. You cannot use Tomita in every show with every kind of visual. I will get down to specifics in the future.

Meanwhile, two of our music producers, Astral Projections and Loch Ness Monster Productions, have new music products out. The LNP has joined show producers with their first “Show Track.” This is a complete program soundtrack, with narration and original music. You supply the visuals. “Light Years from Andromeda” is a “Mini-Show Track” lasting about 20 minutes. Price is $50. The Astral Projection show “Dialog with Galileo” includes slides and soundtrack and is about 30 minutes in length.
The properly-used planetarium is an excellent vehicle for the teaching of astronomy and related subject areas. The unique capabilities of the planetarium facility have offered strong support to elementary science education for many years now. However, an area that requires greater consideration is that of planetarium usage for secondary students.

At present, many school-related planetariums provide the majority of their instructions for elementary students with only minimal offerings for junior and senior high students. There are various complex reasons for this situation. For example, if one planetarium is forced to serve too large a population, it may find it impossible to adequately handle the elementary program, let alone the secondary program. However, because of declining school enrollments, this situation may be changing for many facilities.

For those planetariums located in buildings other than the junior/senior high, one of the most significant problems is scheduling. Because of the strict time limitations in effect in most secondary buildings, a typical lesson in the planetarium would require two “periods” of time away from the home school. One period would be spent transporting students to and from the facility and one period would be required for instruction in the planetarium. This not only disrupts the student’s day, causing him/her to miss classes, but also causes the accompanying teacher to be absent from classes. Another problem directly associated with this is the cost of transportation for students. This situation is certainly not going to improve in the foreseeable future, but for those planetariums located in secondary buildings, it may give impetus to developing good secondary programs. By serving those students already in the building, it may be possible to cut transportation costs.

Uncooperative administrators and teachers are additional problem areas in developing secondary usage of the planetarium. Considering all of the aforementioned points, the two most important problems are still to be mentioned. They are:

1. Convincing teachers that planetarium instruction is a worthwhile and valuable use of class time, and
2. Demonstrating the applicability of the planetarium to other curricular areas.

Many teachers unfortunately still possess the idea that the planetarium is nothing more than a place to send their students for free time; a place to see a “show” perhaps, but not a place for meaningful learning. Changing these attitudes takes time and personal involvement with the faculty. The planetarium is an effective learning tool, particularly if “Participatory Oriented Planetarium” techniques are used in the instructional process. This has been clearly shown by a recently conducted national research study. (Mallon, 1980)

Yet, the process of convincing teachers of this is a slow and arduous task and is best accomplished one on one.

The second major problem, the area of curriculum, can be a monumental dilemma for most people. The planetarium director must not only be competent in the fields of astronomy and education, but must also be knowledgeable in all areas of curriculum. It is the rare individual who is so qualified. True, one can research an unfamiliar topic or for possible use, but it is difficult to energetically apply oneself to this task unless there is some assurance that one’s time and energy will not be spent in vain. Yet, many teachers are not interested in considering a proposal for a lesson unless one can demonstrate concrete examples to them of how the planetarium can be utilized for their classes. This puts the planetarium director in a seemingly impossible situation. He/she must supply materials that are not yet developed.

The purpose of this section of the Planetarian then, is to address the problem area of curriculum, by serving as a forum for the exchange of ideas about the educational uses of the planetarium for secondary students. People interested in this area are invited to share their ideas with others through this column. One of the most important objectives of a professional organization is to communicate ideas among its members. Included in each issue therefore, will be examples of lesson plans submitted by concerned planetarium directors for various subjects commonly found in the secondary curriculum. It is important to note that these plans are not meant simply to be adopted as is, but used for discussion. As Jeanne E. Bishop recently stated, “It is clear that the best educational use of the planetarium occurs when objectives of the planetarium lesson closely match those perceived by the teacher for his/her course units. In order to facilitate this situation, planetarium teacher and classroom teacher must communicate..." (Bishop, 1979)

These materials may facilitate this communication process by offering the involved members a concrete base for initiating contacts. The planetarium instructor can approach the secondary teacher on a one-to-one basis with one of these lessons and together they may be able to adapt, adopt, or devise an appropriate lesson for their students from these materials. As an additional aid in this process, it is suggested that those interested also review the bibliography on interdisciplinary approaches to astronomy recently published in the Planetarian. (Fraknoi, 1980)

In conclusion, developing planetarium usage for secondary students is a difficult and problem-laden task. The concerned planetarium director will encounter many setbacks and obstacles in his/her work. However, considering the tremendous potential that the planetarium offers for the educational growth of secondary students, it is a task that is certainly worth the effort.
THE NEAR FRONTIER

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PREFACE

"The Near Frontier" is designed to coincide with the orbital flights of Space Shuttles scheduled for 1981. The time format of the Planetarium Program allows it to run before, during, or after the test flights without having to be revised. The program runs just under an hour as written. It subdivides naturally into the following sections which can be used individually or combined into a shorter program.

A. Introduction of Program—Pilot speaking.
B. Blast-off (filmed narration).
C. Introduction of CPU and Rescue Ball Procedures.
D. Flight Deck.
E. Star Navigation.
F. Space Telescope.
G. The In-Space Experience (filmed narration).
H. Shuttle Projects.
I. Space Stations: Salyut, the Space Operations Center, Power Satellites.
J. Landing (filmed narration).
K. Epilog.

All starred visuals are available along with the script. One set of slides and film copied directly from original artwork has been sent to the president of each regional planetarium society and to the president of I.P.S. These can be copied by any planetarium. The Burke Baker Planetarium is also able to duplicate materials but the cost is greater because of the labor involved. Artwork is being published with this script so planetarians can do much of their Kodakith directly.

Two audio tapes have been made (at 7½ ips) for this program—one complete with music and one of narration only. Copies have been sent to each regional organization along with slides and films. These are also available from the Burke Baker Planetarium. Write for cost information.

Funding for this program came from the Cullen Foundation. Invaluable information and visuals were supplied by the always helpful Public Affairs Office of NASA's Johnson Space Center. Members of the Southwestern Association of Planetarium provided insights, suggestion, and constructive criticism which were most appreciated. The space ship line drawings are taken from a Robert McCall mural at the Johnson Space Center.

Any use of these materials should credit the Cullen Foundation, the Burke Baker Planetarium of the Houston Museum of Natural Science, and the Johnson Space Center for artwork.

THE NEAR FRONTIER
A Script by Dr. Carolyn Sumners
(Funded by a grant through the Cullen Foundation)

VISUAL

Lights down.

COMMENTARY

The following voyage is science fiction—but with public enthusiasm and adequate NASA funding, this fantasy trip could become a journey into the future...

NARRATOR NO. 1

Good afternoon and welcome to Shuttle Flight 24. This is your pilot speaking. Weather conditions along our orbital entry path are partly cloudy and calm. Routine ascent is anticipated.
All Shuttle systems including those in the cargo bay passenger module are go for launch. As Shuttle passengers, you will experience normal room temperatures and breathe normal air at sea-level pressure throughout your flight. For passenger safety we ask that you keep your seat belts and shoulder harnesses fastened during the lift off sequence.

Smoking throughout the mission is prohibited. For your safety and comfort we will throttle the main orbiter engines so that the maximum G force reached will be only three (3) times what you feel right now. While cabin lights dim, we will project an animation of our ascent stages.

NARRATOR NO. 2

Welcome aboard! As the manned payload specialist for this flight, I will describe all inflight procedures. This Shuttle craft takes off like a spacecraft, and lands like an airplane. At blast-off from Cape Kennedy, our three main Orbiter engines ignite—consuming hydrogen and oxygen from a blimp-like external tank now attached to our side. Four seconds later, the two solid rocket engines burst into flame, like giant fireworks on the Fourth of July. Once clear of the launch pad, our computer arches the Shuttle over its back and we enter space riding upside down. At two minutes into the flight with an altitude of 31 miles, we jettison the solid fuel boosters. They will be recovered for use in another mission.

Our three main engines continue firing until eight minutes into the flight and shut down just before orbit is reached. Ten to fifteen seconds later the tank is discarded—breaking up as it reenters the earth's atmosphere. Two small maneuvering engines then fire for almost two minutes to reach our final orbital velocity of 17,500 miles per hour. Over Australia, an hour after lift-off—the huge cargo bay doors above your clear plastic roof open and our space mission begins.

As final orbital systems are being checked, I would like to welcome our new Transpace passengers. As you know, we book commercial sightseeing groups for these crew transfers and satellite repair shuttles on a space available basis. You are riding in our latest Cargo Passenger Unit, or CPU, furnished in much the same way as a DC-9 terrestrial transport jet. This particular Shuttle is normally a reconnaissance craft specializing in monitoring of natural phenomena and world wide surveillance. Removal of the main antenna structure allows room for your CPU. We ask that you watch the forward viewing screen again for our on-board safety procedures. If a system malfunction indicates that cabin depressurization is a possibility, a warning alarm and flashing cabin lights will signal your to begin your own rescue operations. Depressurized rescue balls are stowed under all passenger seats. Each passenger must crawl into a ball and zip it closed. Once inflated, it expands to 34 inches—not exactly roomy, but tolerable. Crew members get into their space suits during the rescue operation. Each space-suited astronaut also dons a manned maneuvering unit or MMU. This device is a nitrogen propelled hand controlled jet backpack which can carry an astronaut to a neighboring rescue Shuttle. In this manner the crew will ferry you in your ball through space to the rescue ship. During the operation, you will be briefed through a link inside your ball. In zero gravity a rescue ball is just like a balloon—toted and tossed across space. The hazard to passengers in this maneuver is negligible.

If this is your first space trip, you are now invited to join the commander and pilot on the flight deck. The windows on the bulkhead in front of you look aft from the cockpit area. An airlock tube connects us with the lower flight deck. Please follow me to the forward viewing area. As we enter, you will first notice the similarity to a terrestrial jet transport. All of our astronaut pilots must first train in a military or civilian terrestrial fleet.

Four crew members can work on the flight deck at one time. The ship's commander on the left handles the spacecraft flight controls. The pilot on the right checks spacecraft systems and prepares for in-flight operations. An astronaut mission specialist and a scientist payload specialist ride behind the pilot and the commander. Like their terrestrial equivalents, flight deck instrumentation has duplicate sets of switches, levers, pedals, and hand controllers so that either astronaut can fly the Shuttle.

Alongside the forward flight deck are two stand up stations. The one to the right contains controls for Orbiter innerconnections with payloads and with our passenger cabin. All payload malfunctions show up here. Behind the commander on the left is a payload station for specific payloads operations. Interchangeable individualized modules for specific payloads are channeled through these controls. All air-conditioning and electrical consumption information on your passenger unit is displayed here. Actually two astronauts, and four primary computers are flying this craft. Astronaut hand controller commands are converted to programmed instructions for the computers. The computers converse with the engines, altitude thrusters, flaps, and rudder. Data on shuttle operations now displayed here is also being routed through the computers from gyros, accelerometers, star trackers, thrusters, radar altimeters and other performance sensors. All four computers perform the same calculations just to make quadruply sure! Each compares results with the others and agreed upon commands are executed. If computers disagree, the majority rules.

When you turn around, you see the aft flight deck. On the left is the rendezvous and docking station with instrument controls for moving the Orbiter close to another craft. To the right is the payload handling station with controls to deploy or capture payloads. The crew member here can open the
payload doors, operate the remote manipulator arm, control the lights and TV cameras in the payload bay, and sight the stars.

NARRATOR NO. 3
An Astronomer Astronaut like myself usually also volunteers as ship star navigator.

One of my first onboard tasks is star tracking—a process very similar to stargazing down on earth—except the unpolluted starfield above the earth's atmosphere is even more dazzling. See if you can identify any star patterns as we fix our orbital altitude.

Throughout this orbit we will feed the computer data on selected star positions. Above the aft crew stations are two large windows providing views of the starfield. As Navigator, I first identify a particular pattern, select a navigation star within it, and feed its identity and location into the computer system.

We are currently flying eastward on a circular equatorial orbit. In this configuration star patterns rise in much the same way as they do for a terrestrial observer located near the earth's equator. Our 90-minute orbit causes the starfield to roll by 16 times more quickly, however, than the 24-hour turning of the earth's surface. From your seats in the passenger cabin, northern stars will rise to the left and southern stars will rise to the right. We will project the ancient patterns for your reference in naming the constellations. We are now flying into the night side of earth. Once the sun is behind us, the mighty hunter, Orion, rises into view. In this region we see the hunter's 4-starred body frame, his 3-starred belt, and his sparkling sword. Orion rules the winter nights back in the northern hemisphere on earth. In Orion, I identify three of the four main stars—red Betelgeuse in Orion's right shoulder—the blue-white Betelgeuse in his left shoulder and the blue-white Alnitak at his right knee. Below Orion, Gemini, the twins soon appear. The bright stars Castor and Pollux mark the twins' heads with two lines of stars for their bodies. In navigation, the computer recognizes Castor and also Alchena in the Pollux's foot. As these patterns roll over the earth's surface, we can see the patterns almost as if we were at the base of the teapot's spout—and Nunki, another navigation star in the teapot's handle. The hazy band running through the teapot's spout area is the Milky Way—easily seen from orbit but often obscured by urban lights and smog down on earth.

Once Sagittarius has cleared the cabin area, the summer triangle is also in view. This pattern lies overhead for summer and fall evenings in the northern hemisphere. Each of the triangle's corner stars is used for navigation. Highest is Vega in Lyra's heavenly harp. Next rises Altair marking the eagle's eye. And finally comes Deneb, tail light of Cygnus the swan. My favorite pattern also lies here—a tiny starry dolphin, called Delphinus, a truly beautiful constellation.

In a few moments the sun will rise as we fly out of the earth's shadow. The patterns close to the sun are difficult to observe—even with our lofty view.

The sun's arrival reminds us all of our first mission priority: the repair of a solar power panel on the giant Space Telescope.

NARRATOR NO. 1
Forward sun shields into position—sunrise momentarily over earth's equator.

NARRATOR NO. 3
When I see the sun rise from Shuttle, I think of the centuries of dreaming that led to our voyage. Ancient astronomers on Earth and on the Moon built man-made Stonehenge, a solar observatory to mark the seasons and years. The mind's eye can almost see the monumental effort required to build Stonehenge as it stands starkly vigilant before an ancient summer sunrise in the distant past. ""

The space telescope now sailing into view shows how far we have come—from rough hewn stone monuments to tubular telescopes with optical precision 60 times greater than the wavelength of visible light. Yet our technology cannot yet hide the similarities of shape and purpose. Thousands of men erected each megalithic stone. A 336 million-ton Space Shuttle lifted space telescopes into place. Stonehenge dates back over 4,000 years—the space telescope project began in the 1980's. The remote manipulator arm, like a giant human hand, swung the 12-ton, 14-foot wide telescope from the cargo bay. Modern sun catching solar panels began supplying power for remote astronomy operations.

Because it operates far above earth's atmosphere, this has become the most powerful telescope ever built. Light enters the space telescope through the open front end and strikes the primary mirror deep within. Light is then directed back to a second mirror where it is projected, through a hole in the first mirror, to a focus inside the scientific instruments package in the rear. Sensitive guidance sensors point this telescope as carefully as would human eyes
The space telescope observes our universe as it really is—not filtered and distorted by the earth's atmosphere. We want to know how the universe began, what causes it to change, and what is its future. These answers all lie out here... and the space telescope is prepared to look for them. From its special position above the earth's atmosphere, this telescope sees 10 times as much detail as any terrestrial telescope. It can detect fainter and 7 times farther away than those viewed from the earth's surface.

There is a special significance to seeing objects 7 times farther away. In astronomy, distance is measured in 6 trillion mile units called light years. The name comes from the fact that light takes one year to travel a distance of 6 trillion miles. An object one light year away lies at a distance of 6 trillion miles. As the name implies, light year is also related to time. Since all our astronomical scenes come to us at the speed of light, an object's distance can tell us how old the image is before we see it. If an object is 10 light years away, for instance, then its light has been traveling 4 years to reach us. We see the object as it was 4 years ago.

We live within a vast spiral galaxy of stars called the Milky Way. A moment ago as we flew under Sagittarius, you saw the galaxy's disc. Light years are required to give meaningful dimensions to this system. Our Milky Way Galaxy is 100,000 light years across. Our earth lies 30,000 light years from the galaxy's center. Light from the galaxy's center beyond the Sagittarius starfield takes 30,000 years to reach us and the earth is 30,000 years behind in place as it was 30,000 years ago. Our Milky Way contains hundreds of billions of stars like our own rising sun.

As we look beyond our galaxy, we discover a universe filled with these island systems—in a variety of shapes and sizes—from tiny irregular collections of stars and gas to majestic spirals and to giant ellipticals. Spirals like our Milky Way are rich with brilliant new stars and star clusters while the elliptical galaxies glow with the dull light of old and dying stars. We can wonder how brightly these giant oval galaxies shone when their stars were young and prodigal. The space telescope probes deep space for distant ellipticals whose images have been traveling so long that they date back to a time much earlier in the universe, a time perhaps when these galaxies were also young.

In this way the space telescope paints us a dynamic picture of how island galaxies evolve. Most distant of the galaxies are the quasars. A quasar 2 billion light years away is the farthest object seen by a telescope on the earth's surface. With the space telescope, we can look for quasars up to 14 billion light years away—images taking us 14 billion years into the past—to a time perhaps very near the beginning of our universe when the first galaxies, the quasars, were forming.

The space telescope's ability to detect faint objects also helps in studying nearby galaxies. A special variable star called a Cepheid can be used as a distance indicator. Cepheids observed throughout our galaxy change in brightness with very regular periods. The greater the period the brighter the Cepheid is. If we see a Cepheid anywhere, we can observe its change in brightness and derive how bright it really is from this true brightness with how bright it appears to be, we can determine how far away the star is. In this way, Cepheid variable stars have given us the distance to the nearest spiral galaxy, the Great Andromeda Spiral—2 million light years away, with space telescopes, Cepheids are also picked up in more distant galaxies such as M-101 in Ursa Major. The space telescope is now working on the Virgo Cluster of galaxies for an improved distance measurement to this giant collection of galaxies.

Even nearby objects yield new views through the Space Telescope. Before us in Orion's sword is a hazy patch—a stellar incubator where the mysterious process of star creation continues today. Photographs of this Orion Nebula taken with the Space Telescope are 10 times sharper than those made by earthbound telescopes.

A space telescope can also see colors of light that are absorbed by the earth's atmosphere. In this manner, the space telescope studies ultraviolet and infrared radiation coming from bizarre stellar corpses like the Crab Nebula. Here we recorded the explosion of a massive star in 1054 A.D. Over 900 years later we detect the pulsing stellar core still veiled in expanding clouds of star debris. The rare cataclysmic events are called supernovae. We have seen none in our galaxy since the discovery of the telescope, and the space telescope is still waiting for its first glimpse of such a dramatic event. Despite these forces are at work when a star flares to become a billion times its former brightness—outshining its entire galaxy for a moment. Ultraviolet and infrared images of supernovae and supernova remnants will hopefully bring more understanding of these stellar grave yards. We know that the stellar remnant buried here is one of the most fascinating objects in modern science—a collapsed star with the mass of a million earths compressed into a ball 10 miles across. This is an astrophysical laboratory with conditions far more extreme than any on earth—where physicists can put their theories to the ultimate test. The universe accessible to the space telescope is rich in such dramatic scenes challenging human imagination and creativity.

The terrestrial astronomer waits for a clear night to do his work. This observatory above the clouds works twice as long in weather-free darkness, unhampered by the blue sky of scattered sunlight. And every extra moment of darkness is needed. The list of uses for this telescope grows longer with each passing year.
Now we are even looking for faint traces of planet systems around nearby stars. From the earth’s surface, only the 8 other planets in our sun’s solar system are visible. Planets around any other star would be far to faint—except from outer space.

For further exploration of our own solar system, a combination space telescope, probe mission has evolved. The space shuttle now launches deep space missions to carry our mechanical eyes and ears to the solar system’s giant planets. The Galileo orbiter and probe, for instance, can see heat, smell and even taste Jupiter’s violent churning atmosphere. During the Galileo mission, the Space Telescope provides continuing global coverage of Jupiter’s atmosphere. With these detailed space telescope photographs from the Jupiter orbiter in context of other planet-wide weather systems; and we can select the best spot for the probe to descend. From orbit the Galileo craft also makes close encounters with each of Jupiter’s big moons: the volcanic Io, the smooth, ice-covered Europa, the “dirty” looking ice ball called Ganymede, and the ancient crater-scared Callisto.

The solar cell array now being repaired should keep this space “eye” running at full power for another five years—and for many more planetary encounters.

NARRATOR NO. 2

With our docking maneuver several hours away, we will return to our passenger briefing schedule. While in space, we urge you to enjoy the out-of-this-world beauty beyond your overhead window, and the freedom of your now weightless condition. If you will turn your attention to the front viewing screen, we have prepared a training film to show movement procedures in Zero G. As you have already noticed, being in space is an experience all by itself. Gravity is easy to take for granted until you don’t feel it any more. If you unfastened your seatbelt, you will probably find yourself floating above your seat; Once we’re in space there is no up and down perspective. Don’t be surprised, for instance, to look up from reading a magazine only to find yourself looking down.

There are other weightless conditions to be explained. The restrooms are located at the back of our CPU. Although these look like terrestrial facilities, please follow operating instructions carefully. Remember that everything floats and nothing falls in space. In Skylab we had a similar situation with water clumping up on the skin during a shower. A vacuum cleaner solved that drying problem. A similar procedure is now used in the restroom toilets.

Even getting to the restroom can be challenging. We recommend swimming strokes or bouncing whenever possible.

At the front of your cargo passenger unit is a small storage area that doubles very well as a racing and rolling track for the gymnastically inclined. Other forms of exercise are also possible—but sometimes the results are quite unexpected. Traditional pushups become quite impossible so we suggest more complex variations carefully executed.

Acrobatics is effortless—anyone can somersault or pirouette. Team sports have not yet been perfected, but we are certain that the gymnastic pyramids will never be the same. While you are enjoying this three dimensional freedom of movement, let me assure you that Zero-G for short periods of time is not harmful physically and quite refreshing psychologically. Weightlessness does cause slow changes over long time periods such as loss of bone calcium and muscle mass as well as some weakening in the heart and blood vessels. These changes seem to be reversible once the crew returns to earth and meanwhile can be minimized by exercising.

In a moment we will be serving lunch. First watch how liquids behave without gravity to make them flow. For this reason, we serve all drinks in squirt bottles. Your meal can also get away from you. In case of floating food, just reach up, grab it, and put it back on your plate or in your mouth. Once the food is in your mouth, digestion will proceed as usual. A bit of earthbound experience will remind you that you can swallow in almost any position.

After dinner we are scheduled to rendezvous and dock with the Space Operations Center, or SOC. Passengers bound for the SOC will deplane through the forward bulkhead entry port after the docking procedure is completed.

NARRATOR NO. 3

The Shuttles in our fleet display the versatility of our 1990’s space missions. Shuttles still carry routine passive payload experiments. With a cargo bay configuration like this, a week of inexpensive space time is available for an endless variety of small projects—many of which are designed or suggested by school children of all ages from all around the world. For the research community we still fly the Spacelab developed by the European Space Agency. Hundreds of scientists have brought research on animal behaviors, medicines, crystals, and Zero-G solutions into this weightless environment. We now have new composite materials, metal alloys, electronic and optical crystals, new kinds of glass, and better medical treatments because of earlier experiments here on Spacelab.

For improved ground communications we now have two special Tracking and Data Relay Satellites. Each floats far above us in a geosynchronous orbit where they remain fixed over the Atlantic and Pacific Oceans. With their assistance, we can go almost anywhere and still bounce our signals back to the mission control center in Houston.

Communications satellites were our bread-and-butter missions at NASA for long before Shuttles—but Shuttles have added a new dimension to the
*Shuttle building antenna unit

*Shuttle antenna unit 2

*Shuttle beam construction 1

*Shuttle beam construction 2

*Shuttle with power array 1

*Shuttle with power array 2

*Flying Salyut moving slowly overhead

*SOC moving into view

*SOC close up 1

*Fade to inside view

*SOC close up 2

*SOC close up 3

In the early 1980’s, our first communications missions involved carrying payloads like this Intelstat satellite into space and deploying it with the remote manipulator arm. Now we are working on high data rate satellites with antennas assembled in low earth orbit and later carried up to geosynchronous positions. The multi-beam communications satellites will eventually serve hundreds of thousands of “wrist” telephones down on earth. We also have an electronic mail service with nearly instantaneous duplication of letters and documents. One satellite is even developing space-to-underwater communications links.

Soon our various projects required bigger solar collector systems than could be carried in a cargo bay. So Shuttle astronauts entered the construction business in a very big way. In the 1980’s automatic beam builders formed the first triangular space trusses—and these early machines are still used on a few Shuttle missions. With space-suited human supervision, this machine takes a flat roll of material, extrudes it in one direction and then another, until the huge structure is ready for operation. These beams and girders would snap like toothpicks if they ever had to support their own weight. But such is not the case in space and thus gossamer-like sculptures fly freely. Usually they are dressed in solar cell blankets and used for collecting the much needed solar power. This Shuttle project is now testing our ability to collect this energy and beam it back to receivers on earth.

NARRATOR NO. 1

T minus 10 minutes for rendezvous with the SOC. Shuttle power substations approaching on the right.

NARRATOR NO. 3

Great, the rest of the Shuttle story involves these power arrays. Once we got our beam builders in operation, it seemed logical to make orbiting solar arrays that a space shuttle could dock with and perhaps leave in orbit. The system began with a simple mission extension unit like this and evolved to the more complex unit which follows. Now the power assembly also has three space station modules attached. In these early units, designs for living quarters, laboratories, and construction areas were perfected and grew larger and more versatile. Soon space operations required more power and more flexibility than either of these Shuttle projects could deliver. Then the United States decided that it really needed a space station.

Perhaps the real impetus came more from the old “Model T” space station coming over the horizon. This is one of the original Russian Salyuts.

In the decade after Skylab fell to earth, the U. S. manned space station program fell far short of Soviet endeavors. Back in the 1970’s, the Soviet Union launched six of these 20-ton Salyut space stations over a short span of years. These were resupplied by manned Soyuz craft and by unmanned progress vehicles. A Soyuz always remains docked to the Salyut in case of emergency return to earth.

Through their continuing space program, the Russians perfected an automatic unmanned docking system which passes supplies across the docking interface. Within the Salyut station the crews developed long term maintenance techniques and built a 10-meter radio telescope. These Salyuts carried earth resource survey cameras, material-processing furnaces, infrared and gamma ray telescopes, a long duration exposure platform, medical equipment, and various unspecified military operations. Only a Sputnik-type reawakening by the United States citizens kept us from falling woefully behind the Soviets in space exploitation. In the early 1980’s Americans finally realized that space was being inhabited and in a sense colonized by Russian cosmonauts always flying overhead and busily perfecting scientific and military processes.

The Space Operations Center or SOC is our answer to the continuing Russian space presence. The SOC handles construction of all projects beyond the scope of Shuttle—such as large solar power modules, and communications platforms. As we approach the SOC, notice the dimensions of its components. Each is sized to ride into space in a Shuttle cargo bay. While docking operations are being completed, let me give you a quick tour of the facility. Two identical service module halves form the central spine of the SOC. Each provides control systems, communications links, connecting airlocks and electrical power taken from the solar arrays. Two inhabitation modules are berthed to the service module. Each has four floors with a space station control center, private crew bedrooms, a galley, restroom and recreation areas, and a laboratory. Habitation modules are connected by a tunnel at the top and by the service module at the bottom. Once you are inside, however, top and bottom are meaningless. The SOC “floors” are constructed back-to-back to reduce wiring and connection costs. So what is up on one floor is down on the other.

A logistics module attached below stores consumables and space parts. This module is replaced regularly by supply Shuttles. These modules are the only dependence link between the SOC and earth. The SOC is almost a closed system—a terrarium in space.

Space Operations Center crews tend to be engineers and construction workers rather than astronauts. The SOC itself is really a kind of factory for construction, assembly, and servicing of space systems and satellites. Such activities require human supervision while scientific data collection can often proceed without crew direction. Unmanned science satellites like the Space Telescope are repaired and occasionally tethered here.

The SOC is now being configured to fabricate a large solar power array. First notice the construction equipment attached to the service module. Here a
specialized beam builder much like the one first tested on Shuttle turns flat stock into triangular truss beams. The process of solar cell blanketling has also begun. This solar collector will eventually become part of solar power station now being assembled far above us in geosynchronous orbit.

The SOC also assembles the transport vehicles for the trip to high earth orbit. A ladder-like structure here holds rocket stages for assembly. The SOC manipulator positions and mates components on the structure. After systems inspection, a tilt table turns the vehicle away from the strongback and readies it for launch.

Manned missions to geosynchronous orbit require a reusable Manned Orbit Transfer Vehicle or MOTV. A MOTV has docked at the lower service module part of the SOC. Before launch it will be refueled and checked out here. The MOTV's first unmanned stage returns before the second stage during a mission. It is stored on the stage assembly strongback. Upon mission completion, the manned second stage returns and is mated with the refueled first stage.

A decade of components testing by Shuttle made the Space Operations Center construction a relatively simple task. In like manner, SOC crews are now developing and testing the component systems for tomorrow's large solar power satellites.

A bit of dreaming and we can see the developmental process from this small SOC to larger low-earth-orbit factories and on to complex solar collecting units built in low earth orbit for transport to geosynchronous positions. Ultimately we will have giant Solar Power satellites in high earth orbit directly above the equator. Here there is ample free sunshine, isolation from populated areas, savings in natural resources because of lightweight space construction, plus no earthquake hazards, no undue heating of the atmosphere, no corrosion of components, no pollution, and no need for complex energy storage.

The solar energy captured here will be beamed earthward on microwaves to antenna arrays on the surface. One satellite can power a city. Several can meet a significant portion of the U. S. energy demand. Solar Power Satellites are quite expensive but with prices of fossil fuels going sky high, we have finally begun the construction phase. Solar power can become a reality in the 21st century both for orbital space missions and for the energy-starved economies back on earth.

NARRATOR NO. 1

Halfway around the world from our Florida landing port, we are now preparing for earth atmosphere reentry. As we close from spacecraft to aircraft our speed will slow from an orbital velocity of 18,000 miles per hour to 225 miles per hour for landing. In space we use small rocket engines to change our orbit. In the lower atmosphere we will control our path with a conventional rudder and flaps. It takes two astronauts, and four computers, to make this control transition for a safe, smooth landing.

Cargo bay doors closed, we edge into the strato atmosphere. First we point our nose up to push the bottom of our craft against the air below. Air molecules striking and rubbing against our lower surface raise the outside temperature to more than 1,000 degrees C. At 50 mile altitude, the air becomes thick enough to support the Shuttle somewhat and our orbiter turns into a heavy glider.

Remember that we have no main jet engines to use to control where we land. We'd better pick our path correctly because we have no second chance—we are going to come down somewhere!

As we begin our final approach, I will direct the view from the forward flight deck window to your front viewing screen. At a height of 15 miles we begin our final approach. We are now 57 miles from the runway. At the 2,000 foot altitude, with our airspeed at 355 miles per hour, we begin to flatten our glide and readjust our tilt to almost horizontal. Then we apply the speed brakes, lower the landing gear and prepare for touchdown. And soon we're rolling down a 15,000 foot runway—just 30 minutes away from the gentle weightlessness of outer space.

"This is Mission Control in Houston. We copy you on the ground." Mission Control in Houston—what a familiar part of our space program.

COLLAGE OF VOICES

"This is Mission Control in Houston."

"Shuttle 24 reporting—EVA in progress."

"Mercury, Freedom 7—suborbital flight completed."

"This is Gemini 12, we've just attained orbital velocity."

"This is Apollo—the Eagle has landed."

"Skylab 2—solar panels deployed and sunscreen in position."

"Apollo preparing to dock with Soviet Soyuz."

"Shuttle Columbia—all systems are go for reentry."

"Power Station America—transmitted power has reached 1,000 megawatts."

NARRATOR NO. 3

The Near Frontier lies just over the clouds. Its existence is of far greater value than improved terrestrial communications systems or space technology spin-offs. It is a place to go—for people as well as machines.

NARRATOR NO. 4

No more hardware, please . . . We have too much of that down here on Earth. Don't show us more data we don't understand or astronauts who aren't our neighbors. Your pictures are beautiful and we cherish them—but they are as cruel as they are exciting if they tell of new worlds we can never touch. It is not a promise we're asking for—just an opportunity for ourselves and especially for our children. Our request is simple: Make space for the people.
Naturally, preparing a script, selecting slides, and making titles are additional tasks. Hard as we try during our programs, photographing the children at work is often impossible. Sometimes, as in this case, we ask the children to return for a photo and recording session.

We used music in this program for the dialogue which takes 8 minutes, 56 seconds. The opening is about 1 minute, 2 seconds from Rick Wakeman's record, "War of the Worlds." The voice sounds like Richard Burton. Its music fades at Planetarium Logo Slide 10 and is replaced with "Jupiter" from "The Planets" by Holst, played by the Baltimore Symphony. That fades at Slide 34, where Sandra is questioned about Mars. The piece is from Tomita's "Snowflakes are Dancing" and continues to Slide 44 which fades as Slide 45 appears. There is no music until Slide 49 when Matt answers the question about Mars airplanes. A piece from Tomita's "Pictures at an Exhibition" is played that fades at Slide 61. The end title is the Exit piece from the Strassenberg record by Tim Clarke.

We recommend using a slide show with music to present your paper. It's worth the effort. The slide show indicates the depth and quality of your planetarium programs.
Intuitively aware of the significance of the revolutionary technology that put unrivaled computer power into the hands of girls and boys with whom a Mars landing is all but reality and possessing the accumulated knowledge based on unmanned flights of discovery by Pioneer ... and Voyager One and Two, aware of the computer-created images of Europa enhanced and rectified Ganymede, brightened, contrasted, and corrected images of Callisto and Io, surprise, unlike any other planet in the solar system, the source of plumes of ionized sodium and sulfur of caldera and fresh sulfur salt flows ... of molten sulfur lakes, images of Jupiter's Red Spot of colors only a computer imagines, pixel by pixel computer robots ... doing work man could never do ... they would perish in radiation on Ganymede at Jupiter's threshold.

at Titan, an unimaginable and inhospitable cold, a methane atmosphere ... fit only for a computing machine ... certainly not man.

These must be planning documents for Mars within reach ... more hostile than Antarctica for sure. The planning includes:

Systematic surface exploration that requires orbital communication, teams of multiwheeled sample gathering rovers, and design studies of a Martian colony.

Q. Why do you want to go to Mars, Sandra?

Maybe, it's like mountains, you know (Pause) it's there and we've got to go. But it really is a lot more. Suppose something bad began to happen on Earth Then we ought to have a Mars colony.

and even a Moon colony too.

Q. Is a Mars colony a lot like a Moon colony?

Well, there are differences. There is a little atmosphere on Mars. That means clouds, sand storms, maybe even gliders.

There is also water on Mars at the poles ... radar echoes from Earth indicate water at Solis Lacus.

The gravity is less than four-tenths Earth, and things can be built lighter.

We might be able to drill water and gas wells right in the colony.

Naturally we have to survey and drill test wells ... No. Mars is a whole lot different from the moon.

The study of Mars in the lesson plans of the Herkimer Boces Planetarium is really about children and the possible worlds in their future.

Computer programs which are simulations of alternate possibilities ... dangers and calculated probabilities in the success or failure of a rocket launch from Earth ... a two-thirds of a year journey from Earth's orbit to Mars' orbit ... the manned Mars landing, and a simulation of the manned expeditions which face the dangers and problems of shelter, finding water and fuel, coping with low temperatures, the lack of oxygen, a thin, noxious atmosphere, and sand storms.

Given fundamental information, the students made their own unique contributions and sometimes failed.

Q. But what do you see as the problems with the Mars airplane?

Well, you can't really call it an air-plane. Mars has no air.

The Mars atmosphere is carbon dioxide and the pressure is below 17 millibars, less than 1/100th of Earth's pressure.

I would call it a Mars flier with engines that turn so the propeller can pull the plane up vertically.

Q. Would it be a helicopter?

Oh, no ... helicopters are not very efficient ... so complicated they're unreliable.

NASA has looked at target drones with wing changes and a hydrazine monopropellant one could fly for 26 hours at 320 kilometers per hour and cover 6400 kilometers, about a quarter the way around Mars.
54. Matt

Or it could look like a U2 and have a ducted fan. The U2's fly regularly at 20,000 meters up.

55. Matt

Q. Could it be a jet plane then?

56. Matt

Probably not, a propeller is almost always more efficient at low speeds. A turboprop might be the best compromise of efficiency and reliability.

57. Matt

and of course, without air on Mars, planes must carry their own oxidizer. It will take a while to build runways.

58. Matt

Q. What's important about the U2 design?

59. Matt (at computer)

Oh... it's lightweight... sort of a super Gossamer Condor.

60. Matt (with model)

The efficiency of the airfoil can be calculated on a microcomputer now...

61. Matt & Sandra

So there you are, with imagination... by computer... starting from where we are, with a whole new set of fundamentals...

62. Mars Colony

The children have begun to explore Mars and to build their colonies.

63. Planetarium Logo

(Music Up)

TROUBLE SHOOTING:

A One Shot Advice Column for Planetarians

Dr. George Reed, West Chester State College, West Chester, PA.

Dear George,

I know that you will never print this. You will not like it. And even if you did, the editor wouldn't let you print it. I learned why one day while I was eating a candy bar—a Milky Way. They are out there, but they don't want us to know. They are all over the place. Some are probably even here. Maybe everywhere. You may even be one for all I know.

I used to love Milky Way candy bars, but that was before I found out. There was a time when that vast expanse of shimmering evening stars that we call the Milky Way was considered to be the whole universe. It was everything and we were in the thick of it. The candy bar was big enough to share then. Remember how you could pull it apart and share it with your friends? I didn't mind sharing a Milky Way then, Now I do.

Things change. Our knowledge of the Milky Way has changed. The Milky Way is now known to be just a small part of a universe that is stocked with an enormous number of different kinds of galaxies. Do you realize just how much smaller the Milky Way is today? Sometimes you can hardly find it. And there are also just too many different kinds of candy bars today. This makes them hard to find.

The Milky Way is now known to be part of a cluster of galaxies called the local group. There are 20 or more in the local group. Soon after this was discovered, Milky Way began to appear in family packs of 20 or more.

Cost. That's another thing. The cost of astronomical information today is astronomical. There was a time when you could study the Milky Way all by yourself. Time was what you needed most. Time and the initial investment for a telescope and some auxiliary equipment. But not now. The cost of information about the Milky Way has risen in the last few decades. Now each new discovery requires a rocket launch to put the equipment into orbit. We also need telemetry equipment to get the information back to earth, and a computer to reduce the data to a meaningful form. Worthwhile feedback costs more today. Milky Ways cost more today. Do you know what that means?

You may think that these parallel events are unrelated. They are not. Look at the wrapper and see who makes these candy bars. I know that they are out there and I know that they are coming. What should I do?

D. H. from N.Y.

Dear D.H. from N.Y.,

You are suffering from a rare mental disorder that is indigenous to senior members of the planetarium community. Its psychiatric name is astroparanoia. Among themselves the psychiatrists refer to you as a "cosmic catastrophe nut." Your disorder comes from seeing too many of the planetarium programs coming out of Rochester about the end of the earth and the existence of other life forms in the universe.

I would suggest that you take your mind off your obsession. Try to read two books tonight about plane crashes, mass murders, and devil worship rites, and call me in the morning if you are not feeling much better. If I were you, I would also stay indoors for a while. You know what they say, "Just because you're paranoid, doesn't mean they aren't out to get you."

D. H. from N.Y.
Alan J. Friedman, Director of Astronomy and Physics Education of the Lawrence Hall of Science, sent me a unique "Star Chart" to review for this column. It is a trial version of a new education activity in astronomy that is being funded through the National Science Foundation. The kit contains what appears to be a standard star chart with a rotating circular wheel, but closer examination shows the wheel is not attached. In fact, it is removable. There are six wheels that fit the holder and are included with the package: 1) Introductory Wheel (basic constellations); 2) Native American Constellations; 3) Binocular Treasure Hunt (deep sky objects); 4) Test Your Eyes—Test Your Skies; 5) Where Are the Planets?; and 6) Invent Your Own Constellations. Also included is a Program, Leaders Guide listing activities for people ages 10 and older, and a copy of Star Gazers Gazette. Last, but not least, is a Lawrence Hall of Science Star Clock which can be used to determine the time of evening by using the Big Dipper and Cassiopeia.

All in all I found it one of the most flexible star charts I have seen and I think it would be a nice addition to your personal library, gift shop, or bookstore. For more information, contact the Lawrence Hall of Science, Astronomy Education Program, University of California, Berkeley, California 94702.

Catseye Productions/Galactic Imports of 720 West Huron, Ann Arbor, MI 48103, is a small design studio that is setting a new standard in the T-shirt industry. In turn, their designs are setting new levels of sales with twenty or so of the leading space centers and planetariums across the country. Some of the astronomical designs include Jupiter's Great Red Spot, accurate and labeled sections of the Martian and Lunar surfaces, the M-51 Spiral Galaxy, A Black Hole, and an Apollo mission space suit in T-shirt form for the kids. These designs are three to five colors, many printed with air brushed half-tone effects on brightly-colored, top quality shirts. Recently the company was asked by NASA to design their new shirt which will be released for the Space Shuttle landing.

A new list of 180° films has been released by Cinema 180. A partial list includes: A) Thrills of America; Dune Buggy, Giant Dipper Roller Coaster, Eyeryl Monster, Cork Screw by Arrow Development; B) International Thrill Show; Sky Wheel, Runaway Cable Car in San Francisco, California; Grand Canyon (Birds-eye view); Aerobic Airplane (Pits Special); C) Galaxy of Thrills; Mind Bender (6 Flags), Skateboard Scene, Lava Canyons (Kauai, Hawaii), Rivera Auto Chase.

For information on these and other 180° films contact: Omnimvision, Inc., P.O. Box 15767, Sarasota, Florida 33579.

AZP, Inc., 128 Crooked Hill Road, Huntington NY 11743, has announced a new 6:1 zoom kit consisting of zoom assembly, basic zoom control and instructions. All you need is a Carousel type projector with a 4-inch projection lens. The price for the kit is $995. They also have "Planetarium" Computer Programs. This educational/game program to teach star and constellation positions has been expanded into four sub-programs. Program I gives instructions on how to use the other three. Program II is the original interactive student controlled display of star areas. You choose which area and the constellations within it are shown. Program III automatically displays each of the major constellations. Program IV tests and grades the student on his progress. All four programs are contained on a single tape cassette for the TRS-80, Level II, 16K computer. Price: $25.

The Creative Corner page is being printed in the format of the Special Effects Handbook (soon to be published), so that you can xerox the page for insertion therein if you wish. Pages from The Planetarian will be sequenced alphabetically so you may order them in future handbook indices.

Continued on page 25
UTILITY SLIDE PROJECTOR

The UTILITY SLIDE PROJECTOR is made out of a simple wood or sheet metal housing and provides an inexpensive method of obtaining a set of auxiliary projectors. With the addition of the removeable slide holder in Figure 2, the projector gate becomes accessible for color wheels, image rotators, and other special effects that require the modification of a standard projector. The top metal ventilator may be found in some building supply stores. If you want to boost the lamp to 150w, be sure and include some sort of fan so you won't end up cooking your slides.
INTRODUCTION

It was bound to happen, micro-computers have come to the planetarium. Now, in a natural sequence of events, we have a column dealing with the use of these computers in teaching astronomy and producing programs. This is not to say the use of computers by planetariums is new, just that the purpose of this column is to promote their use and to share applications.

Interest in computers for planetarium use has been around for some time, but the complexities of large computers, and restrictive budgets, have slowed development of their use. Now personal computers allow complete self-contained units at less than $1,000 in some cases.

Micros (as these computers are often called) can be used for any number of things in and around the planetarium. A partial list should include:

- positions and rising/setting times for sun, moon, and planets,
- constellations identification (Blake, 1980),
- simulations of a Mars flight and colony (Carr, 1980), and
- demonstration of astronomical concepts which are difficult to show in the planetarium.

A good example of this last category would show the effects of proper motion. This is almost impossible on the planetarium dome, but easily done on the screen of a small computer (Sharrah, 1980).

Astronomical concepts transferred to computer screen should help in obtaining PR, also. It is much easier for a TV camera to "see" a TV screen than a special effect on this dome. Our first experience of this sort came in the summer of 1979 when the Cincinnati Planetarium became officiator of a local "Skylab is Falling" contest by supplying up-to-minute orbital plots. All thanks to a micro-computer.

Computers are quickly becoming as basic to the operation of the planetarium as the star machine. We must be ready to use them for fundamental education, control of equipment, interactive display systems, in the office, and even to meet the astrological menace.

The director of the National Astrological Society, at their August 1980 meeting, urged members to go technological and use computers. Perhaps if the misinformation comes from a computer it seems more believable to the general public. In any case planetarians now have a powerful tool available.

To better use this tool all of us need software, computer programs. This author's work has been on a Hewlett-Packard 9830A and Apple II's in extended BASIC and FORTRAN, but this column should be for every computer user from Radio Shack TRS-80 to Digital Equipment Corp. PDP-11. So, please help. If you are using a computer, please send the following information:

- Name
- Institution
- Computer
- Primary Uses
- Are you willing to share programs?
- What subjects?
- Programs desired

To: Memory Bank, Cincinnati Planetarium
1720 Gilbert Avenue
Cincinnati, Ohio 45202

References


PREPARING ASTRONOMICAL DIAGRAMS
-A BASIC APPROACH-

Carl J. Wenning, Director
I.S.U. Planetarium
Illinois State University
Normal, IL 61761

The following program is a series of BASIC computer language statements that can be used to prepare astronomical diagrams. This listing, adapted to any computer, will permit calculation of altitude and azimuth for any celestial object as a function of time and under user specified conditions.

Uses of this program include calculation of star positions and planetary apparitions. These calculations are performed not as a function of sidereal time, but as a function of the sun's distance in degrees below the horizon. In this fashion diagrams can be prepared for the end of astronomical twilight (H = 180°) or at any other time.
This program takes into account the observer's latitude. Diagrams so prepared are independent of longitudinal complications. Horizontal parallax for the moon is also taken into account. A mean value of 3422.7 seconds of arc has been used. Refraction due to atmosphere is ignored.

After inputing the direction of the sun, the right ascension and declination of the sun and celestial object, calculation for altitude and azimuth is performed. Output will range from 0° (horizon) to 90° (zenith) in altitude. Azimuth is defined as 0°, north; 90°, east; 180°, south; and 270°, west. Calculation of azimuth is carried out by means of an auxiliary angle with corrections applied as a function of hour angle.

Input of R.A. is called for in terms of hours and minutes. Declination is input in terms of degrees and minutes. Internal conversion puts these values into usable form. If greater accuracy is desired, seconds of time and arc can be included by inputing minutes of both in decimal form. For example, 5h31m15s becomes 5.31.15.

Output is by way of CRT or printer. Values of output include date, altitude, and azimuth. The original program also includes graphics output, either in terms of polar plots (altitudes greater than 40° and declinations greater than 50°) or cartesian plots with horizons drawn in. Altitude and azimuth variables are indexed in this program—to facilitate recall and plotting. Since plotting format is different for every computer these program steps have been deleted from this listing.

As presented, the program requires 4.4 kilobytes of memory. Deletion of comments will reduce this to just under 2.4 kilobytes.

This program was developed as part of a never-ending effort to maintain visibility and a high public awareness of the planetarium. The calculations of this program are used in a weekly newspaper column. Diagrams so prepared add greatly to the attractiveness and appeal of the newspaper column. Each planetarium should consider undertaking such a regular column as a means of developing a rapport with the public. Columns prepared in a professional manner give that certain touch to the persons and institutions preparing the materials.

Diagrams calculated and plotted by computer. Graphics by author.
**ALTIMETE-azelMUTH PROGRAM**

By Carl J. Wenning

I.S.U. PLANETARIUM

ILLINOIS STATE UNIVERSITY

NORMAL, IL 61761

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***************************************************************

! SET MODE!

DEG

PRINTER IS 0

DIM A1(20)

DIM Taz(20)

! INITIALIZE...

Z=-1

I=0

CONDITION I/O...

INPUT "WHAT OBJECT ARE THESE CALCULATIONS FOR?",P$

INPUT "IN WHICH PART OF THE SKY IS THE SUN (EAST, WEST)?",D$

INPUT "NUMBER OF DEGREES SUN BELOW HORIZON?",H

INPUT "LATITUDE?",P !DECIMAL DEGREES ONLY

PRINT " THESE CALCULATIONS ARE FOR ";P$; " ";

PRINT " WITH THE SUN LOCATED IN THE ";D$; "."

PRINT " THE SUN IS ";H; " DEGREES BELOW THE HORIZON."

PRINT " THE CALCULATIONS ARE FOR LATITUDE ";P; " DEGREES."

! DATA INPUT AND CONVERSION..........................

IF D$="WEST" THEN 910

A=-H

INPUT "DATE (DAY, MONTH, YEAR)",D, M$, Yr

INPUT "R.A. OF SUN (HH, MM)",C, D

GOSUB 860

As=15*X

GOSUB 860

INPUT "DEC. OF SUN (DD, MM)",C, D

GOSUB 860

Ds=X

INPUT "R.A. OF PLANET (HH, MM)",C, D

GOSUB 860

Ap=15*X

INPUT "DEC. OF PLANET (DD, MM)",C, D

GOSUB 860

Dp=X

560

! ALTITUDE - AZIMUTH CALCULATION...........................

Hs=2*ACOS((SIN(A)-SIN(Ds)*SIN(P))/(COS(Ds)*COS(P)))

Hp=Hs-Ap+As

I=I+1

A1(I)=ASIN( SIN(Dp)*SIN(P)+COS(Dp)*COS(P)*COS(Hp))

Az=ACOS((SIN(Dp)-SIN(P)*SIN(A1(I)))/(COS(P)*COS(A1(I))))

640

IF SIN(Hp)>0 THEN 700

670
AUXILIARY AZIMUTH IS SET EQUAL TO TRUE AZIMUTH IN "EAST".
GOTO 760
Taz(I)=360-Az !SUBTRACT AUXILIARY AZ FROM 360 FOR TRUE AZIMUTH IN "WEST".
! 730 ! ...............CORRECTION FOR HORIZONTAL PARALLAX..............................
740 ! (MOON ONLY)
750 !
760 IF P<>"MOON" THEN 810
770 A1(I)=A1(I)-.95*COS(A1(I))
780 !
790 ! OUTPUT.............................
800 !
810 PRINT "DATE =";Day;M$;Yr,
811 FIXED 2
812 PRINT "ALT =";A1(I),"AZ =";Taz(I)
820 GOTO 430
830 !
840 ! CONVERSION SUBROUTINES..............................
850 !
860 IF C<0 THEN 890
870 X=C+D/60
880 RETURN
890 X=C-D/60
900 RETURN
910 2=1
920 GOTO 420
930 END

Venus as an Evening Star
1979 - 80
LETTERS TO THE EDITOR Continued from page 3

☆ Dear Editor:

Fred Karr’s letter (Planetarian, 9 (1), 3(1980)) and Sig Wieser’s article (Planetarian, 6 (3), 10(1977)) along with the direction in which we are moving brings up the very important question of “Should a set of standards be proposed and adopted for computer automation/operation in planetariums?”

Even today, problems exist in the computer industry between the IBM extended binary coded decimal interchange code EBCDIC and ASCII. The development of the RS-232-C data bus interface has significantly eased the problems of data transfer from one manufacturer’s equipment to another.

Should the standard or a standard be developed around a specific word length? Should there be a total set of instruction from which subsets could be constructed to maximize interchangeability of planetarium programs?

These questions rise because a planetarium show as a planetarium show is but a sub-set of a much greater set and direction now can save many problems in the future.

Sincerely,
David C. Taylor, Associate Professor
The Rocket Room
Department of Chemistry
Slippery Rock State College
Slippery Rock PA 16057

☆ Dear Editor:

Our school would like to build a small planetarium as a school project. We would appreciate any ideas or plans your readers could share with us.

Tom Smith
Upper Kalskag Grade School
Upper Kalskag, Alaska 99607

☆ Dear Editor:

Julius Staal is doing quite well since his retirement from the Fernbank Science Center Planetarium in 1977 and will soon have his second book, Stars of Jade, published. It will be about Chinese constellations and related mythology. His first book, Patterns in the Sky, was written while he was a lecturer at the London Planetarium in 1961. It is an easy reference to the stories about the constellations. For the last few years it has been available in too little supply. A Norwegian edition, written in that language, is available but difficult to obtain in America.

Divided into the four seasonal groups of constellations, with separate headings for each constellation and accompanying star charts, Patterns in the Sky is a handy and quick reference book for the planetarium lecture, student, or amateur star gazers. It is available from the author in paperback at $7.50. His address is 1154 Rogers Street, Clarkson, Georgia 30021.

John Gurgess
Fernbank Science Center
Atlanta, Georgia

Special Programs for Special People

Conducted by Rita Fairman,
Science Museum of Virginia, 2500 West Broad Street, Richmond, VA 23220

Very early last spring I thought I had a really great idea. I was going to do a planetarium program for the deaf! No one that I knew had done such a show before. Don’t laugh, this is why I am writing this.

Well, I never did get enough time to either write or give my program, but before the school year was out I received a notice from one planetarium announcing that it had a program for the deaf available at minimal cost, and that there were more on the way. At the I.P.S. meeting in Chicago last summer, I heard of other programs for other kinds of special groups.

O.K., so my big idea was nothing new. Actually, deep down, I was pretty sure that someone, somewhere, had already done this type of program, much though my ego would have liked me to have been first. The main point is that I didn’t know where to start. I did not know whom to contact, or what kinds of problems I might run into. I just didn’t know where to get any help.

Now I know that I have a really great idea. In an effort to direct help to planetarians everywhere who want to do a program for a special group, let me ask those of you who have done anything along these lines to share scripts, describe the problems you ran into the program, and how you solved these problems. Let this column be a clearing house of information. Send your material to me at the above address. Also welcome would be information about where it might be possible to get funding for the software or hardware.

What kinds of groups will we be talking about in subsequent columns? Blind, nursery school age, gifted, retarded, senile elders, pre- or post-delinquents, as well as the deaf and any other similar groups I may have failed to mention. I will try to match solutions to problems and will include in this space those of general interest, perhaps highlighting a particular group from time to time. If you would like specific information, send an SASE.
How about that Drake Hotel in Chicago (the conference hotel for the 1980 I.P.S. Conference)? Wasn’t that fabulous? The most impressive room was (no, not the Gold Coast banquet hall) the women’s powder room off the main lobby! Each cubicle was complete with its own vanity, chair, basin, john, and lighted mirror. Did anyone else but Doris Forror, planetarian of the Schuele elevator operators wore white cotton gloves until 4 p.m. then removed them? And that bit of wrapped chocolate resting on the pillow of your nightly-turned-down bed; now that’s class!

All of the conferees looked good, dressed to fit the occasion of the Adler Planetarium’s 50th anniversary. Jack Horkheimer, planetarian of Miami Space Transit Planetarium in Miami, Florida was wearing a tie tack which looked remarkably like the Southern Cross; four gold stars with a diamond offset from the center of the grouping of four. He reports that it is a Southern Cross design, given to him by a group of retired Miamians when he was a guest speaker at one of their meetings. George Reed of State College in West Chester, Pennsylvania was then reminded of a present he once received when he spoke to a religious group in his community about Astronomy. It was a frisbee that had printed on it: “Go with God!”

I asked George if he had enjoyed the Adler planetarium show on Sunday. He said, “I missed the last show. Someone told me that the Adler was within easy walking distance of the Drake!”

“Lookin’ Good!” at a planetarium conference doesn’t just mean wearing suits/dresses or beautiful tie tacs. You must make a statement about yourself or your profession. I saw at least fifteen crescent moon with a star inside the curved portion belt buckles, a name tag with “Your planetarium needs me!” and innumerable celestially inspired ties, necklaces, earrings, and T-shirts. John Hare of the Bishop Planetarium in Bradenton, Florida wins the “Best T-Shirt” award: an original design which said “Planetarians don’t do it—they just planet.” Tom Stee, of Central Bucks East High School Planetarium in Buckingham, PA, always a contender in these clothing contests, came in second with a T-shirt imprinted with an adequate “Skylab Shield.”

I.P.S. Presidents are not immune from the adornment challenge; Jim Hooks wore a brand new suit when he presided over the business meeting, one which had the pockets still sewn up! (Tom Gates, a past I.P.S. president, always carefully chooses a special shirt for the business meeting. From afar, it looked like a beautifully figured sport shirt; up close, it was evident that the figures were tiny Mickey Mouses.) During the business meeting, Jim announced that he has been overwhelmed by 560 planetarians who have volunteered to run for positions on the I.P.S. council. (I’m thinking of running for Assistant Archives Director myself.) It couldn’t have anything to do with Dennis Simopoulas of the Eugenides Planetarium in Athens, Greece’s tentative offer to sponsor an I.P.S. Council meeting in Greece, could it?

During Frank Drake’s talk at the conference, I was sitting in the back of the elegant Gold Coast room, near the Carousel projector used for his presentation. A wonderful drawing of a quasar came up. I became a victim of fantasy; I imagined quietly twisting and removing that Carousel tray ring and surreptitiously pulling out that quasar drawing. I was so close . . . could I pull it off? Charles Smith of the Science Museum of Virginia, in Richmond, sitting in the back also, was asking himself important questions, too. When Dr. Drake began to show slides to answer “When did the Universe begin?” “How will the Universe end?” Charlie added to himself, “How can I read those charts from this distance?”

Planetarians don’t always meet in beautifully appointed Gold Coast rooms. Sometimes they gather in hotel lobbies, hotel rooms, or hotel bars. Jack Horkheimer, Bill Nixon of NASA, and Ben Casados of JPL-NASA realized one evening that all these traditional conference rooms were crowded, so they had a business meeting at the Playboy Club across the street from the Drake. When Jack introduced Carolyn, the playboy bunny waitress to Ben and Bill with, “These are the men who take you into space,” she was obviously impressed. After a moment, she asked, “Do you go to Hawaii, too?”