PLANETARIA

and their use FOR EDUCATION

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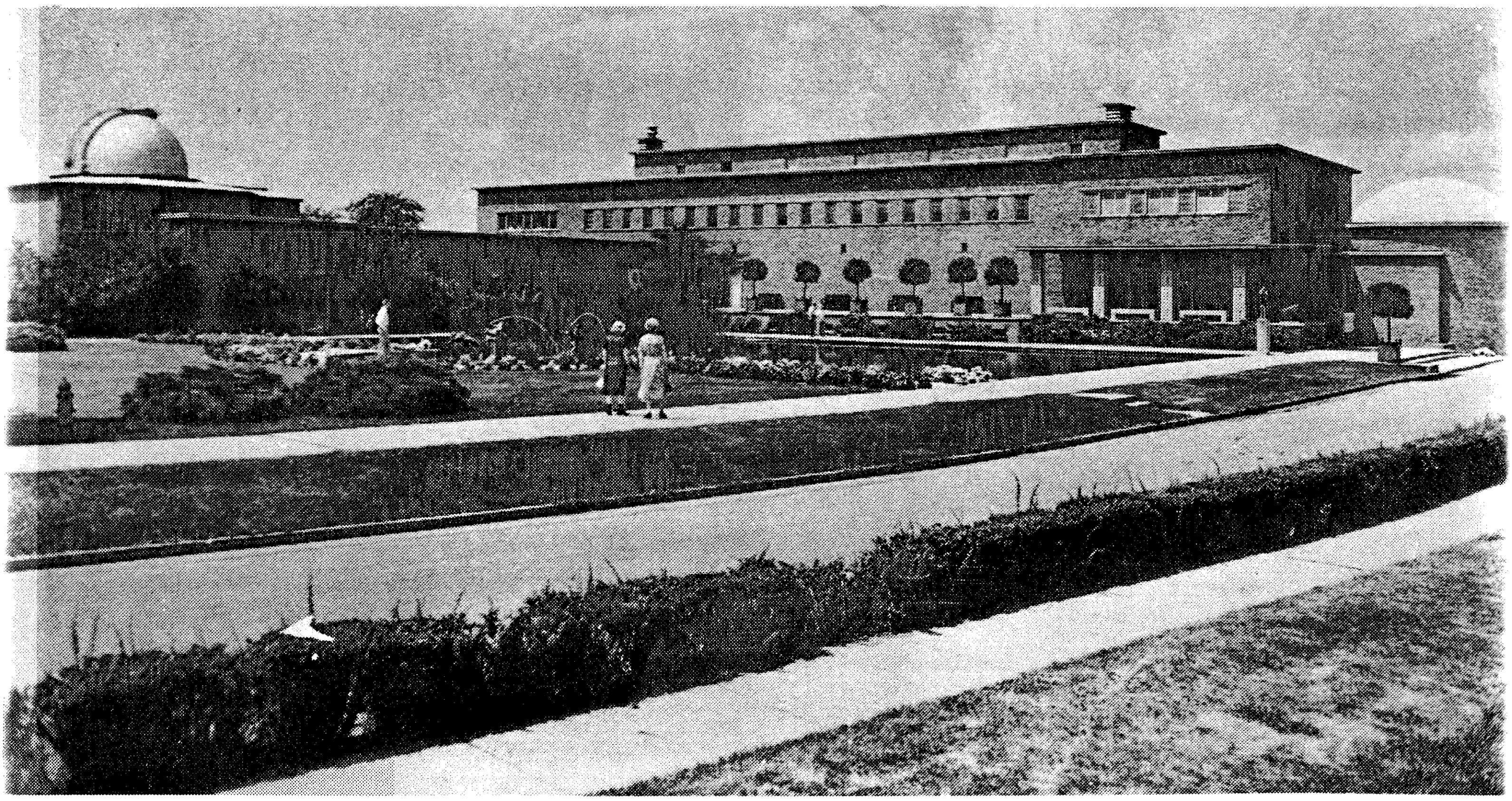

Observatory Museum Planetariu[m]

Cranbrook Institute of Science

PLANETARIA

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USE FOR

EDUCATION

PAPERS FROM

A SYMPOSIUM

HELD

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Miriam Jagger, Editor

Dr. Donald H. Menzel's lecture represents an elaboration of an article, "The Astronomer's Stake in Outer Space," which first appeared in *The Atlantic Monthly* for November, 1958.

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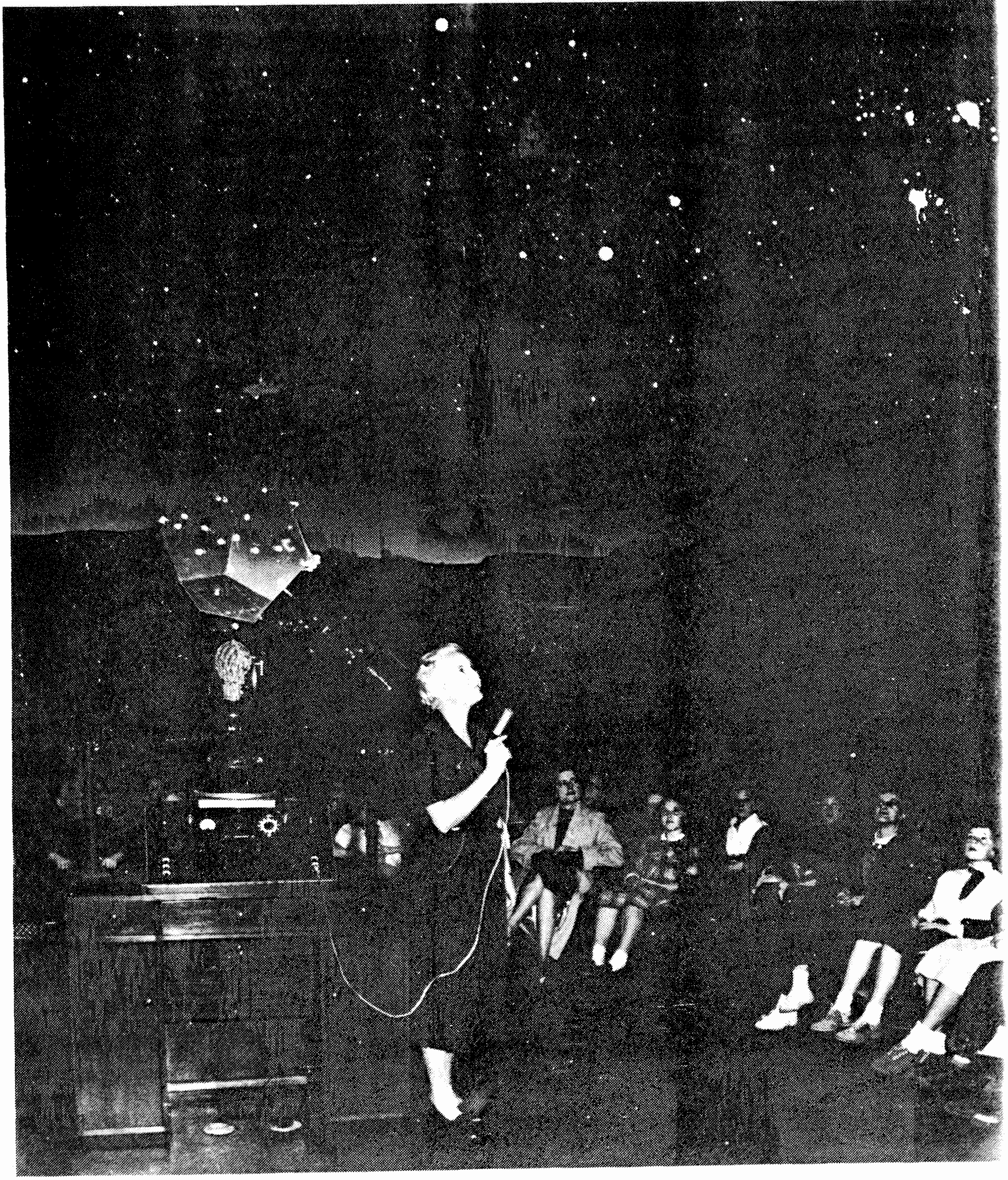

Robert R. McMath Planetarium

SYMPOSIUM ON PLANETARIA

AND THEIR USE FOR EDUCATION

The Symposium on the Educational Use of Planetaria,* of which the collected papers are here presented, was held at Cranbrook Institute of Science, September 7 through 10, 1958. This is the first such symposium to concern itself particularly with the problems of the smaller planetaria, and it is to be hoped that the papers here published will have widespread use.

Representatives from each of the 120 planetaria in the United States were invited to attend. 101 persons registered, representing 67 institutions; one delegate came from Hawaii. Though it was felt that the Symposium would be of greatest benefit to persons associated with the smaller planetaria, there were representatives from the larger planetaria in New York, Pittsburgh, Chicago, Flint and the Air Force Academy.

The plan for the Symposium was prepared by the undersigned, but its organization and conduct were in the hands of James A. Fowler, Curator of Education at this Institute.

The sessions were held in the Robert R. McMath Planetarium of this Institute, a room designed by William Edward Kapp, equipped with a Spitz Model 1-A projector, and seating 95 persons under its 30 foot dome. Delegates were housed and fed at an associated institution, Cranbrook Academy of Art, to whose staff we are most grateful for cooperation.

The Symposium was conducted under a grant from the National Science Foundation.

The delegates to the Symposium so welcomed this opportunity to present their ideas and to discuss their problems that they proposed that this event be followed by similar ones. To that end they formed a Committee to plan a Planetarium Association and named James A. Fowler as its chairman.

Robert T. Hatt

Director, Cranbrook Institute of Science

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*The group discussed the need for establishing a standard plural form and a standard definition for *planetarium*. The word is now used to define a building, a room or an instrument.

Director Hatt spoke in favor of following Webster's New International Dictionary (Merriam) in using *planetaria* as the plural form. Dr. Armand Spitz expressed preference for *planetariums* (to correspond with museums), a choice in which he has the backing of Sir Harold Spencer Jones.

No open discussion took place in the matter of definitions, but these proposals came out in private conversation: it was suggested that the instrument be called a "sky projector;" the room, a "sky chamber," "sky-room," or "planetarium;" and the building, a "celestium," "celestarium," "sky center," "sky-dome," "star-dome," or "stararium."

PREFACE

This Symposium contains abundant evidence to show that in the field of audio-visual aids there is perhaps no more fascinating or potent an educational device than the planetarium. At its best, the planetarium is a broadly informative, dramatic stimulus to learning; at the very least, it is an effective means of presenting certain astronomical concepts. There is an inherent drama in the planetarium demonstration which reinforces its educational function and which largely accounts for the spectacular popularity that it has enjoyed in the relatively few years since it first appeared on the national scene. Speakers at the Symposium cited one instance after another in which planetaria have not only drawn capacity audiences to their own programs, but have stimulated new public interest in the programs of affiliated museums and observatories.

The speakers were unanimous in their assertion that the planetarium is primarily an educational device, but they differed in their emphasis on its dramatic aspect. There is apt to be more emphasis on "good theater" among planetaria which are engaged in public education than among those which serve chiefly as specialized teaching or training aids. For example, there is very little importance assigned to the dramatic content of demonstrations which are presented in connection with the instruction of astronomy and celestial navigation at universities and military establishments. In these installations, the major emphasis is on factual demonstration; the planetarium is regarded less as a theater and more as a tool which helps the instructor to demonstrate or to explain various phenomena and concepts.

No matter how prosaically it is used, however, the planetarium retains its particular fascination; it is so intriguing a device, in fact, that instructors are reminded by one speaker that the demonstration is subordinate to the lecture and should not be allowed to consume a disproportionate amount of teaching time. It is interesting to note that many institutions which originally installed their planetaria as specialized teaching aids have since capitalized on the dramatic resources of the instrument to develop auxiliary educational programs for the general public. Several military establishments were represented at the Symposium by spokesmen who observed that such programs conducted for civilian groups have proven to be of considerable public relations value to the military and of inestimable educational value to neighboring communities.

Educational programs which are presented for the general public have two broad purposes: the first is to stimulate interest in astronomy and related sciences; and the second, to increase the layman's understanding and knowledge of the universe. In discussing specific ways in which these purposes may be accomplished, speakers repeatedly emphasized the importance of adequately preparing audiences for the demonstration and of properly fitting demonstrations to the audience.

It was pointed out that although the planetarium demonstration is nearly always an exciting and memorable experience for school children, it is not always as fruitful an educational experience as it might be. Students derive the most educational value from the planetarium demonstration if it is correlated with their classwork. It has been amply demonstrated that field trips to the planetarium are most profitable if the students have been adequately prepared in advance, if the lecture is tailored to the needs of the class and if the visit is intelligently followed up in their subsequent classwork. Since correlation of this nature can only be achieved with the full support of school administrators and teachers, the necessity for cooperation between schools and planetaria and between school teachers and planetarium lecturers was a recurrent theme at the Symposium.

Most speakers agreed that good showmanship is indispensable to an effective program of public education. Several of the papers here presented reveal the ingenuity that has been exercised in exploring and developing techniques which not only add to the educational value of the demonstration but intensify its dramatic impact. Music, sound effects, narration and the special effects achieved with auxiliary projectors have all been imaginatively adapted to the specialized purposes of the planetarium theater. By allying entertainment with education, the planetarium successfully attracts and holds audiences, kindles an interest in science among children and adults and ultimately inspires many young people to pursue careers in science.

Delegates to the Symposium could scarcely fail to be aware that the "cold scientific war of the Sputnik era" has had far-reaching consequences for planetaria. The swift-moving events of the space age have imparted a new urgency to the study of astronomy; the solar system and the universe have suddenly become areas of immediate concern to unprecedented numbers of laymen; and there is a growing demand for the services which the planetarium provides. The current surge of public interest in astronomy probably ensures planetaria of large audiences for some time to come, but it entails major educational responsibilities which they may not as yet be fully prepared to handle. As many speakers pointed out, the planetarium is still a comparatively new and rare phenomenon in our national life, and the tools and techniques needed to improve its educational services are still in the process of development. It is to be hoped that this Symposium will expedite that process — that it will hasten the development of planetarium programs which teach and inspire every audience with maximum effect.

Miriam Jagger
Lincoln, Massachusetts

INTRODUCTION OF DONALD H. MENZEL

ROBERT R. McMATH
Director, McMath-Hulbert Observatory, University of Michigan, Lake Angelus, Pontiac, Michigan

Every now and then your emotions and your judgment correspond and you get a job which turns out to be a pleasure. My job tonight is to introduce to you Dr. Donald H. Menzel, a very old and fine friend of mine. Donald and I first really got together in astronomical matters sometime prior to the eclipse of August 31, 1932, at which time we were both on the campus of the Fryeberg Academy at Fryeberg, Maine. I think out of the eighteen or twenty stations on the whole eclipse line, our station was one of the two that actually saw the sun that day. So you see that Dr. Menzel and I were well introduced a long time ago.

I have pages here about Dr. Menzel's honors, who he is, and what he has done. I'm going to omit them and be a little more personal, if you don't mind. Dr. Menzel has made a tremendous contribution to science in the United States of America, as shown, in one way, by the number of superbly able and fine men who have been turned out under his tutelage. Three of them are here in the audience tonight. Some of the topnotch astrophysicists and scientists in this country were students of Dr. Menzel's at the graduate level. He has done a superb job and I think the country owes him a debt for that. In my opinion, this is the most important single contribution among two pages of them that I could mention. So I'm not going to go on any further. I have the great privilege and pleasure of introducing my old friend, Dr. Donald H. Menzel, who is the Director of the Harvard College Observatory.

OPENING ADDRESS: OBSERVATORIES IN SPACE

DONALD H. MENZEL
Director, Harvard College Observatory, Cambridge, Massachusetts

The telescopes borne in rockets and balloons today may be only the precursors of large telescopes to be mounted someday on satellites in orbit several hundred miles above the surface of the earth; unobstructed by the earth's atmosphere, these space observatories will collect information which may profoundly alter man's interpretation of the universe and will certainly accelerate his exploration of outer space; the long-range investment required for such basic research will yield major dividends for business, industry and national defense.

It is a great privilege and something of a challenge to talk to you tonight on a subject which a few years ago would have been called anything from science fiction to absolute nonsense. But this new age in which we are living is an age of satellites, an age of outer space. Satellites themselves have become a fact, and the term "shoot the moon," which used to be an expression implying extreme improbability, is now a phrase that merely describes impending reality.

Before long we shall add to the satellites that are now in outer space. We shall launch probes that will go as far as the moon and perhaps may even reach the planets Venus and Mars. These probes will relay back to us information about the chemical composition and the atmospheres of these planets, and the general conditions in the space around them, information that we cannot get today by direct observation with telescopes. And it will not be long, I confidently predict, before man himself will achieve space flight. He will succeed in going into orbit and, what perhaps is more important, returning safely to earth. Then, as a final step in this first stage of the journey into space, man will eventually land on the moon, and establish there some sort of a base for further scientific exploration.

These plans aren't imaginative fancies. They are topics of sober conversation in almost every scientific meeting that I have attended during the last couple of years. Not only the scientists but the businessmen and industrialists as well, and the leaders in the Departments of Defense, and the military of all nations, are discussing problems connected with the exploration of outer space.

New rocket techniques and new fuels have greatly simplified the technical problems of space exploration, and the cost of putting an expedition into space has been enormously reduced during the last few years. One of my Harvard Observatory colleagues, Dr. Theodore Stern, recently calculated that it would cost, today, about two to three billion dollars to send a man on a round-trip expedition to observe the planet Venus. Now that sounds like a lot of money, but we should remember that it's only a fraction of our annual military budget. I think it is particularly interesting to note, also, that if we had planned this trip only four years ago, the calculated cost would have been about a thousand times greater. This marked reduction in the estimated cost of the trip is due to improvements in fuels, the fuels which we use to shoot our rockets into space. Although we probably can't expect similar reductions in fuel costs in the next few years, nevertheless the cost of space exploration in general is to be something that we can afford. A round-trip to Venus would not break the national budget and I might mention parenthetically that the cost would be very, very much less if we would give up the round-trip feature and plan to stay on the planet permanently!

The ancient pyramids of Egypt are supposed to have represented an investment of perhaps ten per cent of the gross national income over a period of about twenty years. If we wanted to make a similar investment of our own national income, according to calculations I have made with Dr. Fred Whipple, an Observatory colleague of mine, we could easily put the pyramids themselves into orbit, and for a figure somewhat less than the annual military budget we could easily put into orbit the now mothballed battleship, *Wisconsin*. Now don't misunderstand me, or misquote me. I am not advocating that we put either the pyramids or the battleship *Wisconsin* into orbit. I just want to show that we can carry out researches in space without imperiling the sound financial status of our democracy.

Let me emphasize that it does take vision and courage to put money into any basic research because basic research always represents a long-range investment. The basic research we envision with these satellites in outer space may seem a particularly long-range investment, one that requires great daring on the part of the investor. And yet, let me remind you that most of our great industries owe their existence, today, to basic research, yesterday. Radio, television, electrical power, atomic power, electronics, plastics, yes, even automobiles — none of these could possibly exist without earlier research in pure science. I can't think of a single major industry that does not trace its ancestry back, more or less directly, to some discovery made by — so-called — impractical scientists.

The chief ingredient of basic research is imagination. Imagination and a strong dash of curiosity yield understanding. The scientist knows very well what he is looking for when he is undertaking basic research. His investigation is never aimless. Even though the puzzle may seem a trivial one, the scientist knows its solution may reveal a fundamental fact of nature. Occasionally nature will surprise him with an extra dividend in the form of some entirely unexpected result, but most research is an orderly process, as it is in our program for exploring outer space.

Until now, more than a dozen small telescopes have rocketed momentarily into outer space to explore conditions, mostly those connected with the radiation from the sun. The collection of data and photographs have then been parachuted back to earth. Thus we've already learned a great deal about the sun that we were not able to learn before, because so much of the sun's radiation, especially in the far ultraviolet, is absorbed by the gases in the upper reaches of the earth's atmosphere.

Having a satellite for an observing station will give us an enormous advantage. This observing platform, which will move at an altitude of at least several hundred miles above the surface of the earth, will be substantially above all of the earth's atmosphere. We can then observe and record all of the different kinds of radiation that come to us from the sun and the stars. Also we can observe there the fine particles called "micrometeorites" that are known to course their way through our solar system. These tiny particles are no larger than a grain of dust. We are greatly interested in these dust-like particles because, small as they are, they can give us basic information about the origin of our earth and the evolution of our solar system.

Astronomers at the present time are making some of the first steps that will have to be taken in order to put a telescope into outer space. In particular, some astronomers from Princeton Observatory have already sent a fairly large telescope high into the earth's atmosphere, to an altitude of about a hundred thousand feet. That's roughly twenty miles. This height is still far below the optimum value of at least three hundred miles that I mentioned previously, but even at twenty miles the telescope has soared above some of the most turbulent and convective regions of the earth's atmosphere, the regions where the winds are the greatest and where the earth air currents make the stars seem to twinkle, and distort and otherwise interfere with the reception of the images of stars and of the sun. Dr. Swartzschild of Princeton, who carried out this study, has obtained some very fine photographs showing the mottling on the surface of the sun. When I show you these pictures later on you will be able to see that the surface of the sun is indeed in rapid convection. These direct photographs of the sun confirm, in a different way, some of the very important observations that Dr. McMath, Dr. Goldberg, and their colleagues here at the McMath-Hulbert Observatory have carried on with their special equipment.

Information of this sort is throwing new light on the sun, and enabling us to understand better than we did before the real nature of the sun itself. Some of this information is extremely exciting and perhaps almost frightening. For one thing, this study seems to indicate that the sun's outer atmosphere extends much farther than maybe a few solar diameters above the sun's atmosphere, as we had supposed. Actually, it may reach out almost to the boundaries of our solar system, so far that even the earth can be said to be moving inside the sun because the hot outer envelope of the sun extends far beyond the earth. Dr. Sidney Chapman, who is due to come to the University of Michigan shortly, is responsible for this new concept, which seems to account for a great many of our recent observations of the sun.

For example, if we could take a thermometer and travel up above the surface of the earth to a distance of say five hundred miles, and read the temperature there, we would find ~~that the~~ temperature is about seven hundred thousand degrees centigrade. That means that it's more than a million degrees Fahrenheit. I said that this sounds frightening. If you happen to be thinking of going out to explore outer space, and learn that you will have to pass through a layer of gas heated to over a million degrees, you would certainly wonder whether you could possibly survive such an ordeal. Well, a little calculation shows that you would not be in the least affected, no more so than if you rapidly passed your hand through the flaming burner of a gas stove. The flame may be burning at a temperature of six or eight hundred degrees or more, but if you move your hand through it very rapidly, you don't get enough of the hot gas on your hand to burn you. Perhaps you may even barely feel the warmth.

The same thing would happen in this region that I am speaking of, a few hundred miles above the surface of the earth. The temperature of the gas may be very high, but there is very little of it. The molecules of gas are so sparse and so far apart that if I put a thermometer up there and waited for it to come into equilibrium, I'd have a long wait. It would take thousands of years for an ordinary type of thermometer to read the actual temperature. The thermometer would radiate into space as rapidly as it was collecting this energy. The same thing would happen to a man on a space ship. Hence we would not be in any danger of being burned, and a projectile or missile going through this region would not be subject to any risk of being melted by the heat.

Some of these bits of information are theoretical, and some of them are obtained from photographs made from the surface of the earth. Some of the newest and most startling facts, however, are those we get from the balloon-borne telescopes. And we can expect an enormous amount of new information as we send up more and more of these balloon-borne telescopes to study the sun, and the stars, and the atmospheres of the moon and planets. But these floating telescopes are only the first step towards putting a large telescope into orbit, as an observing station in space. Astronomers visualize that a large satellite containing a telescope can be put into orbit and that the satellite itself will have on it a system of jets. Also, it will probably have a television receiver and transmitter which will send back to the earth the information that it has collected during the course of a revolution about the earth.

When we look at the sky through this television receiver we shall first see the heavens turning rapidly, as the rocket spins on its axis and tumbles around in space. But by controlling these jets, and letting them out at just the right moment and in the right direction, we expect to be able to control the amount of this tumble until it is finally reduced to zero. With these jet controls, a large rocket, instead of spinning wildly as it moves around the earth, will always move absolutely parallel to itself, so that the telescope it carries will always be pointing in exactly the same direction in space. If we want to change the direction of the telescope and point it at something else, we turn the telescope and the rocket itself by remote control. Then stop the controls and the rocket will be pointing to a new position, and we may get information about some other portion of the sky. This controlling of position is something which we shall certainly be able to do. A great deal of invention is necessary first, however, and much basic research, before we can produce devices that will operate effectively in this fashion.

One of the first projects planned for the telescope in space, and one which the Harvard-Smithsonian Observatories are hoping to carry out jointly, is a study of the ultraviolet light, the ultraviolet sky. As I mentioned a few minutes ago, this ultraviolet radiation does not get through the earth's atmosphere at all. It's stopped high above the earth by the gases, mostly the ozone and oxygen, of the earth's atmosphere. So when we put a telescope up in space we shall be able to see and photograph the ultraviolet light from the stars for the first time, and the sky will look very different from the one we are used to seeing. The bright red stars like Betelguese and Antares will be extremely faint because they are cool stars and do not send out much ultraviolet. The planets, which shine by a reflected light from the sun, will also be faint because the sun is weak in ultraviolet light. And as we look down into the depths of the Milky Way where the great gas clouds are sending out enormous amounts of hydrogen radiation, in the far ultraviolet, many of the stars will be lost or dimmed in the glow of the vast clouds of glowing hydrogen gas.

The information that we will collect when we can use our space telescope will be extremely important in shaping our interpretation of the past and present and the future of the universe. It will help us understand the whole evolution of our planetary system, and the evolution of stars. The mysterious cosmic rays will become accessible for study. Some cosmic rays come from the depths of space. Others apparently come from the sun in some type of solar explosion. Even our tiny Explorer satellites are already giving us intensely interesting information about these cosmic radiations, facts that we never suspected from our previous studies, made at the surface of the earth. In other words, the research results are already beginning to pay the bills for sending these satellites into space. I think everyone will admit that, over the long-range view, the more we can find out about the nuclei of atoms and the methods of getting power out of the atom, the more valuable these researches will be, because they will enable us in the future to build more effective nuclear power plants. And the cosmic rays are one of the keys that will help unlock for us the secrets of the atom.

Another interesting bit of information which we did not know until the last war is that the sun sends out radio waves in intense blasts, sometimes so powerful that they can interfere with radio communications on the surface of the earth. These radio waves are the subject of study by radio telescopes in a number of observatories throughout the world, and they give us facts about the explosions that are going on continuously on the surface of the sun. Astronomers now visualize the possibility of putting radio telescopes out into space. They are so large that they may look something like a giant radar screen, about the size of a football field. For use in space, they might conceivably be constructed in the form of an umbrella. They could be sent up in the collapsed form, somehow or other be made to expand as they get into outer space, and then used to collect the radio waves from the sun and the stars in interstellar space.

Now if we may have some slides, I'm going to run through some of the more or less imaginative concepts that have been suggested by various people during the last few years. In man's rush to outer space the first steps are already indicated — the satellites. These will be followed by probes to the moon and to the planets. The first probes will probably not even land, or if they do land on the moon they will simply give information about its surface. And we also expect to send to the moon some sort of machines with television transmitters on them, and micromanipulators, which we can control from the surface of the earth. They will carry out our experiments for us and relay back the information. You might say that before man goes to the moon in person, he will first project himself on the moon by sending a robot — a telerobot — which will work by remote control.

But finally, man, himself, will find it necessary to go into space. Here is an artist's concept of what this first stage of space travel may be like. Here is a ring-like satellite, 500 or 600 miles at least above the surface of the earth, high enough to be completely above all effects of the earth's atmosphere. This satellite is a sort of cosmic hotel in the form of a giant ring which slowly rotates. The rotation is intended to provide some sort of a centrifugal force which we hope will take the place of gravity and give us some of the effects of gravitation. This hotel will serve as sort of a half-way station to outer space. We won't necessarily send up this satellite-hotel as a single, completed structure. It might very well be built in partially collapsed form and shot in sections into outer space. These telerobots would assemble the various sections and put them together, so that, eventually, our hotel would be ready for man when he takes his first flight into space.

In the next slide we see great activity. Beside the hotel are two large rocket ships floating there in space, themselves also satellites. Pieces of material and a collection of debris are floating around. Some of this material is being assembled to become larger ships, ships which will soon be ready to take off and carry us to the moon, out to the planet Mars, into the planet Venus, or perhaps even further into the solar system if we desire.

The next slide shows what we would see if we were in one of these ships looking back at the large blue planet which is the earth. The blueness you see is the earth's atmosphere. We know that the air will look blue because we see the sky as blue when we look up. When we look back at the earth from our space ship we can still see the blue sky, but it is underneath us.

Now we have left the earth's atmosphere completely behind. We are out in interstellar space and even though the sun is brilliantly shining, we can see the moon in the distance off to the left, we see the stars, and we can even see the sun in the sky with the stars shining brightly around it. The sky itself is black because there is no air to be blue.

And here is the big rocket ship, completely assembled. There has been a good deal of discussion about what kind of fuel we would use in such a ship. For ordinary cruising around the solar system, however, ordinary rocket fuels may turn out to be much less convenient to use than what we call ion accelerators. An ion accelerator means that we take an atom and we shoot the atom out behind the ship with a tremendous speed. Now I think you all know that if you shoot a gun the gun will have a certain amount of kick which you can feel against your shoulder. Also, if you shoot a big gun it will have a bigger kick than a little gun. On the other hand, if you took a little gun and you shot a little bullet with a speed that was a hundred times greater than you would normally give the little bullet, the impact of the gun against your shoulder will be a hundred times greater than the kick imparted by the little bullet at normal speed. The same principle works with our ion accelerator. Even though the atoms themselves are very tiny, and although we may not send off very many of them, if we can send them out fast enough they will provide tremendous power. With even a few hundred pounds of fuel, we find that the ion accelerator will allow us to cruise great distances around the solar system. This power source is not a very efficient means for getting off of the earth when we need to have so much power delivered in a very short time, but out here in space where we've got plenty of time and don't have to worry too much about moving fast, we can use these ion beams to operate our rocket ship very efficiently.

Here one of these rocket ships is coming in for a landing on the moon. The ship now has its rockets operating in reverse, and when it finally comes to a rest on the surface of the moon, we are ready to get out and begin our exploration.

Here we see a number of rocket ships. They have completed their exploration and are taking off from the surface of the moon.

Here a rocket ship is hovering over the surface of the moon. It has become a satellite to the moon, and is doing some exploration. A great many problems about the moon are still unsolved. We hope that these lunar probes, perhaps even the unmanned lunar probes such as we hope to launch next month,* will give us some of the answers. For instance, they may help us decide what forces actually made the vast craters such as those you see in the picture here. Most astronomers believe that giant meteors crashed into the surface of the moon, perhaps millions of years ago, and made these big scars, some of which are actually hundreds of miles in diameter. There are big ones, there are small ones. I'm sure there are some craters, crater pits we call them, which were evidently not made by meteoric impact. We judge this because we can see a long crack on the surface of the moon, and perhaps hundreds of these tiny craters

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*Launched October 11, 1958. Ed.

all along the edge of one of these cracks or crevices. We believe that when the big meteor hit the moon and exploded, it cracked the surface perhaps for many miles, and tiny craterlettes formed as the hot molten material seeped up to the surface, making hundreds of miniature volcanoes.

Another question we would like to answer, when we land on the moon, is what is the surface made of? Most astronomers, I think, would say that the surface is probably composed mostly of rock and a certain amount of broken rock around the craters. But other astronomers have suggested, and certainly with reason, that the surface may have vast areas of lunar dust, deep seas of dust, perhaps several miles deep. A lunar probe will be extremely important in answering this question. If we had a lunar probe equipped with a small bomb, not an H-bomb, not even a uranium bomb, but simply an ordinary TNT bomb, then we could tell from the nature of the dust cloud raised by the explosion whether the bomb had landed in a vast field of dust or on a region of relatively hard rock.

All of this type of information that we can get will be of great assistance to us when finally we decide to send a manned expedition to the moon and actually land there and explore. Before this, of course, our telerobots on the surface will presumably have explored not only the visible half of the moon, but the opposite side as well. This opposite side is forever invisible to people on the earth because the moon rotates on its axis in exactly the same time it takes to go around the earth. Therefore we have seen only one side of the moon and only by going to the opposite side can we be sure exactly what it will be. Most of us feel that the lunar topography, craters, mountain ranges, etc., found there will be similar to those on the visible side of the moon.

Here our explorers have finally landed on the surface of the moon and are conducting experiments. They are standing on the side of one of the craters and they are shooting out small bombs or perhaps merely blasts of dynamite. These will explode, and when the sound waves from that explosion come back through the surface of the crust, the explorers will be able to tell not only what the nature of the moon's surface is, but something about its sub-surface nature. On the earth we use this same sort of technique as a means of geological exploration. The geologists use it to explore and find oil, for example, when it may be many thousands of feet below the surface of the earth.

There are many other experiments which we could perform on the moon, but we won't be able to plan them all in detail until after we have found out more about actual conditions on the moon's surface. For this reason, a new science has already come into existence.

This most infant of all the astronomical sciences is known as astro-logistics. Logistics is a military term. It means providing support for any type of expedition, a military expedition, an exploratory expedition or something of that sort. In the same way, astro-logistics means the supplying of men on the moon or men in space with the necessities of life. Since the moon is an airless, waterless world, the astro-logicians have to know in advance something about what the conditions are going to be. A careful study is now being made of all of the relevant information that can be obtained from the surface of the earth, or from satellites near the earth, because these facts may be useful later on to our lunar explorers.

It is quite conceivable, for example, that we may be able to set up on the moon's surface large solar furnaces which could provide intense heat and would be able to melt even rock. Ordinary rock on the surface of the earth contains a certain amount of water. We call it water of crystallization. Does the lunar rock contain similar water of crystallization? If so, perhaps we will not have to take all of our own water with us. We can set up our solar furnace and refine our water directly from some of the lunar rocks. This is a possibility, something that can be at least considered and perhaps tested.

Another thing that we would like to know is how hot is the surface of the moon? What we already know about the temperature looks rather formidable at first sight. When the sun is directly overhead, the surface of the moon is hotter than boiling water. When the sun has gone down and we are on the night side of the moon, and the sun perhaps has not shone for a couple of weeks, the temperature has cascaded down to about the temperature of liquid air. These differences of temperature would seem almost impossible for any manned expedition to guard against. And yet, some of the evidence we have indicates that these heated layers are just skin deep, perhaps only a fraction of an inch thick, and that if we go down even a couple of inches below the surface we come to a layer where the temperature remains about the same day and night, somewhere near the temperature of melting snow, not too cold and not too hot.

Another thing it is important to know in advance is the depth of the dust. If there are vast layers of dust, very deep, we should then have to provide our explorers with space skis so that they will be able to traverse these vast dust seas safely.

Here on the next slide we see a large caterpillar truck which is being used to explore the moon's surface. There in the distance, up in the sky, we see the earth, a large circle ringed with light, the light being the earth's atmosphere. The sun is hidden just behind the round dome of one of these space ships. We are very near an eclipse of the sun, and you may notice that halo extending from the sun out towards the earth, diagonally across the sky. That is the sun's corona, the sun's outer atmosphere, that hot layer of gas which, as I mentioned a few moments earlier, may extend out to the earth and far beyond.

As we go on in our exploration of space we may find it quite within our range to reach the planet Mars. In fact, it's easy to calculate that perhaps observing Mars from some distance is easier than actually landing on the surface of the moon and then later taking off. An ideal way to observe Mars would actually be to land on its nearest moon, because the moon is so small and has such a low gravity that we could easily take off from it again, after making our observations. Here, on this slide, is the way the planet Mars would look as we approach it. That whitish area near the top is the polar cap. It is not extensive like the polar cap of the earth because it completely melts and disappears during the course of the Martian summer, which is almost twice as long as our summer. The polar cap is probably a layer of hoar frost something like the accumulation of ice that you get inside of your refrigerator, and it may be only a few inches or, at most, a few feet thick. Those grayish green areas that extend downwards and show some linelike markings are the famous Martian canals, although they are certainly not canals in the sense of being artificial waterways. In my opinion they are probably river valleys, fertile river valleys perhaps in regions that have otherwise reverted to desert. That pinkish area I interpret as being desert sand, colored something like the reddish sands of our vast desert regions in the southwest of the United States.

Here are some interesting photographs of the surface of Mars. In that left-hand photograph, for example, taken with a red filter, you clearly see the markings on the surface. The blue filter which we used for the central picture does not show these markings, and we assume that the uniformity is due in some way or other to the presence of some atmosphere on the planet. Indeed, the planet does have some atmosphere, although we do not at this time know exactly what its chemical composition might be. Certainly the amount of atmosphere present on Mars is far, far less than that we have on the surface of the earth, much less even than above Mt. Everest.

We see now three pictures taken in different years. The one on the right was taken in 1926, the one in the middle in 1924, and the one on the far left in 1908. In all of these you see some similarity, but there are points of difference as well. The one on the right looks something like an inverted deer's head — you can see the antlers extending downward towards the right. In the middle picture you see that one of the antlers is gone and the shading in the neck of the deer is entirely different. The third picture shows a similar difference. There are changes, definite changes, in the planet, not only from year to year, but apparently from season to season as well. My own opinion is that the changes probably result from some sort of vegetation, although other causes have been suggested, such as volcanic dust distributed by prevailing winds.

We do know that occasional dust storms occur on the surface of Mars. We do see reddish clouds, and there are also blue clouds on the surface of Mars.

Here is what we might see from the surface of Mars. The sky sometimes may be very blue although the blueness is different from that of our sky. Here we see the hoar frost of the polar cap and then some of the long lines. I think this picture is much too imaginative, because it's just the river valleys that we see, not the rivers themselves. The rivers would be much too narrow to show in a picture, and there is certainly not that much water in the atmosphere of Mars.

While we are moving around in this region we want to take a quick view of the planet Venus, and as we come down close to it presumably we might see something about like this picture. The view is similar to the one we see from an airplane coming down for a landing when the earth is enshrouded with clouds. Venus also is enshrouded with clouds and there is considerable doubt as to the nature of these clouds. I think most astronomers would say that they are probably dust clouds and that the planet is complete desert. Dr. Whipple and I recently suggested that they are more likely to be water vapor clouds, after all, in spite of some of the objections that have been raised to this rather elementary interpretation. In fact, we suggested that, as we penetrate these cloud layers and come down to the surface of the planet, we might perhaps find the planet completely covered with oceans, without any islands such as we see here. Since we know that the atmosphere of Venus contains a large amount of carbon dioxide, the oceans would be oceans of soda water. (Hence when you plan your visit, be sure to take along your own Scotch!) The temperature down below the clouds would be something like that in a turkish bath, while the clouds would be fairly cold and perhaps even contain a certain amount of ice crystals. If this picture is correct, if there are Venusians, or people on Venus, you would expect them to be more like mermaids and mermen than human beings.

And finally, while we are out in this region of space, let us take a look at this most fascinating and probably the most important of all the astronomical objects from the standpoint of mankind — our sun. The more we know about the sun and its activity, the better we can interpret the many different kinds of effects that the sun can have upon the earth. This subject is much too complicated for me to detail to you tonight, except to mention that the sun in its various kinds of activity does have a well-known effect upon radio communication, that it helps cause the Aurora Borealis, and that it may very well also influence our weather. Here you see our rocket ship making a turn around the sun. Notice those pinkish objects imbedded in the silvery corona. Those are prominences. I now pause for just a moment to show you motion pictures of these prominences which were taken at the Climax and Sacramento Peak Observatories in Colorado and in New Mexico.

This motion picture technique, which was developed especially by Dr. McMath at the McMath-Hulbert Observatory, has contributed enormously to our understanding of the sun. These are large clouds of hydrogen gas raining down. In these pictures it's about half a million miles from left to right on the screen. The pictures are speeded up about six hundred times, which means that six hundred minutes or ten hours of observation are compressed into just one minute on the screen. Here you see the fiery edge of the sun projecting from behind that black disc — what we call the chromosphere of the sun. There is a lot of activity in this layer. There is a sun spot, on the edge of the sun, and here in this region we see intense explosive activity. The sunspots themselves, according to the most recent views of my colleagues and myself, are relatively quiet regions. I used to say that they were very stormy layers, but we now believe that a sunspot is extremely quiet. An intense magnetic field has frozen the gases into immobility and as a result, right around the edges of the spots which we are seeing here, the activity is greatly increased, to make up for the relative inactivity of the spot itself. Great clouds of gases are sometimes ejected out of the space to form these bright prominences which have a pinkish color when they are seen by the eye. In fact, a study of these prominences was one of the objectives of Dr. McMath and myself when, as he reminded you, we first met back at the total eclipse of 1932. Look at that peculiar funnel which cascades into a nearby sunspot. Stuff cascading in there from the corona becomes visible in the region of the prominences and occasionally we see a large geyser-like object shot into space. This one goes up about 150,000 miles. We have recently photographed one that had a record speed of about 800 miles a second. These great balls of gas, ejected from the surface of the sun, guided in part by the sun's magnetic fields cause the Aurora Borealis when they reach the earth. These atoms make the gases of our upper atmosphere glow in the same way as the gas inside of a neon tube will shine.

Notice these peculiar shapes, the prominences which look something like enormous waterfalls flowing downward. These are loop-type prominences, characteristic of big sunspot groups in this region. Magnetic fields and intense electric currents play an enormously important part in this type of solar activity. This is about the largest prominence, I think, that was ever photographed. It became much bigger than the sun itself. Notice the peculiar rotation. Matter kept cascading back to the sun for many hours after this explosion occurred. Some of this material that is shot off from the sun, on occasion at least, may reach the earth.

These motion pictures have given you an idea of what we can see from the surface of the earth. I'm sure that Dr. McMath would join me in wishing that we could set up some of our solar observatories on the surface of the moon, in the vacuum where there is no atmosphere and where we would not be troubled at all by the scintillation or poor seeing conditions. We could really have a wonderful time up there, and Dr. McMath and I are looking forward to going on the first expedition.

Studies and probes of the other planets are perhaps somewhat more visionary than those that I have been discussing. Jupiter is much farther away than the moon or Mars. It's about five times more distant than the sun, and the temperature at the surface is that of liquid air. Jupiter would be very difficult for us to approach because of the intense gravitational field. It is the largest planet, ten times as big as our earth. We know a little about the chemical composition of the atmosphere, which consists of ammonia, methane, probably hydrogen, helium, and other gases. We'd like to be able to make detailed studies from a satellite or from a probe, which would give us more information.

Jupiter, cold as it is, occasionally sends us great blasts of radio signals. Now when I mention radio signals from the sun or the moon or the planets, I don't mean that there is anybody there sending us radio messages. All I mean is that radio waves are generated there, just as radio waves are generated in the earth's atmosphere when we have a violent flash of lightning. You see that reddish spot on the surface of Jupiter, a little bit above the right of center? That general area has been recognized as the center where some of these lightning flashes, or whatever it is that produces the radio waves, occur. The sun also produces radio waves and sends them out in intense blasts from active sunspots. In a relatively new study which has not received any marked publicity up to the present time, Dr. Thomas Gold and I have theorized about the possible existence of waves which might travel all the way from the sun to the earth in this tenuous atmosphere. We have found some evidence that waves of a peculiar type do exist, an electric pulse that has come all the way from the sun. They sound like a slow whistle that starts at a high pitch, and they may take something of the order of a good many minutes to go from the high pitch down to the low pitch. Sound waves like these have actually been detected and we believe that they are of solar origin. There is some evidence that they are tied in with solar activity.

Here is that red spot again, and our planetary exploring ship has developed a flat tire. We are outside repairing it and exploring the neighborhood, in the meanwhile, in our space suits. Here is the planet Saturn, still farther out and presenting many interesting problems. The ball of that planet is very similar to Jupiter. If we could get close enough to the ring we would see that it is composed of myriads of tiny particles of dust and rock, fairly close together. Some astronomers have predicted that our earth will eventually have a ring around it something like the ring of Saturn, composed of debris thrown out of space ships. It is my earnest hope that this ring will not consist solely of empty Vodka bottles and caviar tins.

I have taken you on an excursion into space, trying to let you see with the eye of an astronomer what we can hope to find from exploration, first with rockets, next with satellites, then with probes that actually land on the surface of the moon and the planets, and finally, with manned space vehicles. These are all coming, but at this moment I will not venture to predict whether this program of exploration will be carried out as a U. S. program or as a Russian program. I think that the evidence is very clear that we are quite a way behind the Russians. On the other hand, I have just returned from Russia and, although I must say that their accomplishments are indeed impressive, I don't feel that their head start is so great that we cannot catch up with them. At the present time they are treating us with condescension. We have been able to put into space these little tiny satellites weighing only a few pounds, while the Russians have put up satellites weighing tons.

I'll leave you with one of the stories that is going around in Russia. The Russians told it to me when I was there. They said, "One of the greatest troubles that you Americans have with your satellites is that you can't find a dog small enough to go into them!"

DISCUSSION

Question: Is space travel hindered by the intensity of cosmic rays?

Dr. Menzel: Yes. Our Explorer satellites have indicated that the intensity of cosmic radiation a few hundred miles above the surface of the earth is considerably greater than we had expected it would be. This extra radiation may constitute a serious hazard to space travel. There are several questions to be answered. How thick is this layer? Can we get through it fast enough, or can we provide sufficiently effective shields for man if man is going to go through it? These are problems for the future. I believe that the intensity of this penetrating radiation will eventually decrease with height.

Question: Is there any possibility that cosmic rays extend indefinitely?

Dr. Menzel: I suppose there is a possibility, because we haven't gotten out there yet to find out. I think that most people feel that the penetrating radiation consists of low-energy cosmic rays trapped in the earth's magnetic field.

Question: Can you think of any one thing that we as planetarium people can contribute to the young people who come to our planetaria, to prepare them for this fantastic future?

Dr. Menzel: This is a very interesting question. How can planetarium directors and people in planetaria inspire young people and prepare them for scientific careers. I think that, apart from increasing their interest in science as a whole and astronomy in particular, we should try to encourage these young people to take more interest in mathematics. Many students come to me and say that they would like to be astronomers, but aren't very good at mathematics. Well, you just can't be an astronomer or a good scientist today if you're poor at mathematics. There's no real excuse for being poor at mathematics, except that sometimes your teacher is to blame. Through the seven or eight grades, a student studying arithmetic almost certainly will come across some teacher who does not like arithmetic and succeeds in imparting to the student only his or her own dislike for the subject. As a result, the student acquires a dislike for mathematics from that time on; he doesn't learn the subject and the resulting gap in his knowledge is never repaired. We should recognize that even in the grammar schools we should have specialists teaching arithmetic. We should not just rely on the average teacher for doing that, any more than we rely on her for teaching such specialties as art or music. We need to have the specialist teaching mathematics.

Question: The sound waves you mentioned coming from Jupiter, are they merely the radio-frequency waves reduced in frequency to an audio-frequency range?

Dr. Menzel: No, these are radio-frequency waves that come from Jupiter. And there are radio-frequency waves from the sun. The waves that I said came from the sun are really audio-frequency waves. We call them "solar whistlers."

Question: Do you believe in science and mathematics as elective or as required subjects?

Dr. Menzel: I think mathematics should be a required subject and that a certain amount of science should also be required. I think there are far too many electives in our present day school system.

Question: What is the latest information about the possibility of human life on Mars?

Dr. Menzel: I've already stated my own viewpoint, based at least on some evidence that there is vegetation on Mars. Now where vegetation exists there may also be animal life, and it requires only a stretch of the imagination (and here your imagination is just as good as mine) to believe in the existence of human life or super-human life. On the other hand, if these creatures had reached anywhere near our own stage of development, presumably they would at least have invented some sort of radio signal device. We should be able to hear something of their radio programs, their Bing Crosbys or Elvis Presleys. Up to the present time we haven't heard anything that even suggests an intelligent signal.

Question: How long do you think it will be before we reach the moon?

Dr. Menzel: I think this is a question of how much money we're going to put into the project and whether or not the government gives to scientific research the wholehearted support that it deserves. We could easily reach the moon in ten years. We could probably do it in less than that, but I would say ten years as the probable length of time before we could actually put a manned expedition on the surface of the moon. It could be done in less.

Question: Has there ever been the thought of using atomic power to propel rocket ships?

Dr. Menzel: Yes, but up to the present stage we haven't found any effective way of using atomic power. This has been suggested and I believe that only when we go to perfectly enormous rocket ships can we expect to use atomic power. Atomic power plants, yes, for supplying a rocket with the power that is necessary to conduct its experiments; and atomic beams for cruising in space. But we don't see how to use atomic power to drive the ship from the earth at the present time. I think this problem will be solved sometime.

ASTRONOMICAL SUBJECTS AND APPLIED SCIENCE: INTRODUCTORY REMARKS

EVERETT R. PHELPS
Professor of Physics and Astronomy, Wayne State University, Detroit, Michigan; Chairman of Session on Astronomical Subjects and Applied Science

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A review of the development of the theory of the structure of our solar system

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Probably most of you are fully familiar with the subject matter of astronomy, but perhaps it will be well to review together the development of the theory of the structure of our solar system. These ideas can then be used as a background not only for our two speakers of this morning but also for other speakers of the three-day Symposium as they discuss the uses of planetaria in presenting various astronomical subjects.

I have always felt great respect for Ptolemy and his colleagues who developed the geocentric theory of the solar system. As we look around us and observe the apparently stationary earth and note the daily rising and setting of the sun, moon, planets, and stars, the concept of a central earth with all of the stars on a distant "crystal sphere" which rotates once daily to account for daily rising and setting is a natural one. Great ingenuity was shown by Ptolemy and his later supporters in accounting for the right amount of motion of the various planets among the stars by means of deferents (circles around the stationary earth) and epicycles (small circles around which the planets moved as the centers of the epicycles moved along the deferent). The geocentric theory, or the assumption of the sun moving around a stationary earth, accounts just as well for the eastward motion of the sun among the stars as does the heliocentric theory.

Of course, even more credit must be given to Copernicus (and to the few early Greek philosophers who had suggested a stationary sun with moving planets) for giving us in 1543 his carefully written book *De Revolutionibus Orbium Caelestium* in which he showed the ability to see beyond the apparent motions and to arrive at the true concept of a sun-centered system with daily rising and setting accounted for by a rotating earth.

At first, the future positions of planets predicted by the Copernican theory were no more accurate than positions determined by the Ptolemaic theory. It was not until several years later that Kepler, using the painstaking observations of planets' positions made over a period of twenty years by Tycho Brahe, suggested elliptical orbits for the planets. He also stated his law of areas and the "harmonic law" (the square of the time of revolution of a planet around the sun is directly proportional to the cube of its average distance from the sun) which enabled Sir Isaac Newton to arrive at the general law of universal gravitation.

Although Kepler's elliptical planetary orbits resulted in close agreement of predicted and actual positions of planets, many scientists still were not convinced. Finally in 1838, successful measurement of the parallax of stars definitely established the heliocentric theory.

Meanwhile, observational astronomy was given great impetus by the proper assembling of lenses to form an astronomical telescope by Galileo in 1610.

The telescope enabled astronomers to discover planets other than those formerly known from visual observation — Mercury, Venus, Mars, Jupiter, Saturn (and the earth!). In 1781, Herschel, searching the heavens with his new telescope, discovered Uranus (although he did not at first recognize it as a planet).

As years passed, deviations of Uranus from its predicted path led some astronomers to the conclusion that this was due to the gravitational effect of an unknown planet. Independently, in 1845, Adams in England and Leverrier in France computed the probable location of the suspected planet.

Airy, Astronomer Royal of England, paid no attention to Adams' request that the planet be searched for, but Leverrier's friend Galle did look and found it within a half degree of the computed position — a great triumph for mathematics!

Many years later Lowell believed that remaining slight deviations of Uranus and perturbations of Neptune were due to still another planet. He willed money (probably inherited from the woolen mills of the Lowell family rather than earned as a professor of astronomy!) to establish an observatory at Flagstaff, Arizona. Here, three projects were to be undertaken: the sun was to be studied, the planet Mars was to be studied and photographs were to be taken of sky areas near the ecliptic in an effort to locate the disturbing planet.

On a morning in January, 1930, Clyde Tombaugh, while developing a plate taken the night before and comparing it with an earlier plate of the same region, detected a hazy spot which he thought might be the long-sought planet. He and his colleagues showed the true scientific spirit — they held up the announcement for two months during which time they made sure that this was indeed the new planet. By that time, there had been enough motion among the stars to allow a fairly accurate determination of the period of the planet (about 248 years) and from that the distance from the sun was computed by Kepler's third law (about 40 astronomical units).

Meanwhile, several smaller bodies which revolve around the sun (asteroids) were seen through telescopes. With the advent of photography, hundreds of such asteroids were discovered until now we know the orbits of nearly two thousand.

Several natural satellites have been discovered in recent years — the twelfth of Jupiter by Nicholson in 1951, the fifth of Uranus by Kuiper in 1948, and the second for Neptune by Kuiper in 1949.

Comets, meteors and meteorites complete our solar system and should be considered under special uses of planetaria.

In using the planetarium to portray members of the solar system as well as to show the principal stars of the universe, it must be kept in mind that the planes of the orbits of the planets and the asteroids are for the most part nearly coincident.

(Following these remarks, Professor Phelps introduced the speakers who participated in the session on Astronomical Subjects and Applied Science.)

USE OF THE PLANETARIUM IN TEACHING NAVIGATION

Rear Admiral GORDON S. McLINTOCK
Superintendent, United States Merchant Marine Academy,
Kings Point, Long Island, New York

The planetarium helps to teach celestial navigation effectively and rapidly to novices at the Merchant Marine Academy; fundamental concepts are more readily understood when they are presented in the three dimensional terms of the planetarium demonstration than when presented in conventional textbook diagrams.

During the course of the academic year at Kings Point — September to August — students in our navigation classes spend approximately 16,000 hours searching for the correct solutions to problems celestial while another 18,000 hours are spent by students at sea on vessels of the United States Merchant Marine putting into practice what was learned in the classroom. The fact that most students arrive at the Academy lacking even the most elementary understanding of navigation makes the teaching of this subject unique. Most other subjects — mathematics, English, languages — in the curriculum at Kings Point merely take up where someone else stopped. This, of course, presents problems to the members of the faculty involved in teaching navigation, and they must constantly develop new techniques and search for new devices to best facilitate the upgrading of these young men from zero comprehension of navigation to the point where they can be termed expert.

The biggest single problem connected with this massive celestial navigation program is the one involving the development of a suitable instructional aid to teach the students how to add and subtract. If we only had a device that would teach them to add two and two and consistently get four, the biggest instructional problem would be solved. Unfortunately, however, we have been unable to find a device of this sort.

The second biggest problem, however, does involve a presentation of a perspective view of the celestial sphere and the astronomical triangle - a view essential to the comprehension of celestial navigation. As you probably know, celestial navigation is based on a concept of the universe that has been passé ever since Galileo Galilei looked through his wonderful glass at the phases of Venus and the moons of Jupiter — that is, the concept that the earth is at the center of the universe and that all bodies revolve around it. This Ptolemaic theory presents the universe as a huge sphere of infinite radius with all the celestial bodies placed at equal distances from the earth on the inside of this sphere. Since this sphere is, in effect, merely a projection of the terrestrial sphere, what is true in measurement of arc on the terrestrial sphere must also be true in measurement of arc on the celestial sphere and vice versa. Because the positions of all navigational bodies on this great imaginary envelope have been accurately computed, the position of a similar point on the earth may be computed too, and it is from this position of the body's sub-point that the navigator determines where he is in the trackless ocean.

Textbook after textbook pictures this relationship and the spherical triangle that results in a variety of two-dimensional diagrams, none of which is wholly satisfactory to the beginning student in navigation or to the instructor who is seeking aid in interpreting the text. Some of these diagrams use dotted or dashed lines to indicate that a body is on the side of the sphere away from the observer and solid lines for the other side, while others show various lines and circles in varying colors. Sometimes an author tries to present an entirely new view, one that seems fairly clear to him, and others accompany reasonably simple diagrams with wordy and involved explanations. From the students' point of view, all of these different presentations end up in the same way: a two-dimensional representation of a three-dimensional concept.

By utilizing the two-dimensional blackboard and a large stock of colored chalk, most good instructors can eventually convey the fundamentals of celestial navigation to the better students, at least. After an extravagant number of class periods and much colored chalk dust on blue uniforms, face, and hands, the instructor usually emerges from the classroom with some satisfaction. This can be done, of course, and was done for a considerable number of years at Kings Point. But since we installed the first planetarium at the Academy in 1949, we have economized in time, enabled the students to get a better idea of what celestial navigation is all about, and given instructors the satisfaction of feeling that they are doing a more effective teaching job. There has not been a noticeable decrease in operating costs, however, because of the decreased use of colored chalk.

At Kings Point we lose little time in getting our Plebes — Freshmen — into the planetarium. As soon as they can be taught to know that there is such a thing as the celestial sphere and an astronomical triangle, and that there is a relationship between the equator, the poles, the meridians, and points on the earth and the lines, circles, and points on the celestial sphere, they are given a short lecture inside the dome to get the whole idea in three dimensions. Our planetarium — our second — is equipped with most of the essential accessories, and they are put to good use. The one accessory that contributes the most to the instruction of potential navigators is, of course, the astronomical triangle projector. This projector is a relatively simple device that throws three adjustable lines of light which appear on the dome as circles, and it can be set up to form an astronomical triangle with any star that the instructor chooses. Thus the student can see how the triangle is formed, and how solution of this triangle can be turned to the advantage of the navigator. Armed with this understanding, the student finds that the actual solution of the celestial triangle and the application of the results as lines of position and celestial fixes becomes routine.

In presenting celestial navigation to our beginning students at Kings Point, we give an initial overall view of the whole subject with great emphasis on the end result — that is, finding a ship's position. Following this overall view, which is devoted wholly to principles and which involves about one-third of the beginning course, the actual practice of navigation is begun. This is done by supplying the student with the end results — lines of position — and then gradually withdrawing data as the term progresses until he gets the end result himself by solving the navigational problem from beginning to end. During this gradual withdrawal of data, of course, he is taught how the different parts contribute to the whole. This is done by short lecture periods in which the planetarium and its accessories are used as teaching aids.

The geocentric earth projector enables the student to see at once the relationship between the geographic position or sub-point of any celestial body on the terrestrial sphere and the position of the body itself on the celestial sphere. This is truly navigation made simple. The coordinates projector affords the student the best picture of the ecliptic in relation to the celestial equator. Not only can he better understand why we have the seasons of the year, but he can also see how all the stars maintain their positions in relation to the equinoctial colure — a concept that is essential to the good understanding of celestial navigation.

Of course the very name *Merchant Marine Academy* implies that we take navigation seriously. This is our stock in trade, so we have to make sure that everybody is an expert navigator before he is graduated. Since much of the navigation aboard merchant ships is done with stars, we think it imperative that our students learn to recognize both the stars and the constellations. Before he is graduated each student is required to take a test with the planetarium wherein he must be able to identify a minimum of twenty-five stars. Nearly all the students, however, elect to name in this examination a minimum of sixty different stars, and it is a rare student, indeed, who gets a grade lower than *A* in star identification.

This proficiency in star identification obviously could not be achieved if it were not for the planetarium. Each student is encouraged to use the planetarium whenever he can, and during the three months' time preceding star identification tests, the planetarium is a very busy place. Usually the students form groups of three or four and spend about one half-hour at a time identifying the stars and asking each other questions about the constellations as well as the stars. Some students prefer to work alone. They go inside the dome armed with a star chart and a flashlight and spend about a half-hour at a time in this fashion. We have learned that the planetarium is most beneficial in short but frequent sessions.

We are exceedingly proud of the results of our navigational instruction. Our graduates are navigators of some of the biggest ships, merchant and navy, sailing under the American flag. During the 1958 Newport to Bermuda Yacht Race concluded this past June, one of the Academy entries was navigated by a student. Utilizing every opportunity for observing celestial bodies — the sun, moon, stars, and even planets during the day — he did an outstanding job. When the island was finally sighted after four days' sailing, the boat was right where the navigator said it would be. You can be sure that navigating a forty-four foot sailboat is much more difficult than navigating a big ship, since it would be doubtful if the navigator of a big ship like the *United States* would have to wrap one leg around a mast, while he "shot" the stars, to keep from being swept overboard.

Our plans for the future call for continued use of the planetarium as much as possible, both by members of the faculty and the students themselves. We'll be trying all the time to think up new and different ways to use this teaching aid. One thing we would like to have in our planetarium — and I'm not sure this has even been invented yet — is an astronomical triangle projector that rotates at the same speed as the star projector. This would mean that the different circles could be lined up with any star and would follow that star from the eastern to the western horizon and would give a constantly changing picture of the astronomical triangle. This, I believe, would make a good projector even better and would even further decrease the use of colored chalk on the two-dimensional blackboard.

I could probably talk on and on about the possibilities of the use of the planetarium in the instruction of navigation, as they are virtually unlimited. It should suffice, however, to say that we would certainly dislike to be forced to teach navigation to beginning students without the planetarium.

It would seem, then, that our second biggest problem in getting the principles of navigation across to students is pretty well solved inside the planetarium dome, but there still remains the greatest problem in turning out expert navigators: how to get students to add two and two and get four instead of a variety of other numbers.

CALENDARS AND TIME MEASUREMENT

GEORGE E. FOLKMAN
Planetarium Demonstrator, Cranbrook Institute of Science, Bloomfield Hills, Michigan

Ranging from philosophical inquiry into the nature of time to technical discussion of clocks and calendars, the broad subject of time lends itself to numerous adaptations in planetarium programs, exhibits and publicity; this complex subject should be presented in the simplest possible terms, but a certain amount of precise terminology must be used and explained in programs for the general public.

Time is such an integral part of the subject of astronomy that it would be more difficult to avoid mentioning it than it is to weave it deliberately into our demonstrated lectures. At the planetarium we often overhear the leaders of visiting groups instructing the members of their parties to pay especial attention to the speaker when he explains something having to do with time, clocks, meridians, or calendars, regardless of the announced topic. It is seldom difficult for the speaker to include material which covers the subject of interest to these groups.

There are many phases of interest in the subject of time and its measurement. Students of grade school level are getting acquainted with the astronomical aspects of seasons and time belts. The international date-line and the meridian of Greenwich are introduced at this time, and teachers are quite happy to sponsor trips to our astronomical laboratories to enlist visual aid in teaching this rather abstract subject. Church groups and individuals of philosophic turn of mind attend our lectures for the assistance we give in helping to clarify their various cosmological theories as they evolve their individual philosophies or their religious viewpoints.

Most planetaria are associated with museums or other scientific institutions and have access to material that can be displayed in conjunction with lectures. Clocks of various types, sundials, primitive knotted ropes, candles, hour-glasses and calendars can be found and borrowed from private individuals for display in our lobbies. Suitable material is frequently loaned by industrial organizations, especially the manufacturers of precision instruments. A permanently mounted series of clocks showing various types of time, or time at various places, is of great interest and might be obtained from private or industrial donors. The "eye-appeal" of three dimensional exhibits is of inestimable value and is in keeping with our type of presentation.

With "eye-appeal" we should consider the "ear-appeal" of the titles of our lectures. There are a number of methods available in every community for carrying the announcement of topics to the public. Bulletin boards in our buildings, the seasonal announcements of our programs sent to members of societies, releases to the press and the information published in pamphlets intended for distribution to visitors in hotels should all be utilized. Most company journals intended for distribution to employees consider it a public service to carry announcements of cultural events and welcome the opportunity to do so. Well planned programs given at stated intervals are announced in magazines intended for astronomers at all levels of skill and interest, and there are many persons who try to attend any lecture available on the subject. We all hear comments on our presentations and on the experiences of patrons at other planetaria, and this type of conversation constitutes the so-called word-of-mouth advertising. Not long after the opening of the planetarium here at Cranbrook, we found that we had "fans" who watch for our program changes. They ask for the topics or titles of lectures.

Titles such as, "What Time is It?", "All Kinds of Time", "The Clock in the Sky", "The Stars that Set Our Clocks", "Time Clocks and Calendars", "George Washington's Two Birthdays" or "Christmas Twice a Year" tend to create interest and still convey the announcement that the lecture or demonstration is related to the astronomical aspect of time and the measurement of its passage.

This subject gives us an opportunity to "pull out all the stops" in more ways than one. It is not only an excellent opportunity to put the planetarium through its paces but it is a subject that will draw heavily on the resources of the lecturer. We must remember that when we are presenting involved "eye-material" our "ear-material" should be little more than continuity. When a moment of uncomplicated starry sky can be presented, then we might venture into more involved auditory areas. It might be well to remember that it is much easier to lose a patron's attention by getting too "technical" than to lose his respect by getting too elementary. A patron tends to be tolerant, "for the sake of others", if you are explaining something he knows quite well, but is apt to be annoyed if he is asked to assimilate material too fast and loses his train of thought.

We must remember that we are expected to present the matter of time and its measurement mainly from the point of view of the astronomer rather than the philosopher. This is not easy nor completely desirable. A few well chosen statements from the minds of thinkers can certainly be used to advantage. I like Benjamin Franklin's definition of time, "The stuff that life is made of" – it seems to fit into my philosophical notion of time; and I believe it might be mentioned that what we record as elapsing between events is called time. Historians treat time as the highway of history. We find primitive peoples have little regard for the passage of time and that some of the primitive languages lack a word for time. I believe we should feel free to leave the abstraction to the philosophers and get back to the former ground of our specialty as soon as possible.

Certainly we would demonstrate that a day is a period caused by a complete rotation of the earth around its axis and point out that daylight and nighttime are the result of this rotation. We should define revolution as the motion a body demonstrates in passing around an external point. Hours, minutes and seconds are a man-made method for recording the passage of time consumed in traveling a distance which we record in degrees. We tend to translate our conceptions to more easily understood terminology, but we should point out, or clarify, the movements of the earth in terms of distance and position as well as time involved. A natural step is the concept of the year. While we designate spring, summer, fall or autumn and winter as seasons, we should point out that we could have a year without having seasons and then proceed to the matter of the tilt of the earth's axis to the plane of its orbit, thus explaining the reason for seasons and accounting for the year.

I believe that our patrons are capable of hearing a certain amount of scientific or at least proper terminology. I believe that we are obligated to demonstrate that precision in the use of terminology is essential to the study of astronomy, or at least to explain that proper "tools" are essential to the science of astronomy. "Tools of the Astronomer" might well be a lecture describing our vernacular as well as our physical instruments.

Lectures or demonstrations open to the general public should certainly contain precise terminology up to a point. We might assume that anyone present should hear about and understand sidereal time. We could hardly avoid demonstrating a sidereal day as we point out the apparent rotation of the stars around the pole setting and rising again as they disappear and reappear over the horizons. We might feel free to dwell on the hour angle of the vernal equinox and then go on to a discussion of solar time to account for the difference in length of the solar and sidereal day. After pointing out that the "noon" of sidereal day ranges completely through a solar day, it is easier to explain the desirability of living with the sun rather than the stars. This is a good time to point out that the sun is a star and that our annual trip around it as a member of its family, one of nine planets etc., causes us to see the constantly changing pattern of stars, in *our* back-ground. Apparent solar time should be demonstrated or explained as sundial time. This leads logically to the standard time belts, etc. Now that Alaska is "in" the Union of States we should begin to name the time belts including Yukon and Alaskan as we cross the nation's time belts.

Clocks are man made devices and should be pointed out as such. In the same category are vessels that fill with water and sink with a fair degree of regularity, devices in which sand flows through constrictions between containers, candles that burn down past notches, ropes that smoulder a certain distance in a given time and finally, cog-wheeled clocks that point to numerals or sound bells. The word "clock" comes to us from the German "glocke" meaning bell. Early clocks had only one hand, minute hands being added about the middle of the seventeenth century. Tycho Brahe had to content himself with a clock so unreliable that it never showed less than a fifteen minute error and a full hour error was not uncommon. It was no wonder that time was considered to be in the domain of the astronomer, as only an astronomer was able to tell time in those days. Our present devices are so accurate as to show "errors" in the "clock in the sky". The vibrations of crystals are a far cry from the temporal hours that had to suffice in early Egypt when men were content with "hours" that simply averaged out.

Our use of the coordinates is especially suitable for the demonstration of the longer periods of time recorded by calendars. The word calendar is from the Roman designation of the first day of the month, the "calends". To arrange to do something or keep an appointment on the Greek calends was another way of saying that the deed would remain undone or the appointment would not be kept for the Greeks had no equivalent of this division of time.

Variations in weather conditions are unreliable indicators of seasons. Farmers and business men plan ahead with little regard for present weather conditions; therefore, we have calendars that are known as almanacs. Churches celebrate ecclesiastical dates that vary with astronomical phenomena and therefore we have special calendars for their uses. Much of the development of the science of astronomy is due to the pseudo-science of astrology as practiced by astrologers who were more closely related to religious matters and occult matters than the practical science of today.

In my other profession (medicine), we define an expert as a person who makes a problem look simple and a specialist as a person who can make a matter look difficult. In the planetarium, ours is the privilege of making a matter that is quite complicated look quite simple. Ours is the privilege of opening eyes to the beauty, to the law and to the order ordained in a universe that demonstrates an order which has been called the first law of nature-law. With the aid of this instrument, the planetarium, and the various devices that we can invent, we can enlist the enthusiasm of the child and arouse the curiosity of the adult. We extend an invitation to the individual to broaden his horizons and thus we contribute to the enrichment of human lives. Working in the darkness as we do, we who have chosen to become the voices through which the stars speak would logically be those who would be anxious to exchange our knowledge and skill without reservation.

ASTRONOMICAL SUBJECTS AND APPLIED SCIENCE: DISCUSSION

James Fowler: I would like to bring up something which is quite apart and yet I think belongs here in a discussion of astronomical subjects.

We talk in terms of using the planetarium for entertainment and education. An article in a recent issue of *Scientific American* pointed up another use — that of a tool for research.

Perhaps many of you saw the article written by a German scientist describing experiments with birds where it was discovered that they apparently make use of celestial navigation. In order to test this experimentally, the birds were brought into the artificial environment of a planetarium where the sky conditions could be controlled and the positions of the stars varied in relation to the birds to determine what effect this would have on their orientation.

I thought this was truly a unique experiment, and I was amazed to realize that birds used celestial navigation to the extent that they apparently do. I was even more impressed, however, by the way in which the planetarium could be used as a research tool. I believe it was Dr. Chamberlain who told me that similar work had been done at the Hayden Planetarium.

Joseph Chamberlain: That's right. As a matter of fact, the same experiments with birds have been worked on by members of the Animal Behavior Department of the American Museum although I don't believe it was as extensive as that done by the German workers.

Mr. Fowler: Well, I recommend this article, "Celestial Navigation by Birds" by E. G. F. Sauer (*Scientific American*, Vol. 199, No. 2, August, 1958, pp. 42-47) very highly not only because I think it will show you how the planetarium might be used for research but also because the concept that birds navigate by the stars is so fascinating to contemplate.

Armand Spitz: Another piece of research has been carried on from time to time over a period of years. You've all had experience with it in your individual planetaria but I would be willing to gamble that few of you have thought of it as a research project.

During the very early days of the last war it became obvious that a lot of the pilots were not observing their instruments with sufficient accuracy and speed. It was found that this was because the ultraviolet light shining on phosphors on the instrument panel caused a fluorescence in the lens of the eye. Practically all night fighters had the cockpit so illuminated. The Navy asked the Franklin Institute in Philadelphia to undertake a study project in the planetarium. We set up two Link Trainer cockpits, one with the conventional ultraviolet light on the instruments, the other with subdued daylight, and we ran through there something like 8,000 subjects over a period of time with about fifty experiments on each one. We had different levels of illumination. We studied the rate of dark adaptation. We studied the intensity of the stimulus which was required to be observed — the rapidity of observation and the amount of light required to evoke a response. As a result, I think you will find that virtually every airplane today, commercial and military, is using red light in the cockpit rather than ultraviolet. This phenomenon of the length of time required to become dark adapted is something with which all of us in planetaria are well acquainted. It is inherent in all planetaria.

FITTING THE DEMONSTRATION TO THE AUDIENCE: INTRODUCTORY REMARKS

JOSEPH M. CHAMBERLAIN
Director, American Museum Hayden Planetarium, New York City; Chairman of Session on Fitting the Demonstration to the Audience

This afternoon we are devoting our papers and our remarks to the uses that can be made of a planetarium aside from those which are best known to most people. That is, we are not here concerned with the usual popular lecture. We are concerned with the many other things that can be done in a planetarium — things which in the past few years have been done much more than they were, certainly, in the early days of the Spitz installations, and I think this applies equally to the early days of the older Zeiss installations. Before we get into the program though, I have three brief announcements. The first is a bit of public relations and the other two are advertisements.

My public relations announcement concerns the fact that back in 1951 the institution which I represent changed its name. We have been trying ever since to get people to use our new name and two or three have agreed to do so. We are now the American Museum Hayden Planetarium for two reasons: (1) to show our affiliation with the American Museum of Natural History and (2) because there is another Hayden Planetarium in Boston.

My second announcement is an advertisement for something that is free. The Committee on Education in Astronomy of the American Astronomical Society has prepared a pamphlet entitled *A Career in Astronomy*. This is a modification of a pamphlet written some years before by Professors Otto Struve and Gibson Reaves, whose names certainly all of you know. They did a very nice job I think. The pamphlet is available without charge, and I think you all should have some.

The third item which I have to announce will cost you something. As many of you know, the American Museum of Natural History is now publishing a new magazine called *Curator*. I would simply like to say to those of you who are interested in the planetarium field and in the museum field generally, that if you have not already subscribed, your subscription will be welcome. I have here a very nice article from George Bunton of the California Academy of Sciences. He has described the problems confronting a planetarium executive in deciding what type of program to put on. He's reacting to the various criticisms which we all get — "You're too astute," "You're too space fictionish," etc. — and he is charting a sort of middle course. I like the article and I shall turn it over to Dr. Colbert who is editor and I think it will appear. Your articles, I am sure will be welcome. So think of *Curator* when you get a chance.

(Following these remarks, Mr. Chamberlain introduced the speakers who participated in the session on Fitting the Demonstration to the Audience.)

Version note to pdf document appearing on the International Planetarium Society's website:

The book contains 205 pages. The pdf version on the IPS website included only through page 48.

The remaining pages were added to the online pdf on 9/14/2017 by Sharon Shanks, who scanned the missing pages and updated the IPS pdf file.

TEACHING AIDS USED TO CORRELATE CLASSWORK IN THE ELEMENTARY GRADES WITH THE PLANETARIUM

MARGARET K. NOBLE
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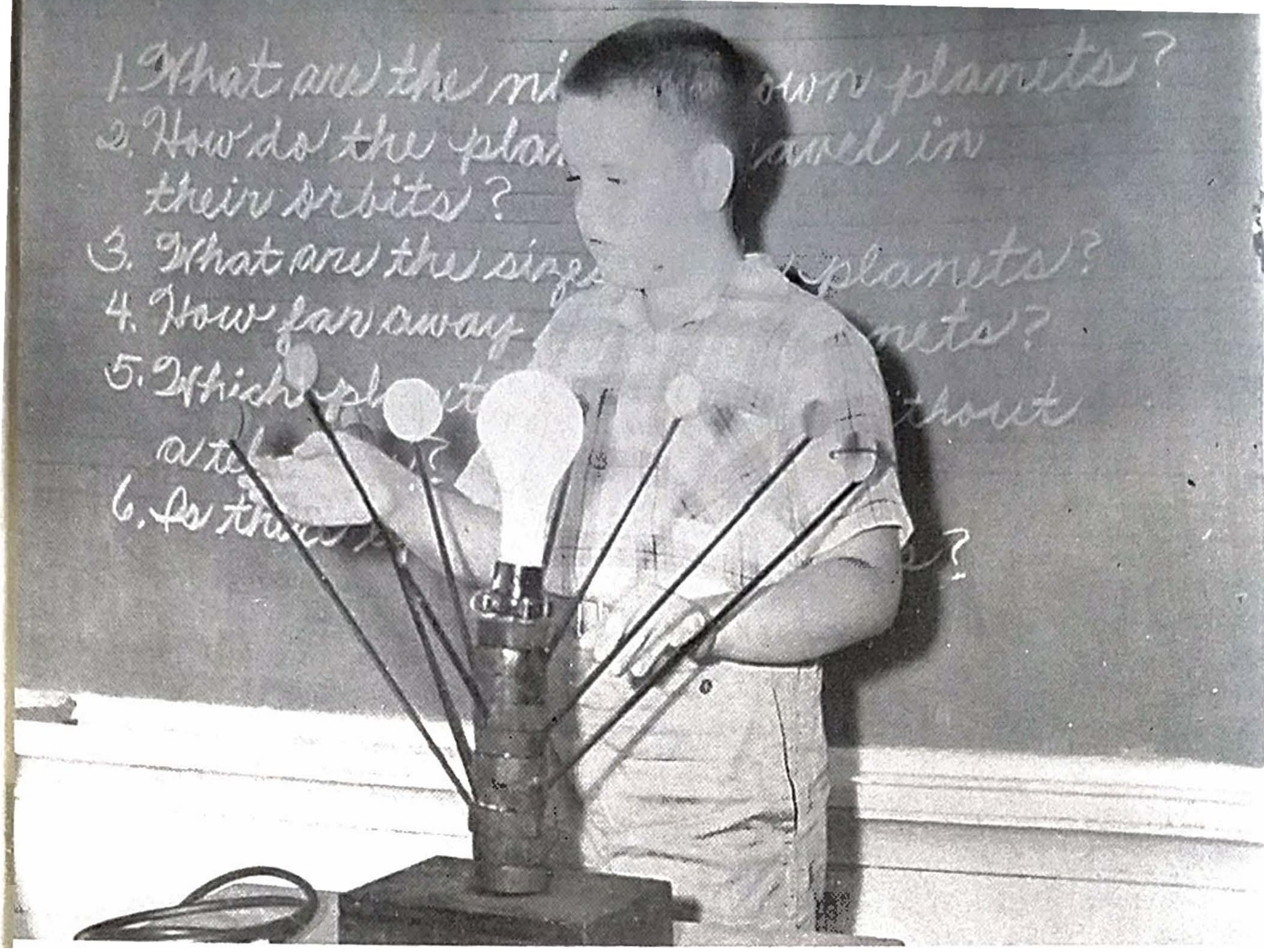
From the kindergarten to the sixth grade, the study of the universe may be supplemented by simple visual aids which give children concrete experience in observing, measuring, charting and recording; this experience makes classwork and field trips to the planetarium more interesting and meaningful to children.

Elementary school science is now being recognized as a basic subject and not just a hobby. Laetitia Bolton's article in *Science*, April 25, 1958, gives us a clue for presenting science in the elementary grades. Miss Bolton writes, "We must start by making science intelligible and interesting to children while they are still young enough to incorporate it into their scheme of values as well as their core of knowledge." Dr. Gerritt Van Zyl, of Holland, Michigan, said in an article titled,* "Need—Scientist? Look in the Elementary Schools," that he saw the elementary school as a beginning ground for scientists. We all agree that in order to teach elementary school children we need to make the subject interesting and real to them by using many visual aids and by undertaking related field trips. In the area of astronomy children can learn to observe, measure, chart and record. Simple teaching aids help to clarify the textbook explanation. These teaching aids give the young child certain real experiences necessary to understand more fully the planetarium demonstration or the trip to the observatory. In Washington we have a small Spitz School Planetarium and we also take groups to the Fort Belvoir Planetarium. Since the group goes only once to the planetarium, as much background work as possible should be done ahead of the trip.

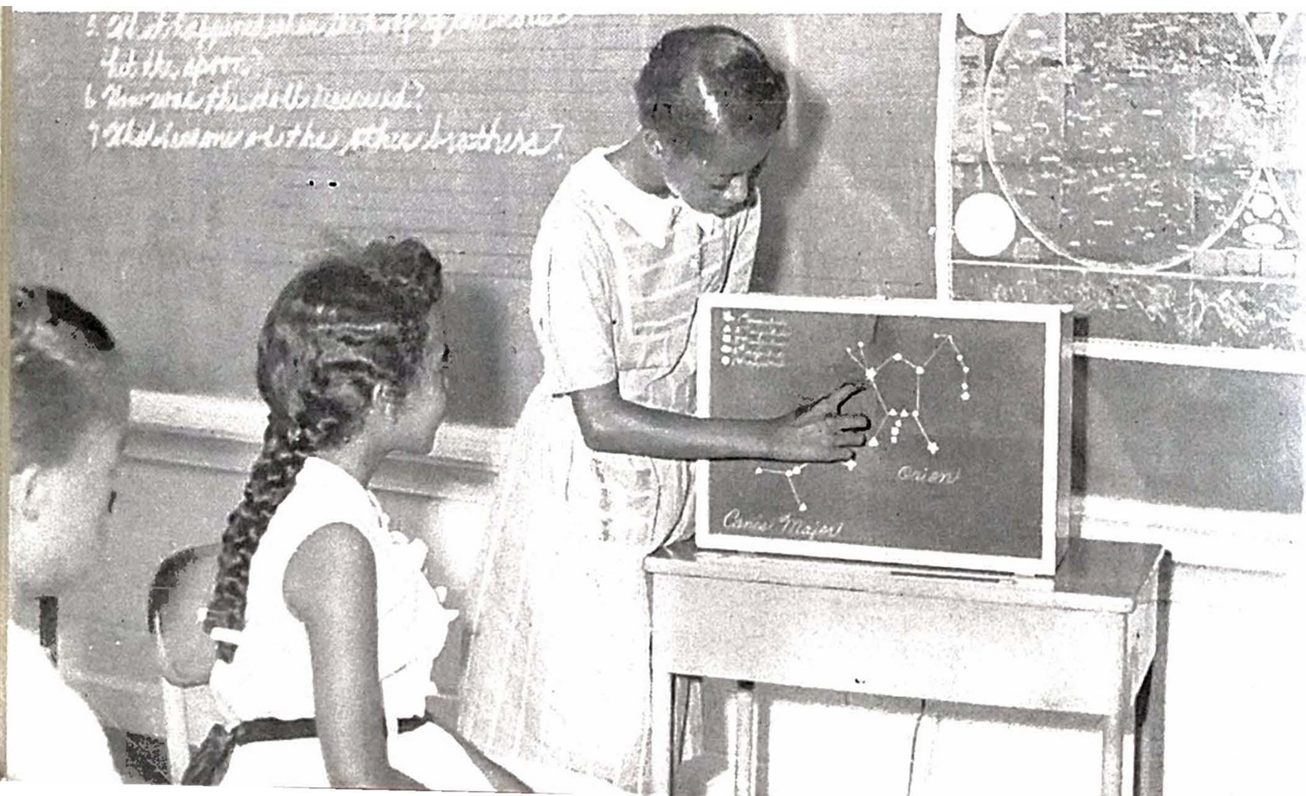
The planetarium demonstration may be, "Skies Over Washington, D. C.," "Animals in the Sky," "A Trip to the Moon," or "Christmas Star." No matter what the topic, it will help children to know in advance about the earth's motion as well as about planets, constellations,

* *The School Executive*, August 1956, p. 51-53.

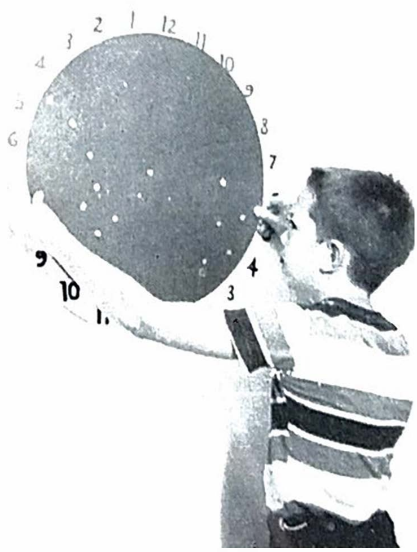


Donald is explaining about retrograde motion. He says, "The planet looks like it is backing up." He will see this demonstrated in the planetarium demonstration.

A star box helps this class to know some constellations before they go to the planetarium. The punched cards also show the magnitude of the stars.



A boy, a ball, a hoop and a light give answers to questions about phases of Venus and phases of the moon. A child can discover these phenomena for himself through the use of this simple teaching aid.



Polar constellations are good for telling time. The planetarium demonstration emphasizes the "apparent motion" of these stars. This revolving disc helps to explain the changing position during the year.

stars and measuring. The study of the universe is included in our curriculum from kindergarten through grade six. As you will see, some of the aids listed on the following pages can be used on several grade levels. These aids are not new ideas but ideas that will help children understand the "why" problems. Fletcher Watson wrote directions for making a tin can planetarium in an article which appeared in *Science Teacher*, 1950, and added a comment that summarizes our point. "Frankly," says Watson, "I consider material of this sort (teaching aids) would do more for the teaching of astronomy — to make it real and sensible — than will the preparation of many more books on the subject."

Directions or ideas for making teaching aids may be found in the following reference books:

Earth motion:

1. Light bulb planetarium
   Making and Using Classroom Science Materials in the Elementary School
   Glenn O. Blough and Marjorie H. Campbell

   Dryden Press, Inc.
   New York 19, N. Y. 1954

   "Making a planetarium" .... pages 90-92

2. Umbrella planetarium
   Discover the Stars
   Gaylord Johnson and Irving Adler

   Sentinel Books Publishers, Inc.
   New York City 1957

   "Our Sky Bowl Turns Into a Twirling Umbrella" .... pages 9-13

3. The Planets — Planetarium
   Stars
   Herbert S. Zim and Robert H. Baker

   A Golden Nature Guide
   Simon and Schuster
   New York 20, N. Y. 1951

   Copernican planetarium illustration on page 12.
   (Children simplified the idea and made one with wire coat hangers and papier-mache planets)

Planets, constellations and stars:

1. Hoop and Ball - to show phases of Venus
   Discover the Stars
   Gaylord Johnson and Irving Adler

   Sentinel Books Publishers, Inc.
   New York City 1957

   "How to Demonstrate Phases of Venus" ... pages 61-63
   (Children preferred to use the Hula Hoop in place of the barrel hoop!)

2. Star Box - Learning the Constellations
   Making and Using Classroom Science Materials in the Elementary School
   Glenn O. Blough and Marjorie H. Campbell

   The Dryden Press, Inc.
   New York 19, N. Y. 1954

   "Constellations" ... pages 94-96

3. "Old-Lens" Telescope
   Mechanix Illustrated Magazine

   Fawcett Publications, Inc.
   Editorial Offices
   67 West 44th Street, New York 36, N. Y.

   Write to editor for directions for making a telescope using old eyeglass lens.

Measuring - Beginning Space Arithmetic:

1. Starscope
   Adventure Book of Stars
   Thomas D. Nicholson

   Capitol Publishing Company, Inc.
   New York, N. Y. 1958

   "Tools to help you learn the sky" ... pages 42-43

2. Latitude Finder (Theodolite)
   Story of I.G.Y. (Pamphlet)

   Educational Relations Division
   Esso Standard Oil Co.
   15 West 51st Street, New York 19, N.Y. 1957

   "Now Try These... Experiments and Activities"... page 31
   (Simple and easy to make theodolite)

3. Cardboard Sun Camera used as a measuring instrument
   Fun With Astronomy
   Mae and Ira Freeman

   Random House
   New York City 1953

   "How to Make a Sun Camera"... page 38
   "Finding the Size of the Sun"... page 40

4. Dipper Star Clock
   Golden Book of Astronomy
   Rose Wyler and Gerald Ames

   Simon and Schuster
   New York, 20, N. Y. 1955

   "Sky at Night... Dipper Star Clock"... page 17
   (This idea was adapted to lower school level in the form of a cardboard clock with a center disc which children could rotate to the correct position for that season)

5. Sun Dial
   Fun With Astronomy
   Mae and Ira Freeman

   Random House
   New York City 1953

   "Telling Time"... pages 10-11

THE USE OF THE PLANETARIUM IN SECONDARY SCHOOLS

JOHN C. ROSEMERGY
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The high school planetarium is a dramatic stimulus to learning in the areas of general and physical sciences; it is an effective teaching aid and it substantially enriches the program of gifted science students; class visits to the planetarium are most profitable if the planetarium lecturer and class teacher cooperate in preparing the class for the visit and adjusting the lecture to the needs of the class.

Ann Arbor High School is one of the first secondary schools to have a well-equipped planetarium. The funds for equipping our Argus Planetarium came largely from a $10,000 gift received from Argus Cameras, Inc. The equipment includes a Spitz Model A projector, a 24-foot fabric dome, 63 theater-type seats, a stereophonic sound system, a 35 mm. slide projector, and a Spitz orrery.

The planetarium chamber was designed for this specific purpose. It is located on the second floor of the three-floor academic unit of our school plant. It is situated conveniently near building entrances. It occupies the floor space of a small classroom, but it is two floors in height. The planetarium chamber is, essentially, a windowless cubicle.

It is, of course, far more satisfactory to have a room designed for this purpose than to try to equip an existing room as a planetarium. With an increasing emphasis on secondary school science programs in this post-Sputnik period, it is probable that high school planetaria will become less unusual. I hope that suitable rooms will be provided in the planning of high school plants when there exists the possibility of establishing a planetarium. The room could be used for other purposes if it were not possible to equip it immediately as a planetarium.

Our planetarium, from an organizational standpoint, is a facility of the science department of the Ann Arbor High School.

The presence of a planetarium within a high school building provides immensely exciting educational possibilities. At Ann Arbor High School we have found that two years has not been sufficient time to explore all of these possibilities.

Astronomy, with varying degrees of emphasis, has had a place in the secondary school curriculum since ancient times. This is evidence of the natural curiosity with which man has always looked searchingly out into the vastness of the universe. In the twentieth century it has been unusual, however, to offer high school courses in astronomy; rather, instruction in astronomy has usually been given as one of several units of the junior and senior high school courses in general and physical science. The opportunity to make unlimited use of a planetarium in a high school immediately suggests the desirability of offering a course in astronomy. An astronomy course is now given at Ann Arbor High School because of the presence of the planetarium. The school has owned for many years a 4-inch refracting telescope, and this is also used in the astronomy course.

The astronomy course is descriptive and non-mathematical in nature; it is open to tenth, eleventh, and twelfth-grade students. It is a one-semester course which meets for one class period on alternate days. The student earns one-fourth unit of credit in the course as contrasted to one-half unit in the academic courses which meet daily. A student may not substitute the astronomy course for any of the required courses; rather, the astronomy course is one of several "minor credit" courses with which the student may enrich his program. The astronomy course is still in the process of development, and course content and instructional methods are not as yet well established. Numerous problems attend the introduction of any new course into the curriculum, but we feel that an astronomy course is a significant educational use for a planetarium in a secondary school.

We have been able to strengthen the units of study in astronomy which have long been a part of our junior and senior high school courses in general science and in physical science. The planetarium not only facilitates more effective instruction in several aspects of these units, but it is an unusually effective device for stimulating the interest of the student and motivating him to learn.

As would be expected, our planetarium can be utilized more effectively with classes from our own high school than with those from our junior high schools. It is obviously a great asset in our junior high school science program to have free access to a planetarium one mile away. On the other hand, it is necessary for the science teachers to arrange for the transportation of their junior high school students to the planetarium, and to attend to the other details involved in successfully conducting a field trip. Within our own building these problems do not exist. It is wonderful, for instance, to be able to take one of our physical science classes to the planetarium for two or three successive class meetings, and to be able to return to the planetarium to clear up some point which the class has failed to understand properly.

Enriched instruction has been possible in several other high school courses because of the planetarium. Specifically, it has been used in our courses in meteorology, air age, world geography, and, in an incidental way, in solid geometry. In our meteorology class solar relationships are considered in a planetarium lecture. The world geography classes also consider solar relationships in the planetarium, as well as the concept of great circle routes. In the air age the planetarium has been helpful in considering a few fundamentals of navigation. On one occasion a solid geometry student with a special interest in the planetarium gave an ingenious planetarium lecture on the subject of map projections.

During the past two Christmas seasons a Christmas planetarium program was presented for all of our twelfth-grade students. This was done for purposes of general education, and not to facilitate instruction in a particular course.

An important educational use of the planetarium has been to enrich the programs of some of our gifted science students. Several students have given planetarium demonstrations and lectures, and undoubtedly they have been stimulated to learn more astronomy than they otherwise would have. The young man already referred to in connection with the lecture on map projections did particularly outstanding work with the planetarium. He prepared and presented our first Christmas program. In connection with this program he built several devices including a very effective super nova projector in which the light comes through the fabric dome from the outside. This young man submitted his Christmas lecture as a project in the annual Science Talent Search which is sponsored by the Westinghouse Corporation. He received an honorable mention; this is a high achievement in that only 260 honorable mention winners were selected from among the thousands of contestants who were some of America's top high school science students.

The effectiveness of the use of the planetarium in our situation is enhanced by the ample opportunity for cooperative planning by the planetarium lecturer and the teacher whose class is to hear a lecture. This opportunity for planning should be noted, I believe, as an important strength of a secondary school planetarium operation.

I have mentioned only uses of the Argus Planetarium in our secondary school teaching program. My reason for emphasizing these uses, of course, is that the uniqueness of our planetarium is in its being a facility of one particular high school. However, it would be incorrect for me to leave the impression that the planetarium is used only in the ways which I have mentioned. Also, if its use were this limited, those of us responsible for its utilization would be guilty of failing to use sufficiently richly an important educational resource.

The administrators of the Ann Arbor High School and of Argus Cameras, Inc., envisioned from the outset of their planning that the planetarium should be used widely by school and community groups in and around Ann Arbor. Accordingly, about 250 lectures have been presented for groups other than secondary students of the Ann Arbor Public Schools. Many of these groups have been elementary school classes from our own system, and elementary and secondary students from surrounding school systems. A few of these groups have come from schools as far as 100 miles from Ann Arbor. Others who have used the planetarium have included groups from the Boy Scouts, Girl Scouts, church organizations, organizations of educators, community service organizations, the U.S. Coast Guard Reserve, and others. On several occasions the planetarium has been used by classes from the nearby University of Michigan and Eastern Michigan College. There have been several occasions when planetarium programs were presented for any who wished to attend, but a service which we have not as yet rendered is the establishment of a regular schedule of public lectures. Nearly all lectures are given to organized groups by appointment. A small fee is charged for groups other than Ann Arbor Public School classes.

Some of the problems of our planetarium operations are probably sufficiently peculiar to a secondary school situation to deserve mention. One of these problems is the amount of staff time which can be devoted to planetarium activities. In my own case, one hour of my day is alloted to planetarium work and the remainder to classroom teaching and other activities of our science department. It seems probable that in a secondary school situation the person assigned the planetarium responsibilities will need to spend the larger portion of his day in other activities. If these activities involve classroom teaching, considerable inflexibility will be introduced into the planetarium schedule. The teacher with the planetarium responsibilities will probably find that at a time when he is scheduled to teach one of his own classes a teacher of another subject will wish to have his class hear a planetarium lecture. This problem is not insurmountable. In our own situation we have found that, in nearly all cases, it has been possible to make arrangements so that all appropriate classes from our own building could be accommodated.

Another problem in the operation of our secondary school planetarium stems from the fact that there is little for people to do while waiting to hear a lecture. It is necessary that groups coming to the planetarium during the school day arrive on schedule. There are no museum exhibits to be viewed by a group which has arrived early, and sixty youngsters can not be permitted to roam through a school house in which classes are in session. This same problem exists, to a certain extent, for a public lecture at a non-school time. If people are unable to obtain a seat for a lecture at a planetarium associated with a museum they may still have a pleasant and profitable tour of the exhibits; at our planetarium they would probably go home disappointed. Again, this problem is not insurmountable, but I wish to indicate that it appears to be a problem to be anticipated in the establishment of a secondary school planetarium.

I suspect that if any unusual techniques for fitting the lecture to a secondary school group have been developed through our experience, they are only applicable to groups which come from the school housing the planetarium. I have suggested, somewhat indirectly, some techniques which are particularly applicable within a secondary school program as contrasted to planetaria associated with other kinds of institutions. I have spoken of the opportunity for the demonstrator to confer adequately in advance of the lecture with his fellow faculty member who will be bringing a group to the planetarium. I have indicated that a student may prepare a planetarium lecture uniquely suited to the needs of his class. I have mentioned lectures directed specifically towards the interests and problems of classes in specific subjects.

It has been my experience that, very frequently, the content of the lecture is not the factor to be altered in fitting the demonstration to a secondary school audience. That is, the content of a lecture may be basically the same for school groups from the seventh through the twelfth grades. This lecture may be fitted to the different audiences by varying the introductory remarks and the choice of words according to the age level and general sophistication of the group.

An important technique in achieving a proper fit of the demonstration to the secondary school audience involves, in a sense, the fitting of the audience to the lecture rather than the lecture to the audience. That is, the secondary school group must be adequately prepared to profit from the planetarium visit. It is likely to be a disappointing occasion if busses bring to the planetarium sixty spirited seventh-graders, all of whom are carrying picnic lunches, none of whom have any concern at the moment for things astronomical, most of whom think they are going somewhere to look through a telescope, and a few of whom understand that the class is to have a picnic at the botanic gardens. The planetarium visit will be most profitable if the class understands clearly the purpose of the visit. Most commonly this purpose will involve the introduction, or the bringing to a climax, of a unit of work in astronomy.

It is important that the teacher understand clearly what the planetarium is, how it can help in achieving the objectives of his course, and what arrangements need to be made to make the planetarium trip a smooth one. We have arranged several demonstrations for groups of teachers so that they might learn how to utilize the planetarium in their work.

In connection with the importance of the teacher's understanding of the nature and function of the planetarium — I suppose that all planetarium lecturers have been amused and astounded by the widespread lack of understanding of these things. A teacher once phoned me and asked, "Are you in charge of that room they've got out there for looking at the stars?" A college senior who was training to be a science teacher asked, "Do you leave the planetarium turned on at night to gather information?" After one demonstration a lady from the audience (not a teacher) said to me, "You mean, then, that you can adjust this machine and tell what the weather is going to be." The Spitz projectors, of course, are acquainting millions of people with a planetarium and with the grandeur of the universe.

After two complete school years of experience with our planetarium we remain, at Ann Arbor High School, excited by the educational potential of this facility. Although, as I have indicated, we have found some problems in connection with the utilization of a high school planetarium, it seems evident that the effectiveness of this educational resource will be limited largely only by the imagination, time, and financial resources of those who work with it. The importance of a planetarium in a secondary school program, however, must be kept in proper perspective. At Ann Arbor High School we neither expect nor hope to graduate swarms of potential astronomers. We will be delighted, of course, if from time to time the Argus Planetarium helps to direct a graduate into a satisfying and productive career in professional astronomy. The dedicatory plaque at the entrance to our planetarium contains an expression of what we believe is the purpose of a secondary school planetarium:

> Presented to the Ann Arbor High School and the citizens of Ann Arbor by Argus Cameras, Inc., to promote an understanding, appreciation and enjoyment of the design and beauty of the universe, to inspire our youth in their search for truth, and to add scientific emphasis to an outstanding educational program.

Sputnik made the American secondary school, and particularly its science programs, the subjects of a suddenly magnified and panicky public concern. High school planetaria, in those institutions which can establish them, are a resounding answer to some of the questions directed to our schools because of Sputnik.

THE USE OF THE PLANETARIUM FOR COLLEGE AND UNIVERSITY CLASSES

FREEMAN MILLER
Professor of Astronomy, University of Michigan Observatory, Ann Arbor, Michigan

In the typical introductory astronomy course, the planetarium is a useful teaching aid, but it should not be allowed to usurp time that could more profitably be devoted to lectures; it should be used as an avenue to discovery; the average undergraduate more truly learns if he discovers certain phenomena himself through planetarium observation than if he is simply shown these phenomena in planetarium demonstrations.

Other participants in this program will discuss the application of planetarium techniques to several topics appropriate to college classes, such as navigation, calendars, and time; I shall avoid reference to these matters. In courses beyond the introductory level a planetarium should be of assistance in unravelling confusing aspects of spherical astronomy involved in the determination of time, stellar coordinates, and geographic position, but this is so obvious as to require no discussion. Graduate students should certainly become familiar with the planetarium in preparation for their own careers as teachers of astronomy— the majority will acquire this knowledge as graduate assistants in undergraduate courses.

In the broad area of formal college instruction I am thus led to confine my comments to the typical introductory course for undergraduates, a negligible proportion of whom will become astronomers, and few of whom expect to follow science as a profession.

Each instructor will naturally compare the capabilities of his planetarium with an outline of the topics which he wishes to discuss in his course. At the University of Michigan we have a two-semester introductory course, with about eighty-five lectures and twenty-four two-hour laboratory periods. In the first semester of this course a great deal of time is devoted to the apparent motions of the celestial sphere and members of the solar system, and to the heliocentric interpretation of these motions. Here the planetarium has great potentialities. We have also a one-semester non-laboratory Introductory course of about fifty-five lectures. Three of us give one section apiece of this course, and each of us has selected independently those aspects of astronomy he thinks such a course should include. I prefer to devote most of the lectures to the physical and astrophysical phases of modern astronomy, and the planetarium, as a classroom device, is allotted only one or two periods.

I think that one needs to use some care in the college course, to keep the planetarium in its place. It is such a fascinating device that it would be easy to let it run away with a substantial fraction of the lecture time. I have had in the past similar experiences with other teaching aids, and especially with motion pictures. During one period I sought eagerly for suitable films, but later found that I was eliminating one after another, because they absorbed time which I wished to devote to conventional lectures.

Whatever the instructor's plan for his introductory course, one topic is certain to be accorded major emphasis: the sequence of observation and interpretation which led through Ptolemy, Copernicus and Kepler to Newton and his Law of Gravitation. I believe that the most important contribution the planetarium can make is a vivid presentation of the naked-eye observations upon which the development of the Ptolemaic and Copernican theories rested. (The later contributions of Kepler depended on observations too subtle for planetarium demonstration.) By illustrating these observations with great clarity a foundation is laid which makes it relatively easy for the student to appreciate the evolution of the early geocentric theories. The further step to an understanding of the manner in which the observations are interpreted by the Copernican theory is far more difficult. Perhaps astronomers, accustomed to the full historical development through Newton's Laws of Motion and Gravitation, sometimes fail to appreciate how difficult it is for the beginner to understand the logic of the Copernican system. Prof. Herbert Dingle, in a 1952 presidential address to the Royal Astronomical Society puts the situation very well:

> Copernicus succeeded in persuading the astronomers who followed him that the results obtained could be expressed more simply if it was supposed that the Earth itself was moving.... It is doubtful if a greater hoax has ever been perpetrated in the history of human thought, for whatever advantages the Copernican view might possess, the one which it most glaringly lacks is that of simplicity.

Fortunately, it is improbable that any one will invent a truly heliocentric planetarium at a reasonable cost in money and space; the student must and should rely on his own intellectual agility in making the transition from an apparently geocentric to a physically heliocentric solar system. Any device which provides a graphic view of the basic naked-eye observations cannot but assist the instructor in presenting this difficult but all-important topic.

Other phenomena of the celestial sphere which the planetarium is adapted to demonstrate may or may not appeal to an instructor. In the one-semester course mentioned above, I have been getting along very happily for quite a few years with no reference whatever to the several systems of celestial coordinates. If I were giving a two-semester course I should still restrict severely the time allotted to coordinate systems, time and related subjects. But this is a matter of taste; the instructor who enjoys presenting such topics will naturally find the planetarium a great timesaver, and it should serve to enliven immeasurably what I consider a rather pedestrian side of astronomy.

Special planetarium attachments to illustrate the visual appearance of such phenomena as the Milky Way, eclipses, proper motions and variable stars are worth hundreds of words in the lecture room. Suitable devices can clear up in a matter of minutes the tendency to confuse comets and meteors. I once saw demonstrated a very good planetarium device which depicted both the motion and changing appearance of a comet. I do not know that meteor-shower projectors are available, but I remember that about twenty-five years ago, Dr. Peter Millman built a very fine one into an ordinary stereoptican lantern.

Special-effects projectors are characteristic of the more elaborate and expensive planetaria, but I should like to mention the value of elementary and less costly instruments. At Michigan we have had for ten years a simple pierced-globe instrument in a dome of our own manufacture which seats about twenty-five students. This planetarium — the "Star Recognition Trainer" — was developed as an aid to navigational instruction during World War II and is now no longer manufactured. It has the usual latitude adjustment, an occulting horizon and two light-pointers. With the addition of a twilight device, a variable-voltage control for the brightness of the projection bulb, and four large holes (closed by corks when not in use) to represent the sun at the equinoxes and solstices, we have got along very well. It is only in the last year that we have decided to acquire a planetarium of the type mounted at Cranbrook. There is something to be said in favor of an inexpensive instrument such as the one I have described; one can give many students free access to it without worrying about possible damage. If classes are small, one can perhaps schedule sufficient instruction in the operation of an expensive planetarium to make individual use a possibility, but with hundreds of students at a time passing through our introductory courses, this is impossible. The advantages for the student of unrestricted access to our inexpensive instrument is such that we shall keep it mounted in its present dome after our new, more elaborate instrument is installed.

Finally, I wish to mention one point upon which I have very strong feelings. I believe that every effort should be made to plan the introductory course in such fashion that a maximum number of the planetarium sessions are *discovery periods* for the student. If the student discovers for himself the character of the diurnal circles centered at the celestial poles, the relation between latitude and altitude of the celestial pole, and the annual journey of the sun along the ecliptic, he will have more truly "learned" about these phenomena than if they were described in advance, and the planetarium used only for demonstration. Depending on the number of auxiliary devices available, this principle can be extended to call for the making of simple but important observations; if planet projectors are part of the instrument, the student can estimate the greatest elongations of Mercury and Venus, and thence reckon their heliocentric distances in astronomical units. Such "planetarium observations" are not a complete substitute for first-hand observation of the sky, but many of us must conduct our classes under skies often obscured by clouds or city lights and dust. In brief, I suggest that, for the introductory college class, the planetarium should, to the greatest extent possible, be an avenue to discovery rather than a piece of demonstration equipment.

THE PLANETARIUM AND ADULT EDUCATION

CLAUDIA ROBINSON
Director, Dallas Planetarium, Dallas Health and Science Museum, Dallas, Texas

Specialized, correlated programs should be prepared for the astronomically retarded adults who are trying to catch up with the space age; adopting an academic approach, making full use of the planetarium's dramatic resources, these programs should present instruction in depth for the "uncommon adult."

Since the last war, the one that ended in '45, the American adult has indulged himself in a scientific inferiority complex. Having grown up in total ignorance of astronomy, he regarded his children's space talk as twentieth century pig-latin for astrology, and turned to the sports page. Then one morning less than twelve months ago he awoke and found he was living on the moon. Having survived in a state of shock until now, this twentieth century adult is beginning to take stock of his surroundings, and a few are attempting to adjust to the new situation. How can we help? Our survival in a free world depends upon the speed with which these concerned few make an adequate adjustment. Fortunately we have the planetarium instrument, a medium of rare dramatic potential capable of quickly transforming scientific facts into visual imagery. How can we use this medium to educate and entertain the curious mind?

Some institutions are attempting to do this by capitalizing on the vogue for "togetherness" in which America is now engulfed. In Dallas this fall the Adult Education School of Southern Methodist University is offering a course on Saturday mornings for fathers and sons titled "Exploring the Sciences." Enrollment is limited to boys over ten accompanied by the appropriate parent. Astronomy is given the nod in the session, "Space and the Stars," to be conducted at the planetarium. In a recent *Sky and Telescope* I noted that Flint, Michigan is approaching the idea in a similar fashion by establishing a course known as "Family Astronomy." The notable feature of this plan, it seems to me, is that in the North women and girls are considered educable! In all such courses the aim will be to increase the parent's knowledge without retarding the child's initiative, and I trust this can be accomplished with benefit to all concerned.

Before attempting to analyze program material designed exclusively for growing adults I should like to digress long enough to wonder aloud why time was not allotted on this symposium for a discussion of the public show where the casual visitor, both adult and child, makes up the audience. Surely this has been the most difficult show to prepare. When the audience's age and background are known factors it is relatively simple to meet their requirements, whether it be a group of Naval Reserve Officers, the Cub Scouts, the Ladies' Garden Club, graduate theology students, or the Astronomical Society. After a time even the profile of the regular week end visitor to the planetarium can be quite accurately drawn. But there are even more heterogeneous audiences which often need to be accommodated. Since Dallas is annually host city to the State Fair of Texas, there are sixteen days during the fall when our planetarium runs stiff competition to the Fat Stock shows, the 4H auctions, the girly shows, the give-a-ways, the freaks and the Midway. It is then that the visitor to the Fair grounds really pays his money and takes his chance of being entertained for forty minutes. If he likes our show he may come back next year, but there is a possibility that this will be his only brush with astronomy, and pardner, you'd better pay off! During our five years of operation I believe we have paid off. The planetarium is consistently rated among the top ten attractions of the Fair. And yet the Fair visitor no longer thinks he is going to see a movie when he goes to the planetarium, nor does he expect that crazy machine to take him on a Midway-type ride to the moon. But in accordance with the public's growing knowledge and taste in such matters, each year he expects, and I hope gets, a more visually exciting and more sophisticated production on the subject of astronomy.

Experience in preparing shows for this type of audience has led me to believe that we could now be of real service to another segment of our population if we offered some specialized, correlated programs in the planetarium aimed at educating the astronomically retarded adult. So far the adult has not been encouraged to learn astronomy in the planetarium. Planetarium shows are for kids, as any public relations man will tell you. But this situation may be changing. The *New Yorker* magazine, which keeps its finger to the wind in such matters, recently shifted the Hayden Planetarium from "Entertainment for Children," to the austere company of the United Nations under the heading "Other Events."

In order that we, too, might do some re-evaluating, I should like to suggest two broad classifications for planetarium programs in the future: those for children and those for adults. These two categories might be in turn broken down into programs for young students, for specialized audiences, for mixed audiences, and for older students. (Before being accused of too much specialization, I should like to state that I earnestly believe that a truly effective planetarium show, with only minor vocabulary changes, can be an absorbing experience for any age group. But we are not here to talk about what we can do, but what we can attempt to do.) If a distinction can be made between planetarium programs for the two chronological groups it might be useful to make it at the point where astronomy relates itself to the aesthetic, unscientific world. To the young child astronomy is already a world of fantasy. The problem is to keep his mind nourished with sufficient accurate information so that in the wonder of the planetarium his fertile imagination can operate independently. In this regard it may be that planetarium shows which painstakingly create a realistic trip to Mars or the Moon are not fully meeting this challenge. For however much a child may enjoy a synthetic experience, it nevertheless denies him the opportunity to be personally creative. The average adult, on the contrary, whose imagination is atrophied and whose mind is clouded with worries and pains needs to have his imagination stimulated before it can begin to operate at all. In program planning this would indicate that the child's program needs to be directed from the specific, astronomical idea toward the related areas. The adult program needs to be directed from the related areas (philosophy, the arts, history, literature, etc.,) toward the scientific. Of course, one of the advantages of a series of adult programs is the more academic approach available to the lecturer. Such a series for beginning adults on the general topic, "Man's Relationship to the Universe," might include some of the following demonstrations: (1) a guide to the changing constellations, accompanied by an outdoor session to help make the adjustment to the larger sky; (2) the nature of the solar system, and the visual relationship of the planets and the stars; (3) the telescope's impact upon astronomical learning; (4) the mythology and theology of the heavens; (5) the development of man's concepts of time and space; (6) the nature of light and energy. In general, the range of subject matter suitable for adult programs is limited only by the taste and experience of the lecturer. However, as in all planetarium programs, a single theme consistently and dramatically pursued is desirable.

Much of the success of such a course would lie in our ability to attract the kind of adult whose imagination and judgment have already led him to be a specialist in his own field. Such an individual responds to what he recognizes as excellence in presentation and content in any field. In order to reach this valuable minority, the courses might be affiliated with the local college, or be offered to selected members of professional groups, unions, churches, etc. The purpose of this suggested program is not, as you can see, to train astronomers, but to teach laymen how to enjoy and respect their universe. As such it will offer endless opportunities for enlisting intelligent support and good will for all scientific achievement.

Many of you have probably experimented with techniques which have proven to be successful in the field of adult astronomy. Whatever skills we have should be shared if we are to take seriously the responsibility for making good history out of the twentieth century. Our job is made easier because of the dramatic nature of the planetarium theatre which gives the lecturer an initial advantage in capturing his audience's attention. His contribution consists, therefore, in maintaining this interest by presenting astronomy in such a way that the uncommon man can find, in the mystery of the planetarium, the harmony he is seeking. In so doing he will give new meaning and dignity to the term "adult education."

THE PROGRAM OF THE FORT BELVOIR PLANETARIUM

JAMES HARRIS
Department of Topography, U. S. Army Engineer School, Fort Belvoir, Virginia

It is the primary function of this planetarium to help teach astronomy to surveying students, but the special programs which are presented for civilian groups constitute a valuable public service and have helped to maintain good public relations.

The U. S. Army Engineer School at Fort Belvoir, Virginia, presents engineering instruction to officers and enlisted men of our armed services through various career and specialist type courses. Within the school organization, the Department of Topography has the responsibility of instruction in the fields of mapping and surveying. Three specialist type courses are established to train enlisted personnel in surveying science and each of these contain instruction in astronomy.

The surveyor relies heavily on his knowledge of astronomy for the location of points on the earth's surface and for the adjustment of the direction of lines between points established by triangulation or traverse. For this reason instruction is presented in star identification, coordinate systems of the celestial sphere, and the relation of these to the earth's coordinate system. Most of these students have recently joined the military service and, after undergoing their basic military training, have indicated a desire for the additional specialist training. They have had at least a high school education including credit for courses in algebra, plane geometry, and trigonometry, and have demonstrated at least average intelligence in the general and technical aptitude areas.

Originally the Department of Topography used assorted training aids in the form of charts, drawings, three dimensional models, and blackboard sketches in presenting instruction on celestial coordinate systems and star identification. These were considered inadequate, and in June of 1952 action was initiated to further supplement the available aids with a device identified as a Celestial Navigation

Trainer and Dome in the Navy Training Aids Catalog. This device is better known commercially as a Spitz Model A-1 Planetarium.

The planetarium was installed by the manufacturer early in 1953, and has proven a most valuable training aid for our astronomy instruction to military students and has been equally valuable in helping to maintain good public relations. The celestial coordinate systems and their relationship to the earth's coordinate system are effectively demonstrated in the planetarium. The familiar astronomical triangle becomes more understandable when projected on the hemispherical surface of the planetarium. The students are no longer left behind when the terms polar distance, right ascension, declination, hour angle, co-latitude, and zenith distance are used and explained in the planetarium. The identification of stars and constellations and their respective location becomes a relatively easy subject to teach and for the student to understand, when pinpointed or diagrammed in the "sky" with the aid of a flashlight arrow. The apparent rotation of the celestial sphere as seen by the observer is another effective demonstration. The ability to simulate a view of the stars for any desired time and date, from any observer location on the earth's surface, while the observer remains seated indoors unaffected by the weather, is an impressive advantage of a planetarium. Upon departure from the School, our military students are more versed in the subject of surveying astronomy and consequently are better surveyors and computers because of the assistance they have received from this device.

The maintenance of a cordial and cooperative relationship between the military establishment and the public is of paramount interest to all military commanders and personnel. The Fort Belvoir Planetarium has assisted our installation in preserving the harmonious relationship with the ever growing surrounding populace. Programs presented for children and adults enable them, as individuals, to become more familiar with the nocturnal skies and also more cognizant of the technical training the modern serviceman must undergo. Using a tape recorder, 35mm. slides, and the planetarium, various programs have been prepared for presentation to interested groups of people. These include "Lunar Excursion," "Trip to Mars," "Miracle of the Universe," and especially for Christmas, "The Star of Bethlehem," to mention a few. Each program is of one hour duration and very popular with both young and old. An approximate limit of sixty viewers per group is necessary due to the size of the planetarium, but through careful scheduling with military requirements, over 18,000 civilians were guests of the planetarium during one season of operation. The children attending the various programs come from elementary and secondary schools located in nearby Virginia and Maryland communities and Washington, D. C. Adult visitors usually come from interested civic organizations and from among dependents of Fort Belvoir military personnel. In the few years of operation, many millions of miles of space travel have been simulated, and though we occasionally have a traveller whose imagination causes him to suffer the discomfort of air sickness, we can state that we have not lost a single passenger to date.

Our use of the planetarium is therefore twofold. First, it is used as a technical training aid in support of instruction in surveying astronomy. Full use is made of all available projection features; the audience consists primarily of young adult military personnel with little or no prior background in astronomy. Second, it is used, to the extent that the capabilities of our personnel permit, to bring a better understanding of the celestial universe to anyone, young or old, possessing the interest to find his reserved seat in the planetarium. It is especially gratifying to see the interest expressed by primary and secondary school children, and in many cases it is a challenge to try to answer their questions. Our programs for these groups are designed to be educational and entertaining as well.

We believe that our planetarium is an educational asset.

PLANETARIUM PROGRAMS FOR THE HANDICAPPED

RAYMOND J. STEIN
Supervisor, Planetarium, Newark Museum, Newark, N. J.

Even children and adults who are handicapped by deafness, muscular dystrophy, polio, subnormal intelligence and blindness can benefit from specially prepared planetarium programs.

The newspaper publicity concerning the installation of a planetarium in a city arouses curiosity and stimulates interest among the young and old alike. Handicapped individuals are no exception, but because of their special problems the privilege of participating in a unique educational experience is often unnecessarily denied them.

Early in 1952, just after the opening of the Newark Planetarium, the deaf children of the Bruce Street School in Newark decided that they would like to visit the Museum's new addition. The group's teacher consulted with me concerning the possibility of such a plan. To satisfy the class' curiosity about the planetarium instruments, a silent show could be given them, but this would in no way aid in making the subject of astronomy more meaningful. It was decided instead that slides bearing basic lecture information would be flashed upon the dome. By using this technique a lecture could be given to those who could neither hear nor read lips in the darkened planetarium.

Perhaps the children were better prepared for the visit than many more fortunate groups. Weeks before the visit their classroom was filled with cardboard solar system models, star charts, umbrella planetaria, and astronomy books. The teacher was pleased to see the proposed planetarium trip acting as a stimulus to encourage interest in speech, lip-reading, vocabulary, and reading on subjects other than astronomy.

Together, the teacher and I made a general outline from which there was prepared a special script to tell, in simplified language, the stories of various constellations, celestial and diurnal motions, and other astronomical phenomena which were to be demonstrated. Each section of the script containing a simple statement or concept that the boys and girls could read with rapidity and ease was typed on a radio mat thus forming a slide. Etched glass covers were then used on the slides to reduce the projected light.

A special light-tight box was constructed to house the slide projector in the planetarium. The projector was then mounted at a 55 or 60 degree angle to project high on the eastern section of the dome where the slides could most easily be seen by the class.

On the appointed day forty-four deaf youngsters ranging in age from eight to sixteen, and fourteen adult parents and educators attended what was perhaps the first planetarium lecture for the deaf. As each slide flashed on the dome, the pointer arrow would slowly lead the eyes of the group to the constellation, planet, or other object which was being described. For forty-five minutes the lecture went on amid the delighted sounds typical of a deaf group, which indicated high interest and understanding on the part of the children.

The thanks and gratitude of the children did not end with the lecture. In the mail I received drawings of the stars and constellations and notes of appreciation from members of the class. Several weeks later I was invited to their school exhibit in which additional astronomical projects, prepared in relation to the planetarium visit, played a large part. However, most gratifying of all was the fact that some members of the class returned with their parents and friends to attend the regular Saturday and Sunday planetarium lectures. Although they couldn't hear the public lectures, their first planetarium experience had given them a general concept which simplified their understanding by sight alone and an enjoyable new field of interest which they could share with others.

Other planetaria have since given similar programs. The regular 2 x 2 inch slides or filmstrips of the popular 35mm. cameras have proven better for copying and projecting the lectures. It is my hope that planetarium programs of this type will continue to improve and to reach a greater number of deaf children and adults each year.

The deaf, however, are certainly not the only handicapped groups that can be effectively served in the planetarium. Cardiac groups have also visited us for special lectures. Although no new projection devices are needed, a thorough discussion of the proposed visit with the leaders is necessary so that any subjects or special effects which may tend to excite or over-stimulate the classes can be omitted. It is also important that prior to the visit, the classes be properly informed by their instructors on just what the planetarium is, and the nature of its projection.

In cases of muscular dystrophy or polio groups, enough chairs must be removed from the planetarium to allow space for the wheel chairs and special braces. The children are placed in such a position as to enable them to see as much as possible of the section of the dome on which most of the lecture is to be concentrated. When the lecture is directed to a different section of the dome, the leaders, who are seated behind the children, can easily pivot the wheel chairs and other apparatus to enable the boys and girls to follow the show.

While speaking to mentally retarded groups which occasionally visit the planetarium, a simplified presentation must be given in order to make the sky show easily comprehensible. If some knowledge of the intelligence level of the class is obtained beforehand, the talk can then be patterned according to the capabilities and interests of the particular group.

A number of years ago Mr. John Patterson of the Boston Museum of Science, gave a planetarium demonstration for the blind. He accomplished this by having the group touch and feel the perforations and lenses of the projection apparatus. Thus the class was able to identify certain stars and asterisms while celestial positions were explained to them.

Whatever their disabilities may be, all handicapped persons can benefit both socially and educationally from a special planetarium lecture. In giving these groups an opportunity to experience a planetarium performance, we are helping them toward better understanding of the beauty and majesty of the universe. The expressions which I have seen on the faces of many of these children after a lecture is most certainly more than enough reward for any extra work that the preparation of a special lecture required. I sincerely hope that all who have done planetarium work with the handicapped will continue, and that those who have not may soon have the opportunity.

THE PLANETARIUM AND THE JUNIOR MUSEUM

JOHN RIPLEY FORBES
Director, Nature Centers for Young America, Inc. (formerly National Foundation for Junior Museums), New York City

No Junior Museum should be without a planetarium, even it if is only a small, simple, temporary installation.

In my particular field of work I am concerned primarily with places and areas that don't have planetaria. This is a concern which we should all share, and it is an area of operation in which the National Foundation for Junior Museums is active.

For the benefit of some of you who may be new to this Junior Museum idea, a Junior Museum is a *community museum* slanted in the direction of our youth from the elementary grades through high school. We feel that in communities where there are no educational facilities or cultural centers, a museum is *a must* and such a museum should be organized as a "Youth Museum," "Children's Museum," or "Junior Museum." I prefer the terms "Junior" or "Youth" since they are more popular with older children and adults.

In developing these museums and in presenting this program to the community, we should include a planetarium as a basic part of the entire project. I'd like to point out, in this connection, that many smaller planetaria have been developed after the museum itself became established— in some cases they have been added several years later. The planetarium is so important that we in the Junior Museum field, when starting new Junior Museums, should no longer say, "Well, let's start a planetarium if we have any money left over or if we can get support for such a project from other sources," which is frequently the way it is done. Rather, the planetarium should be included as part of the original project.

As our Foundation goes into new communities to convince civic leaders, educators, politicians and citizens that the community can no longer get along without a Junior Museum, we should present the project of a museum and a planetarium as one project because I believe the two go hand in hand. I believe that a planetarium is tremendously important and I think the very fact that this Symposium has been developed to devote three days to this subject is evidence of the growing strength of planetaria in the educational picture. Among the Junior Museum projects sponsored by the Foundation, those which have included planetaria have been so spectacularly successful that it is natural for us to feel that any new Junior Museum starting without a planetarium does so with a handicap and is in itself incomplete or unfinished.

As far as the planetarium is concerned, even the simplest type of building, even if such a building is temporary, is satisfactory. As one who works in many small communities, I am aware that many areas cannot consider having a planetarium installation if this is going to involve any large sum of money. I would rather have a small and simple planetarium that would reach many thousands of children than have none at all because the community could not provide what many planetarium experts consider a minimum installation. Let me give you examples of the small and temporary type of planetarium in three different parts of the United States. In Connecticut at the Stamford Museum a small auditorium had to serve both as the auditorium and as the planetarium. A portable dome was hung from the roof of the auditorium and lowered into position when the planetarium audience was seated. A second example is the Sacramento Junior Museum in California where the activity room was designed with a very high roof in which a planetarium dome was arranged. The room served as a planetarium during one part of the day and as an activity room at other times. Screens were used to make two rooms out of the area when necessary, and equipment, such as sinks, cabinets for the children's work, wall tables and benches, was easily covered up when the room was needed as a planetarium. Folding chairs were brought forth from nearby closets. A third project was at the Fort Worth Children's Museum in Texas where a large gospel tent was purchased and arranged on the rear grounds of the private mansion which formerly housed the museum. A fixed planetarium dome was arranged in the tent and successful planetarium shows and meetings of the popular astronomy club were held in this temporary structure for a number of years until the beautiful, new $500,000 museum building and planetarium was completed. One could mention other examples but the important thing to stress is the need for simple and even temporary arrangements when the planetarium is first started.

In connection with this program, especially the school program, a previous speaker has suggested that we as a group should contact the National Education Association and urge them to support us in the attempt to get better cooperation from local schools. I will have to take a position in opposition to this suggestion for I have had a good deal of personal experience on the matter of cooperation between local schools and our various Junior Museums. The question of schools visiting Junior Museums or planetaria is strictly a local matter and, if we were to support such a recommendation, we could not possibly, in my opinion, achieve the good results which can be achieved on a local basis. When we start a Junior Museum one of the first things we do is to go to the public schools and show them how our Junior Museum or planetarium is going to be a basic part of their educational system. In fact they are going to have a hand in helping us plan the museum and they are also going to help pay for it. Before we open a new museum we have the school people help us set it up; we have them serve on our exhibit committee so the exhibits in the museum will have some relationship to the school curriculum. We also have teacher training courses, a very important thing that many of us neglect. We stress the importance of preparing the children for their museum visit. As a result of some of these important steps, school children visiting museums sponsored by our Foundation have proper preparation, behave well in the museum and get more out of the experience. Their teachers, too, are eager to make trips to the museum as a basic part of the school program. Such a relationship means no pressure is necessary to get school authorities to use our museums or planetaria. The schools are eager to utilize our museum and planetarium facilities and this same situation can exist in other areas if the relationship between school authorities and the museum is a satisfactory one.

One other thing I would like to touch on which has not been sufficiently emphasized is the question of what does this program do for our young visitors. We have talked at great length about the details of the planetarium and of its problems but perhaps not enough of their basic effect on our young visitors. What is the impact of the Junior Museum program and planetarium upon individual children? I know of no better way to reach children than by nature study, and its effect upon problem children is well known. I have seen children about whom the police and others have said, "We can't do a thing with them," turned over to museum, zoo or planetarium leaders with remarkable results. Through a program of nature and general science study we can get through to the most difficult youngster for we have found something that has great appeal to him. Far more important than what we can do for problem children is what we do for the average child during his leisure hours on weekends or in after-school hours. The character building potential of our program is one of the most significant things we can offer our young people. The many services which we can give to handicapped children are most impressive; we have programs for spastic, crippled, and blind children. I once watched a spastic child who had never spoken a word before in his life speak for the first time when we gave him a live opossum to handle. Let us not underestimate the remarkable things we may do for our children and young people through our Junior Museum and Planetarium program.

TRAINING PROGRAMS: INTRODUCTORY REMARKS

RICHARD J. PFRANG
U. S. Air Force Academy, Colorado Springs, Colorado; Chairman of Session on Training Programs

The Air Force Academy's new planetarium will aid in the instruction of celestial navigation and star identification and will be used on a limited scale to present programs of greater popular appeal for the general public.

Our topic of discussion tonight is training programs. Before we begin, I feel I should explain how I happen to be here. As some of you know, the Air Force Academy in Colorado will have a planetarium. Part of the course of study at the Academy is aerial navigation, and since celestial navigation is one of our principal methods of navigating, it is quite natural that we should have requested a planetarium to be used as an instructional tool in this subject. We now find, however, that we are in show business in addition to teaching celestial navigation. The wonderful things that can be accomplished under the "ceiling of stars" have put us in this position. We are making plans to give week end demonstrations to the public, on a limited scale. I might add that our programs, at the start, will not be the spectacular Hayden-Buhl type presentations. We are neophytes in this field, not professionals. This is another reason why you see the Air Force uniforms around here; we are here to learn.

I would like to tell you about our celestial training program at the Academy. The basic use of the planetarium is in teaching celestial theory and star identification. All of our instructors are experienced aerial navigators with an average of 2,000 hours flying time. They conduct all of our ground school and inflight classes. To give reality to the theory of celestial navigation, we transfer our normal "flat" blackboard work to the planetarium. With the use of astronomical triangles, the observer's meridian, celestial coordinates, and the geocentric earth, we are able to make our presentations quite vivid. Our normal instructional staff conducts all these classes in the planetarium. We find that our instructors can give a satisfactory class presentation after six to eight hours of practice.

All instructors are required to complete a full "dry-run" program before presenting lessons to the cadets. In the past, we have used the Denver City Park Planetarium which is of the same type that we find here at Cranbrook. Our new instrument is a Spitz Model B.

Following the theory lessons, we cover star identification. We have our own system for finding the stars, which I am sure is not sophisticated, but it does produce results. The square of Pegasus, for instance, is a baseball diamond with Hamal in right field, Diphda in center field, a small baseball cap nearby, and, of course, Fomalhaut in extreme left field. Who's on first? — Alpheratz, naturally. We have tried to avoid old World War II pronunciations such as "beetlejuice," and we have endeavored to use the proper names of the celestial bodies. Our indoor program is followed by outside study and sextant practice. With our new periscopic sextants, the navigator's problem of finding the star has been greatly reduced. By setting in the proper azimuth and elevation, he is able to locate the star easily. We feel, however, that a well-rounded navigator should know the complete sky and have a thorough knowledge of star identification.

Our future presentations will be a little more complicated. We will be giving demonstrations on weekends to cadet clubs, dependents, youth groups, tourists, and the like. For these groups, it is our hope to present programs with a little more popular appeal than we normally give in the classroom. In connection with this, personnel from the Academy recently visited some of the major planetaria in the country. It was our privilege to spend time at the Buhl, Hayden, and Adler planetaria and discuss operating procedures. It was interesting to note the various approaches to demonstrations in the three different areas.

Our general procedure during these meetings was to attend a regular public performance and then to watch one from the projection booth. Later, we would discuss the shows with the staff. These complete discussions included where the basic idea came from, how it was developed, what special effects were required, and audience reception. Several meetings were held regarding educational programs for young people. Exhibit areas were examined closely and suggestions were received on what should be left out of planetaria. We received three, one hour, taped lectures along with several story outlines and cue sheets.

It is our hope that sometime in the distant future we may be of some assistance to a newly organized planetarium staff. The help that has been given to us has been invaluable in the formation of our future plans.

(Following these remarks, Major Pfrang introduced the speakers who participated in the session on Training Programs.)

THE EDUCATIONAL TASK OF A PLANETARIUM

MEIR H. DEGANI
Chairman, Science Department, State University Maritime College, Fort Schuyler, New York

The average planetarium demonstration does not provide a sufficiently complete picture of the universe for the layman; strip films and three dimensional models help to give the public an overall view of the structure and history of the universe as well as an understanding of astronomical time and space.

Many of the people who spoke here throughout the day were lecturers on planetaria and I assume that most of the people in this room now are in the same class.

I should like to spend a few minutes as the representative of the planetarium audience, and for the next minute, I shall speak on their behalf.

I (the public) have visited many planetaria and have listened to many lectures and have enjoyed every single one of them. However, I must say that all the lectures did not add up to a complete picture. I heard lectures about visits to Mars, trips to the moon, the shape of Cassiopeia; but they were all just small pebbles in a mosaic which failed to present a complete picture of the universe in which we live.

It seems to me that it is of utmost importance that a planetarium should offer such a picture. It seems to me that it is the educational responsibility of a planetarium to show how the various parts of the universe are related, one to the other, and thus create a "bird's eye view" of the world in which we live.

The situation at the present time reminds me of the story about a bass fiddler who was a member of the symphony orchestra. He was a wonderful guy, came to all rehearsals, came to all concerts, never missed a show. One day his friends persuaded him to take a day off and when he came back, they asked him how he had spent that day. He said that he bought a ticket to the symphony and listened to the performance from the other side of the pit. And he finished his story by saying that he discovered the most wonderful thing: while he was playing "boom - boom - boom," the orchestra played "one of the motives from Beethoven's Ninth!"

It seems to me that it is of tremendous importance to give the public not only the part played by the big fiddle but the symphony as a whole.

The complete picture should include the four following parts:

(1) The picture should show all the components that make up our world and should show the way these components are put together. In other words, the universe is made up of galaxies, the galaxies of stars, and so on.

(2) The public should be given a scale of distances: not too many, but enough to give them an appreciation of the distances involved between planets, between stars, etc.

(3) The dimension of time is of fair importance. An idea of time should be part of the package that the public takes away from the planetarium.

(4) A brief history of the universe should be offered.

Now the task of sketching a "bird's eye view" for the public is not an easy one. It is greatly complicated by the fact that we on earth see the universe from a platform that is rotating, revolving, mutating, going through space, and so on and on and on. It has been found that a rational approach to this problem is to sketch first the universe that can be seen from a stationary platform (the universe as it is), and then to show it the way it looks to us on this rotating and revolving globe.

In the Hall of Models at Fort Schuyler, we attempt to show the universe as it is. With the aid of 3-dimensional models we introduce the public to the earth, then to the solar system, then to the Milky Way galaxy, and finally to the universe. We then use the Spitz A-1 projector to explain the difference between the universe as it is and the universe as it appears to us. This gadget consists of two concentric spheres. The inner one represents the earth and is stationary; the outer one is a motor-driven celestial sphere.

Experience has shown that this approach gives the audience a reasonably good understanding of the structure of our universe and enables us to place all new ideas in their proper perspective within that picture.

The topics of distance, time and history of the universe are taken up in a strip film that has been especially prepared for this lecture.

SATELLITE TRACKING PRACTICE IN A PLANETARIUM

RICHARD H. EMMONS
Project Engineer, Interplanetary Midcourse Guidance Study Project, Goodyear Aircraft Corporation, Akron, Ohio

A description of the design and use of a device which precisely simulates satellite motion in the planetarium and which enabled a satellite tracking group to train for successful participation in "Operation Moonwatch."

A projection device that simulates satellite motion in a planetarium sky was designed, constructed, and effectively used (in 1956) to train personnel of the Akron-Canton Satellite Tracking Group, which has since achieved a record of successful participation in the Smithsonian Astrophysical Observatory's "Operation Moonwatch." The design is illustrated in Figure 1, and is based on the obtained mathematical analysis of satellite apparent motion. The simple device provides for simulation of satellite motion among planetarium stars in either real or accelerated time, with angular velocities that vary realistically in accordance with satellite elevation angle for a preselected orbital height.

In anticipation of the observational circumstances for satellite observers, and as a basis for the design of the satellite simulator, various parameters affecting the appearance and behavior of IGY artificial satellites were investigated. Values were determined and graphs drawn for satellite elevation angles, angular velocities, flight time from zenith, and eclipses in addition to the visibility threshold magnitudes of stellar bodies during twilight.

SATELLITE MOTION SIMULATOR

The satellite motion simulator, which is detailed in Figure 1, is a mechanical analog of the geometric representation of Figure 2. The triangle OPC of Figure 2 is reconstructed in the simulator by pivot O, preset peg P, and pivot C. Radius rod CP corresponds to

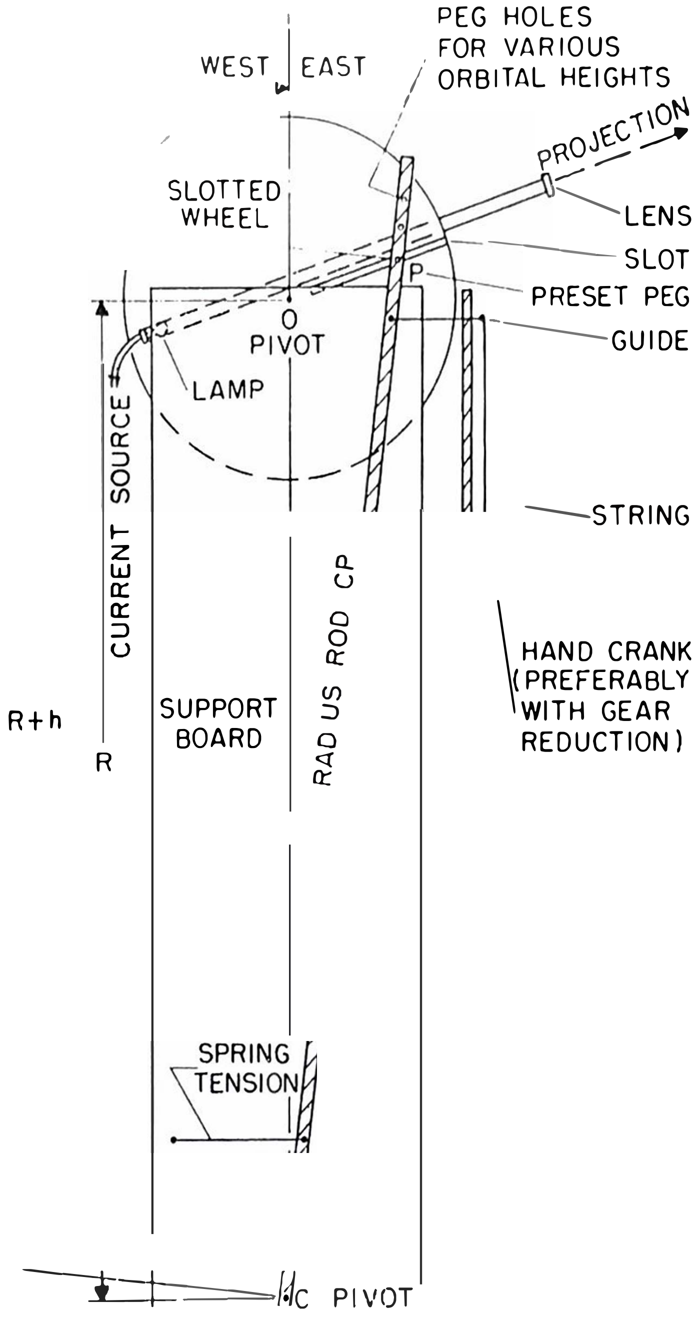
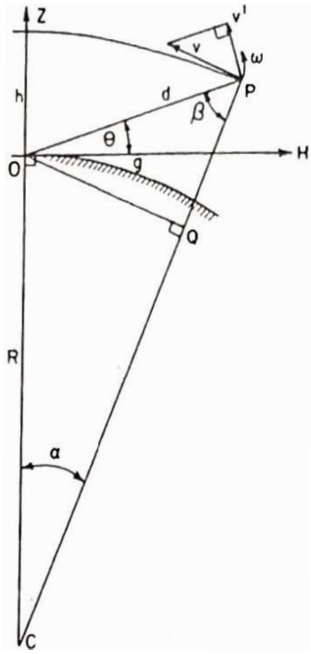


Figure 1. Construction of the satellite motion simulator is based upon the mathematical analysis of the satellite motion that is seen from a point on the earth's surface. Holes at the top of the radius rod, into which peg P may be set, correspond to predicted maximum, mean, and minimum orbital heights. Dimensions selected for R and R + h must be in exact proportion to the observer's and the satellite's distances from the center of the earth.



O = OBSERVER'S POSITION
H = OBSERVER'S HORIZON
Z = OBSERVER'S ZENITH
R = EARTH'S RADIUS
C = EARTH'S CENTER
α = CENTRAL ANGLE
P = SATELLITE'S POSITION
CP = SATELLITE'S RADIUS VECTOR
d = DISTANCE TO SATELLITE
g = SURFACE DISTANCE TO GROUND ZERO
h = ORBITAL HEIGHT
v = ORBITAL VELOCITY VECTOR
θ = ELEVATION ANGLE
ω = ANGULAR VELOCITY VECTOR

Figure 2. This geometric representation describes satellite motion as observed from a point on the earth's surface.

the satellite's radius vector. The holes at the top of this rod accommodate preset peg P for preselected orbital heights of the satellite. The earth's radius (R) is represented by the distance on the support board between pivot O and pivot C.

Construction of the satellite motion simulator is relatively simple. The dimensions selected for R and R + h must be in exact proportion to the observer's and the satellite's distances from the

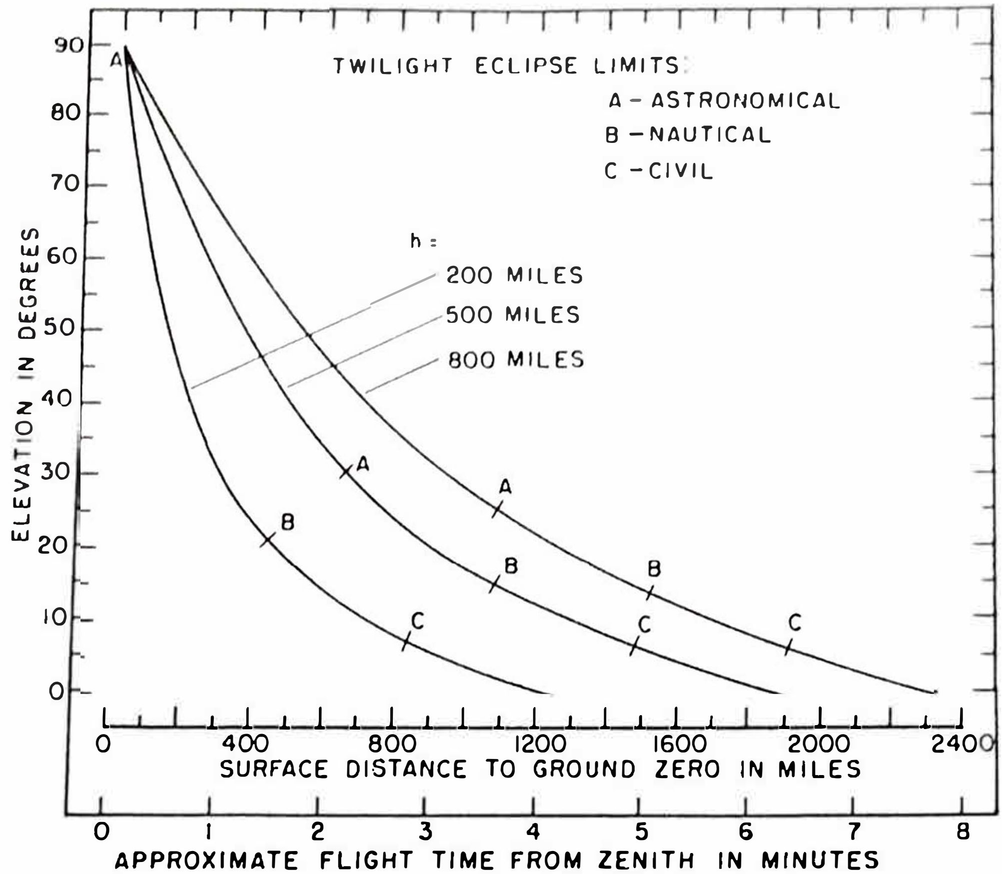


Figure 3.

Figures 3 and 4. These graphs, derived from the mathematical analysis of the apparent motion of the satellite, are: Figure 3, a plot of elevation versus ground distance and flight time, and Figure 4, a plot of angular velocity versus elevation. Correction is not made for the 0.25-degree-per-minute rotation of the earth. The sun and the observer are assumed to be in the plane of the satellite orbit for the eclipse data, and the observer in the plane of the satellite orbit for the remaining data. Limits of astronomical, nautical, and civil twilights refer to solar descents below the horizon of 18, 12, and 6 degrees.

center of the earth. For example, if R is taken as 17 inches, and where h represents 200 miles, R + h becomes 17-7/8 inches.

PARAMETERS DETERMINED BY INVESTIGATION

Figures 3 and 4 are plotted from the mathematical analysis of satellite apparent motion where specific values have been assigned to h and v. Values assigned to h were 800, 500, and 200 miles and to v, 300 miles per minute.

The eclipse elevations in Figure 3 were read from a scaled drawing to define eclipse conditions at limits of civil, nautical, and astronomical twilights (solar descents of 6, 12, and 18 degrees below the horizon). The morning ending or evening beginning of satellite eclipse is given for orbital heights of 200, 500, and 800 miles.

The stellar threshold magnitudes plotted in Figure 5 were obtained from twilight observations made with 7 X 50 binoculars and with the naked eye. The observations were made during June, 1956, at North Canton, Ohio, at 1000 feet above mean sea level. Degrees of solar descent below the horizon are given to permit application of the observed results to other geographical areas and other times of the year.

MATHEMATICAL ANALYSIS

In the drawing shown in Figure 2, the dynamic relationships affecting the observer's view of satellite motion are somewhat simplified. The observer is assumed to be in the plane of the satellite orbit, and the 0.25-degree-per-minute rotation of the earth is ignored.

The distance from the observer to the satellite is d, where C is the center of the earth. O the observer, and P the satellite. The observer's horizon is H and his zenith is Z. Elevation (θ) and angular velocity (ω) of the satellite are derived from orbital height (h), orbital velocity (v), central angle (α), the earth's radius (R), and the surface distance to ground zero (g).

The earth's surface from the observer to ground zero is assumed to be a perfect arc. Therefore,

$$g = R\alpha \tag{1}$$

In the triangle OCQ, where OQ has been constructed perpendicular to CP (the satellite's radius vector),

$$OQ = R \sin \alpha \ , \tag{2}$$

and

$$CQ = R \cos \alpha \tag{3}$$

In the triangle OPQ,

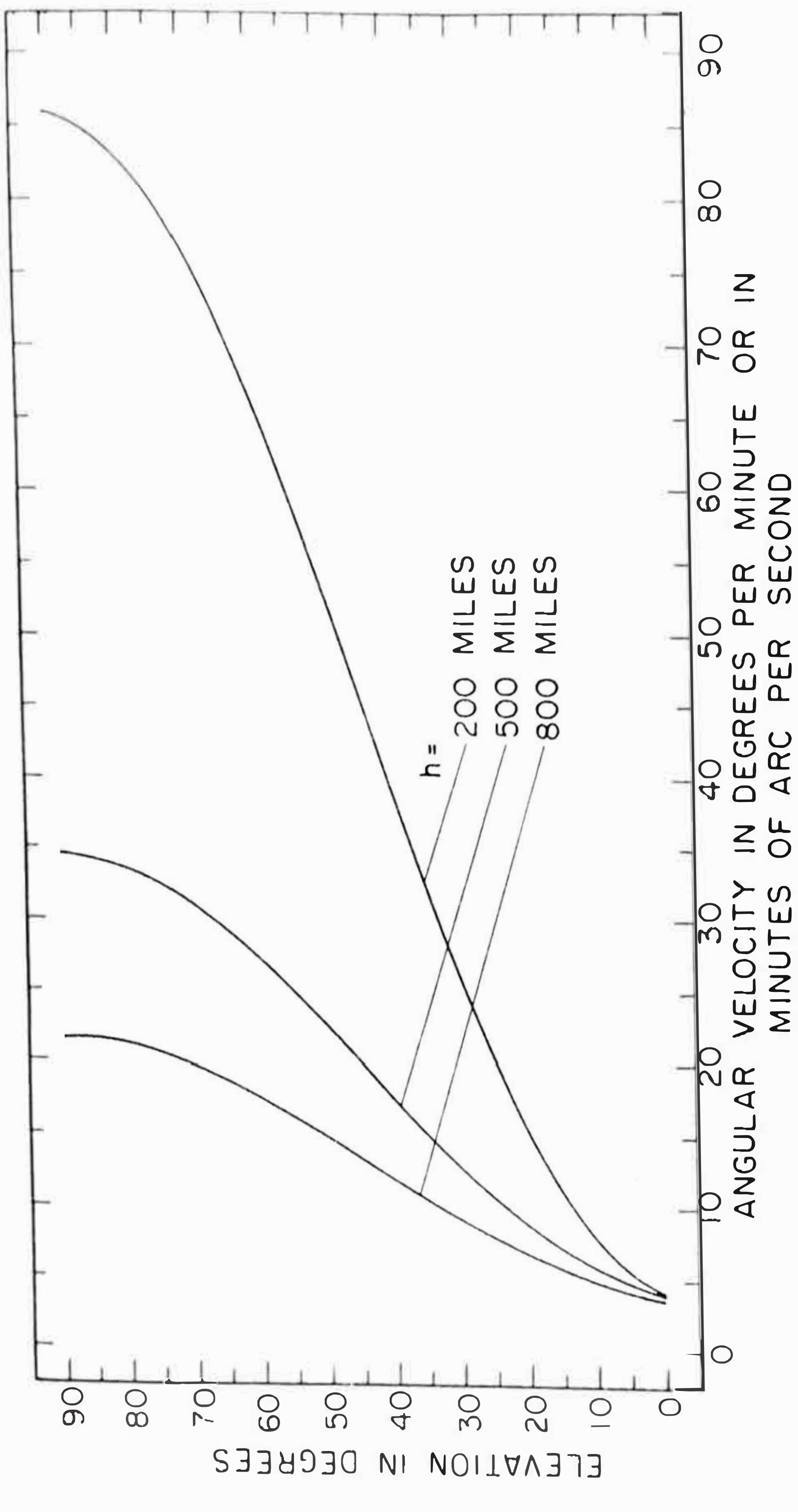

h =
200 MILES
500 MILES
800 MILES
ANGULAR VELOCITY IN DEGREES PER MINUTE OR IN
MINUTES OF ARC PER SECOND
0
10
20
30
40
50
60
70
80
90
ELEVATION IN DEGREES
0
10
20
30
40
50
60
70
80
90

Figure 4.

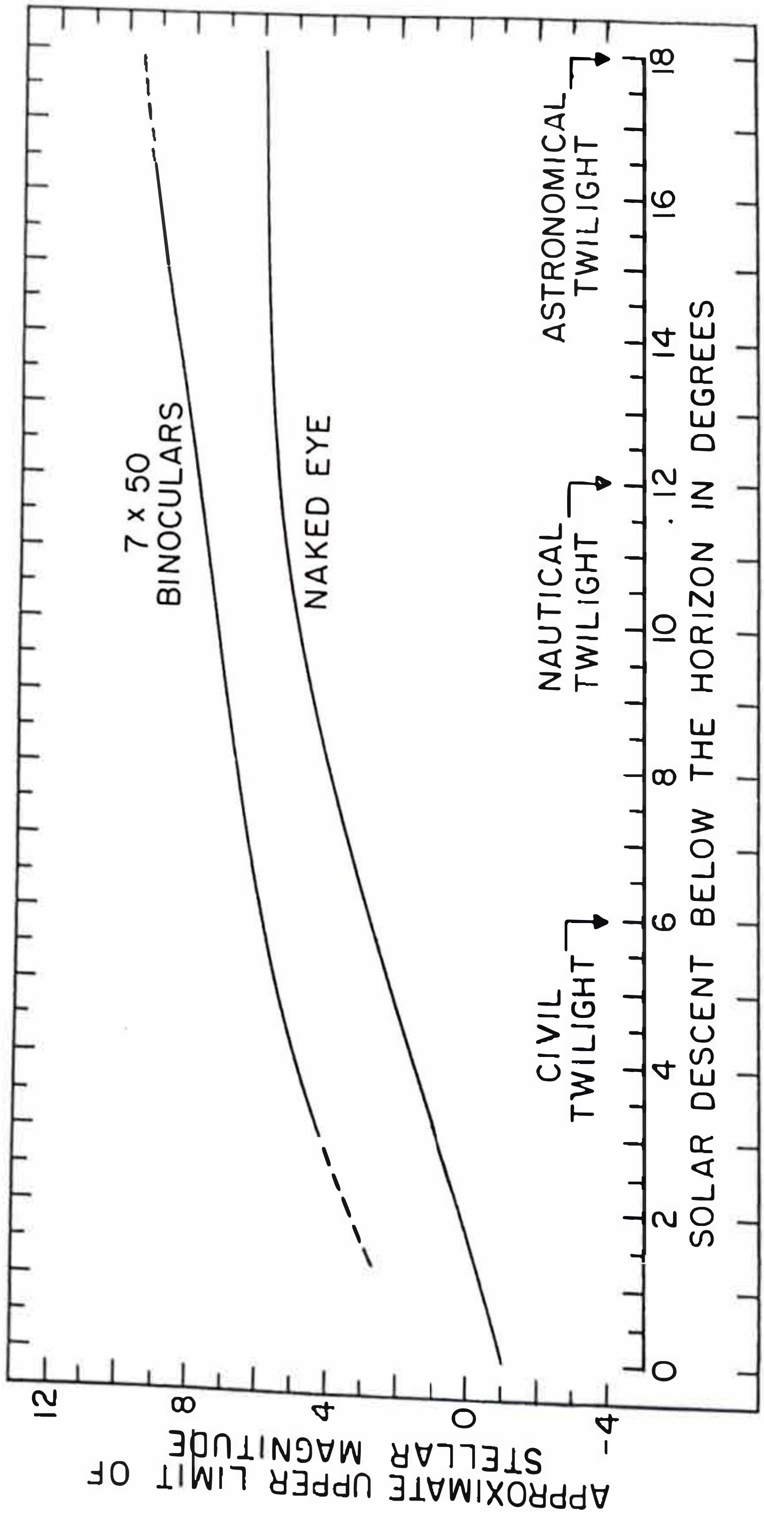


Figure 5. Stellar threshold magnitudes observed during June at 1000 feet above mean sea level and at a latitude of 41 degrees north are plotted against degrees of solar descent below the horizon. Morning beginning and evening ending of civil, nautical, and astronomical twilights are indicated.

$$PQ = R + h - R \cos \alpha , \tag{4}$$

$$d = \sqrt{(R \sin \alpha)^2 + (R + h - R \cos \alpha)^2} , \tag{5}$$

and

$$\beta = \tan^{-1} \frac{R \sin \alpha}{R + h - R \cos \alpha} \tag{6}$$

Since

$$0 = 90^0 - \alpha - \beta \tag{7}$$

then

$$0 = 90^0 - \alpha - \tan^{-1} \left(\frac{R \sin \alpha}{R + h - R \cos \alpha} \right) \tag{8}$$

The angle formed by vectors v and v′ is equal to β, where v′ is the projection of v (the velocity vector) perpendicular to OP (the line of sight).

Finally,

$$v' = v \cos \beta = v \cos \left[\tan^{-1} \left(\frac{R \sin \alpha}{R + h - R \cos \alpha} \right) \right] , \tag{9}$$

and

$$\omega = \frac{v'}{d} = \frac{v \cos \beta}{d} \tag{10}$$

or

$$\omega = \frac{v \cos \left[\tan^{-1} \left(\frac{R \sin \alpha}{R + h - R \cos \alpha} \right) \right]}{\sqrt{(R \sin \alpha)^2 + (R + h - R \cos \alpha)^2}} \tag{11}$$

TRAINING PLANETARIUM DEMONSTRATORS

A GROUP DISCUSSION

A planetarium demonstrator must have speaking ability and a knowledge of astronomy — qualifications that can be developed through training; experienced demonstrators as well as novices profit from sitting in on one another's demonstrations.

James A. Fowler: The third item on the program this evening is "Training Planetarium Demonstrators." This, of course, is a very important topic. To provide us with the substance for discussing this topic, what better way could there be than to have one of our own demonstrators show you what it is to be a planetarium demonstrator. This will pave the way for a discussion which I am hoping will come from those of you in this group who have had a lot of experience in getting the type of planetarium demonstrator you need in your particular situation. So without further ado I would like to turn the program over to Mr. William Schultz.

William Schultz: I know there may be some of you here who have never seen a planetarium demonstration, especially of the Spitz Planetarium. There are many representatives of school boards here, people from various cities who are contemplating the installation of a planetarium, and I doubt that they have seen an actual demonstration. So we felt that we ought to have at least one demonstration during the Symposium.

I have been demonstrating at Cranbrook ever since the equipment was installed three years ago. I also had about a year of experience with "Schultz Model A." I'm not going to tell you how to prepare a planetarium demonstration; I'm going to go through one. I feel that the more we hear other demonstrators, the more we are going to pick up ideas. We have three or four demonstrators here at Cranbrook, and we all attend one another's demonstrations from time to time. I make it a point to sit in on Mrs. McMillan's demonstrations with the school children at least once every three or four months. I also sit in on Dr. Folkman's demonstrations. They do the same to me. So I would suggest that you take "bus-men's holidays" and visit other plan taria and hear as many other p ople give demonstrations as you can.

I'm going to show you how I present a typical program for a mixed audience on a week-end. Mrs. Claudia Robinson has already described the problems involved in preparing programs for mixed audiences. You've got to cover many lev ls of int r st and knowledge. Your audience may include five- and six-year olds as well as adults; many of them will have no scientific ba kground at all and others may have Ph.D.'s in astronomy. We'll run through a typi al demonstration. Our regular demonstration takes forty minutes but I am going to speak rapidly and condense my lecture to twenty minutes. I am going to take you behind the scenes as I d monstrat and tell you why I do the things the way I do.

You should come into the planetarium about five to ten minut s before you put on a show to make sure that everything is in readiness. We have people here who service this machine. With the "Ephemeris" they will set the planets. When we come in to giv a demonstration we hope the phases of the moon are right; we hope that the meridian is on, etc. So let's check the machine first. It's a cardinal sin for any previous demonstrator to leave the machin in any position other than sunset. So any demonstrator coming in knows that the machine is set at sunset.

[Mr. Schultz gave a demonstration lecture at this p int.]

Now that you have seen my demonstration let me make two suggestions to those of you who may be faced with your first plan tarium lecture. First, you must be able to recognize and identify the bright stars and main constellations which are in the early evening sky in that particular season of the year. Second, there already is a lecture prepared for you, written by the Spitz people. Both Mr. Spitz and Mr. Williams should have recognized that during my lecture I followed their prepared lecture in part. I recommend highly that lecture which they have prepared. It was of great help t us h r at Cranbrook in getting started.

One other thing you will have to learn is the position of the controls on the console. You will just have to learn that the planets ar controlled by the first knob on the left; the meridian is th third on over, etc. This will come by experience.

Question: Before my lectures I like to tell my audi nces about the machine. I noticed the lack of this in Mr. Schultz's l cture. Was there a reason for this?

Mr. Schultz: It depends upon the audience. I always start my lectures to high school science students, Explorer Scouts, power squadrons, etc., with a description of the ma hine, what it does, e c. I do not do this with younger childr n or during our w ek nd shows.

Somewhere I read that the audience should not be conscious of the machine – to make the illusion of the sky as complete as possible. However, I always tell my audiences at the conclusion of my lectures that they may come up and take a closer look at the machine, ask questions, etc. At that time I tell those who are interested, in case I have not begun my lecture with a description of the machine, how the machine operates, etc.

I would say in direct answer to your question – it depends on your audience.

Mr. Fowler: What you have seen and heard from Mr. Schultz certainly gives you some idea of what it takes to be a planetarium demonstrator. I hope that we can now have further discussion of this problem, basic to the effective operation of all planetaria, from some of the rest of you who have had experience along this line.

Dan Snow: In Cleveland they were smart. They went off and got someone who had never spoken to a group before, who had never done any public speaking at all, but who did have an interest in astronomy. It was Dr. Nassau who had the extraordinary ability to show me that I could do something when I didn't know myself that I could, and who also persuaded me to try. I am glad to say that it worked out nicely. The important thing is to find a person you can mold the way you want him to be. I think that the successful way to do it – and this is the way they did it at Cranbrook – is to have someone with experience come in from the outside to do the training of the potential demonstrators. I was very flattered and happy to have been the one selected for this job at Cranbrook. I will say, too, that I learned a few things myself in the process. But it seems to me, failing a definitive test for potential planetarium demonstrators which I hope will eventually come out of meetings like this, that the way to develop demonstrators is to go out and find someone to train them who has already learned how.

Armand Spitz: Dan Snow has just described one way to do the job. You've heard Mrs. Claudia Robinson this afternoon and she represents a case in which quite the opposite procedure was followed. In Mrs. Robinson we had someone who had the ability to speak before groups and who knew no astronomy; through training administered by me and Joseph Chamberlain she has developed into an admirable planetarium lecturer and director. It's possible always, as members of the Air Force Academy staff are doing, to visit planetaria and to hear people doing many different lectures in many different ways. There are no two people of any ability or vision who say the same thing the same way twice. Admittedly, for those of us who have given many planetarium lectures – and I'm sure that there are those of you who will go along with me on this idea – it's sometimes hard to give one lecture after another without getting a little bit sick of hearing yourself talk. You may have one lecturer or a series of lecturers on your staff. It's important that the individual who is doing the talking remain fresh in his own mind. Therefore, anyone who wishes to become a planetarium lecturer should listen to planetarium lecturers. Talk to people, talk to others of the staff, get other people in to give a few lectures and listen and be guided accordingly. There is a tremendous need, as I think practically all of us know, for people who have the facility and knowledge — the facility is more important than the knowledge.

CORRELATIONS AND COOPERATION: INTRODUCTORY REMARKS

CLIFFORD E. SMITH
Professor of Astronomy, San Diego State College, San Diego, California; Chairman of Session on Correlations and Cooperation

The topic this morning is "Correlations and Cooperation". Our overall subject, however, is planetaria. I believe everyone will agree that a planetarium is, primarily, a training or educational device. While it may entertain and certainly may provide an inspiring experience, its primary function is to increase understanding and knowledge of astronomy and the night sky. I believe it fitting, therefore, to make some remarks on the advantages and disadvantages of planetaria.

Certainly the obvious and great advantage of the planetarium is that neither daylight nor weather can interfere with observing its sky. Secondly, one can observe the sky as it would appear at any place on the earth's surface at any time of day. In other words, all bounds due to time of day, weather, and position on the earth's surface are removed. A third great capability of the planetarium is that of showing various types of motions in the sky — for example, relative motion of the sun among the stars, diurnal motion of the sun, moon, and stars, and the motion of the moon and planets among the stars. Another area where the planetarium is of outstanding value is in the teaching of celestial coordinates. If a blackboard or paper is used, it requires a great stretch of imagination to picture the sky as it would appear as seen at a second order of infinity looking back. Coordinates are probably the most difficult of all concepts for the elementary student.

But the planetarium as a device cannot do everything. We have been cautioned that we should not be carried away with the planetarium as a device, and several speakers have reminded us that there is no substitute for the night sky: the night sky with its vastness, its myriads of scintillating stars, and its feeling of inspiration and mystery. Recently I spent several days in the mountains. The cabin was situated among the pines. On a clear evening I could see the stars as I looked up through the tall trees. One felt so small in the mountains among the tall trees, yet the trees and the mountains all seemed puny compared to the night sky. Thus the planetarium plays a roll with respect to the night sky similar to that which the record player does with respect to music. The planetarium is an *aid* to the study and understanding of astronomy and the night sky. Robert Baker has ably described this feeling in his book, *Introducing the Constellation*. Last evening Mr. Schultz gave us Longfellow's beautiful description of it.

In a previous meeting we were briefed on the use of the planetarium in the teaching of navigation, in the training of satellite observers, and in the training of planetarium lecturers. That was an example of a special correlation of the planetarium. This morning various panelists will discuss the correlation and cooperation of the planetarium with the community, with astronomy clubs, and with public school classes at the elementary and advanced levels. These subjects naturally parallel closely the discussion on "Fitting the Planetarium Demonstration to the Audience".

I should like to say at this point that my experience with the planetarium has been acquired in using it as a teaching aid at the college level. About eight years ago San Diego State built a new Physics-Astronomy building. The building was designed to provide the best possible teaching arrangement with no emphasis on research. The astronomy Lecture Hall, seating fifty, is just across the hall from the planetarium. The laboratory for evening observation is on the same floor adjacent to the planetarium. The staircase to the roof area, where the observing platform and the three telescopes are housed in domes, is at the end of the laboratory. Thus one can go from the laboratory to the lecture hall, to the telescopes and the observing area with a minimum of time and effort.

San Diego State has, at present, about nine thousand students. About three hundred students enroll each year in the elementary lecture course in astronomy. About one hundred fifty students enroll each year in the one unit evening course in observational astronomy. One of the large divisions at San Diego State is education. Some several hundred students plan to make teaching their life's work, and are working toward some kind of a teaching credential. These students are encouraged to take courses in astronomy. Also, many of the instructors in methods courses bring the students to the planetarium for demonstrations. On these occasions part of the time is given over to a discussion of the current night sky and the diurnal path of the sun and moon during the seasons. Time is also given to a display and discussion of elementary astronomy books and of demonstration equipment. In addition, we have an arrangement whereby groups, by paying a small fee, can come to the college for an astronomy demonstration. It is rewarding to observe many of these students return each year with their own classes for demonstrations. A Latin teacher from a nearby high school brings her class each semester. Offhand, one would not think of a planetarium demonstration as an aid in teaching Latin, but I think the application is obvious. You can be sure we make use of all the Latin terms possible. It is alpha Cygni this, and beta Orionis that, etc.

(Following these remarks, Professor Smith introduced the speakers who participated in the session on Correlations and Cooperation.)

INTEGRATING THE PLANETARIUM PROGRAM WITH GENERAL SCIENCE AND SPECIAL SUBJECT INTERESTS

C. V. STARRETT
Coordinator, Buhl Planetarium, Pittsburgh, Pennsylvania

As a teaching laboratory for the schools, the planetarium supplements the work of the school teacher; programs are tailored to the requirements of visiting classes in cooperation with school curriculum committees; special sky dramas, a junior space academy and student built exhibits all kindle a new enthusiasm for science among children and inspire more young people to pursue careers in science.

I think we all recognize by now that all planetaria are basically different. Different cities, different locations lead to different programs. Tourist traffic, parking problems, nearness of other attractions like parks or cultural centers — all these make a vast difference in operating policies. Today we are here, I take it, to trade experience and ideas, based on the solution of our respective problems.

We believe that at the Buhl Planetarium and Institute of Popular Science in Pittsburgh we have two principal and not unrelated functions: first, to give to all visitors a new and dramatic insight into the wonder, the splendor, the beautifully ordered majesty of the universe in which we live; and second, to arouse in youth an interest in the sciences and in careers in the sciences, so that our industrial region may be assured of the capable technical minds we must have to maintain our place in the United States in the world of tomorrow.

We at Buhl Planetarium and Institute of Popular Science are concerned with *all* the physical sciences — not only astronomy, but chemistry, physics, and biology; metallurgy, mechanics, and electronics; engineering, anatomy, and mathematics. And so is our city!

Our Institute of Popular Science is a teaching laboratory for all the schools — all the school children — of the great industrial and agricultural complex in which we live: the city of Pittsburgh.

To accomplish our first objective at Buhl, the orientation of man in his universe, we rely on the Theater of the Stars, supplemented by a hundred or more exhibits which we change from time to time.

(In fact, at least two large exhibit galleries are changed every month.) Supplementary are the rooftop observatory and the adult evening courses in popular science.

But possibly it is in our children's program that we have made most innovations. I will comment briefly on a few of the major events for schools. For example, sky dramas are presented for several weeks every year to aid in the teaching of geography, history, Latin, and general science subjects such as seasons, weather and climate. Attendance figures last winter were as follows: geography, 7,200; history, 5,400; Latin, 9,500. All these students came in groups with their teachers. (Latin is now the most popular language subject in Pittsburgh schools; we think we have helped the Latin teachers to stage a comeback.) With each of these sky shows we make exhibit gallery space available for as many as 800 student-built exhibits in these subjects. Teachers know how to take advantage of these opportunities for student participation, and the students make the most of them.

Our School Science Fair, now going into its twentieth year in 1959, involves more than 6,300 competitors, 1,100 of whose exhibits are finally shown at our Fair. Attendance last spring totaled nearly 34,000 — mostly school groups with teachers, and mostly paid admissions. Our Science Fair includes grades seven through twelve. If we had more space we'd like to extend it down to grades three to six. Some day we hope to do so.

For grades four to nine, Buhl Planetarium offers annual demonstration-lectures (or "science tours," as we call them) in general science as well as in astronomy, for each half-grade through junior high school. These are tailored to order, in co-operation with the school curriculum committee. (For many youngsters this is the first taste of the laboratory sciences — and they love it!) Attendance last year was just under 10,000.

For the high schools, Buhl offers demonstration-lectures in chemistry, astronomy, physics, electricity and electronics, energy, communications, liquid air, biology, basic anatomy, and applied sciences such as industrial chemistry, plastics and metallurgy. Our high school group attendance at these demonstrations last year was 3,100.

Over-all attendance last year was 233,000. Of these, 65 per cent were school children, and of this we are very proud.

The newest, and to us the most exciting and satisfying, innovation we can report this year is our Buhl Junior Space Academy — a summer school program for children from eight to fourteen years of age, which is just coming to a close.

It began tentatively last winter with Saturday courses in space, rockets, and astronomy, offered to "exceptional children." (We let the parents and the children decide!) They swamped us. Our anticipated enrollments were trebled. The first series brought in 157 youngsters; we expected 50. The next series enrolled nearly 300. Girls came, as well as boys, in about a 1-to-10 ratio.

And so we conceived the idea of a full-fledged summer school of space-age courses to run ten weeks, beginning June 23. We hoped to find 300 youngsters willing to give up baseball and summer vacation time to study science. We enrolled 663. And they meant business. They worked!

In each course subject, the student came for at least one weekday session of one and one-half hours and then returned on ten Saturdays for formal assembly lectures in specialized fields of technology by our distinguished visiting faculty from research and industry. Many students came two and even three days a week — *plus* their Saturdays. They paid their way. Some objected to going away on family vacations, or to camp. They volunteered — they competed — for homework assignments in outside reading, for class reports on special subjects such as rocket history, or Army, Navy, or Air Force progress in the science of rockets and satellites. They wrote and presented papers on astronomy. Our staff unanimously calls them the most serious, best behaved of the many thousands of children who have come to us this year.

It is interesting to note the relative popularity of the course-subjects offered, and the student enrollment in each. "Telescope-Making" led, with 234 youngsters assembling telescopes at a cost of $4.00 each. (They utilized fiber tubes and "salvage" lenses, which we bought in quantity.) Next came "Space Travel I" with an enrollment of 142, and "Rockets," 142. "Space Mathematics" enrolled 139; "Astronomy I," 136. Then came "Space Ships" with 47, and "Space Medicine" with 29. The total number of students enrolled was 663. Total class enrollment, because of the fact that some students took more than one subject, came to 982.

The size of the Academy — and much of its success — was the result of fine co-operation by the *Pittsburgh Post-Gazette*, TV station WIIC, and radio station WWSW, all of which served as co-sponsors. They spread the word with a will. Parents organized neighborhood car pools, one suburb chartered a bus, and the "space cadets" poured in!

Ages, in the Junior Space Academy, ranged from 8 to 14. Instructors were six of our staff, plus fifteen of our city's scientists and engineers, who served without pay — bless their public-spirited hearts! Four classes were given daily, six days a week. And attendance, in spite of conflicting family vacations, averaged 90 per cent for the summer. And so, the summer, which used to be a quiet, family season at Buhl Planetarium and Institute of Popular Science has now become one of our busiest. (For the year as a whole we are running about 10 per cent above last year's attendance, which was our best since 1941.)

The Academy will come to a climax the second Saturday in September in a Junior Space Congress — actually a kind of "commencement" exercise for the Academy. Willy Ley will be our chief speaker, followed by students in the Academy, reading original scientific papers on space mathematics, space medicine, astronomy, rocketry, and the like. We anticipate an attendance of 663 "space cadets," accompanied by an average of 1.5 parents apiece. This will wind up the summer and lead us into our annual fall program of science instruction for school groups.

Will we do it all again next summer? We'll try. Results will probably be less spectacular. But this fall and winter we shall resume our Saturday classes in astronomy and the astronautical sciences. Next summer we'll present the Junior Space Academy, Second Year — if the devoted spirit of our staff *and* the space-age fever continue to endure. All we need is for *one* of the moon-rockets to hit — preferably next April or May — and the Junior Space Academy will be back into orbit, all over again, in 1959.

May I close by saying a word or two as to some of the things I, personally, believe about the function of the planetarium in relation to the school?

No museum, no planetarium, can educate a child in two or three afternoons a year. But if we can send him back to his science classroom asking questions, or to his library looking for books to read, we have done the first part of our job. If a popular science program makes a student realize that a mathematics course is not a hurdle set up by graybearded schoolmen to make him work harder for his diploma; if we can make him see that science in high school can lead to an interesting and challenging career; if we can show him that the study of physics and chemistry and biology may chart a path not only to adventure, but to bread and butter — then our institution has done a good job.

We are not deeply worried about how many specific facts a child learns and retains as the result of a single visit to Buhl Planetarium. We teach — but that's not all. If we can create an attitude, a desire to learn more of the subject, then we have fulfilled a major part of our objective.

Our function is not to replace the science teacher. It is to assist him by ***kindling fires!*** We try to do this by supplementing the good work of the classroom, in as many subjects as the teacher and his curriculum committee desire, through the use of teaching devices that no school can or should try to provide for itself.

THE PLANETARIUM PROGRAM AND THE SCHOOL CURRICULUM

RAY J. HOWE
Curator of Education, Kansas City Museum, Missouri

If it is to be an effective teaching aid, the planetarium program must be correlated with the school curriculum; planetarium educators must cooperate with curriculum planners; and tools must be developed which will help the teacher to prepare students for the planetarium experience and to carry out a follow-up program in the classroom.

I think it wise, first, to establish a frame of reference from within which I speak, for it colors my thinking and should clarify my remarks. I am not a scientist nor am I an astronomer. I am a teacher, one who has the responsibility of interpreting the words of the scientist and astronomer into meaningful significance for students, and I view the planetarium instrument as a visual aid, nothing more. A teacher uses a visual teaching aid only when it illustrates a point better than words and helps the teacher to advance students more advantageously toward a known objective. This places the planetarium in a definite perspective. Dramatically exciting as the use of the planetarium may be, its importance and value as a teaching aid is directly proportional to the degree it helps the teacher accomplish the goal chosen for a particular learning experience.

Merely informative education, which imparts knowledge of facts, is less liberal than the theoretical education which imparts a knowledge of principles, because he who grasps the principles can then apply and extend them for himself. The grasp of principles creates resourcefulness. In terms of education, the best way to cultivate the requisite "bigness" of mind is through the liberal approach to studies, conceived as those areas of knowledge which enlarge the understanding and deepen the insights of men with regard both to men themselves and men in their social relationships, and which, at their highest levels, assist them to adjust more adequately to the world in which they live and to attempt more wisely to control aspects of it. This, then, my philosophy of education, furnishes the frame of reference within which I fit the ensuing remarks concerning the fundamental role of the planetarium in a learning experience.

The elements of astronomy are difficult to bring within the range of children's experiences. The world at the fingertips of children – animals, plant life, rocks, the understanding of the past, and their relationships to people and things of the present – present fewer problems of interpretation and communication since they may be selected, organized and displayed in the myriad ways museums have developed, and which have been adopted by the schools. The sky above, however, the concepts of movement and distances, time and space, and travel therein, and the baffling realities of orbits and satellites and the influences of them all on the earth and its people in terms of climate and weather, of seasons, of daylight and dark, and vocational potentials, are not so easy. The experience of studying these phenomena with a planetarium comes so close to being "real" that the students begin to "feel" and "see" the concepts being stressed.

I have never heard of a situation where the students and teachers were not thrilled and excited by an experience in the planetarium. *But* – what did they learn? What was retained beyond the thrill and excitement? Has the planetarium justified its expense as a teaching aid and the expense of teacher and student time away from the classroom? The affirmative response to these questions may best be assured by correlating the instruction period with the course of study. To this I add that correlating a school planetarium presentation with a school curriculum is not only desirable, but is mandatory if an effective learning experience which meets a pupil at his level of understanding and advances him forward is expected -- and expected it certainly should be.

In studying the titles of school planetarium programs and the descriptions accompanying them from several planetaria, it is evident that these programs are motivated by a sincere interest in bringing pertinent information and concepts to students at levels of comprehension assumed for specific grades. In many instances these goals have been achieved through a naive process of the planetarium staff being acquainted with local school courses of study and "knowing children"; in other instances, it has been good fortune coupled with past experience that has allowed an effective learning experience; and in still other cases, it has been an exciting experience with the lecturer talking above the heads of the students. Let us not be fooled by the numbers of students and teachers who sit beneath our domes and are awed by the spectacle presented by the planetarium instrument. The words thrilling, exciting, and unique, may describe the experience and be sufficient to motivate attendance.

And then, where else may time and space and motion be displayed so vividly? It behooves all of us concerned with planetaria to carefully evaluate our school program goals and content in light of sound educational philosophy and teaching techniques and the curriculum of the school areas we serve.

For those areas where the planetarium visit is an integral part of classroom study, where the visit is an effective learning experience and an enrichment program sought after by educators, we discover a very careful and deliberate correlation with the school curriculum. It is a carefully coordinated and organized venture between curriculum planners and the planetarium educators. The planetarium educator must accept the responsibility of fulfilling the needs which cannot be filled in the classroom. Let me describe a specific example. I choose one with which I am thoroughly familiar, our experience at the Kansas City Museum.

A fifth grade level program about the solar system and a sixth grade level program about stars and constellations had been in successful existence a number of years. The museum educators decided it was time for an evaluation of effectiveness. Things had changed over the years. Some materials were now being studied at the fourth grade level, and satellites were important to the understanding of the universe. A meeting was set with the museum educators and curriculum planners. The areas difficult to communicate in the classroom were well known to the planners. The specific topics and sub-topics outlined for specific grade levels had already been established by the school administration, as had vocabulary and definitions. There were certain concepts and vocabulary the museum educators felt must be included. The frame of reference was established. Each knew his role and the planetarium educators understood their challenge. It was to meet a definitely felt need. Because of some differing vocabulary, a teacher's guide was developed to help the teacher prepare the students for the experience and know what subject matter and concepts were to be covered and what and how certain vernacular was to be used. The program is correlated with the classroom curriculum. It fills a definite need and provides a meaningful learning experience which cannot be duplicated. There is a definite goal in the planetarium visit for the planetarium teacher, the classroom teacher, and the student. Each knows his goal and can measure his accomplishment toward it. The planetarium is vital in the educational experience of the youth of this community.

For students and teachers the trip to the planetarium is a field trip and the degree of value of a field trip may be greatly determined by the classroom follow-up upon return from the trip. Recognizing this, several planetaria have devised "work books," "test sheets," etc., for use in the classroom after the visit, for the responsibility of the planetarium teacher does not end with the presentation. Although I know of no statistical data available, those who provide such devices feel they see much evidence of their value.

In all, a survey of school planetarium programs would indicate a wide variance in how the programs are established as well as their effectiveness as a *learning experience.* There is no statistical data nor objective survey to indicate what constitutes the most effective learning experience in a planetarium, but an indicator survey suggests that the most effective programs, as viewed by the educators, are those which have been carefully correlated with the school curriculum.

To correlate the planetarium program with a school curriculum, then, it is necessary to: (1) have a meeting of the minds of planetarium educators and professional curriculum planners in order to establish a frame of reference as determined by the established school curriculum and modified by the educational philosophy of the planetarium educators; (2) develop tools to aid in the preparation of the students for the planetarium experience and for a follow-up program upon return to the classroom.

Does it work? Is it worth the efforts? You bet your life it is!! As a matter-of-fact, I personally challenge and question the educative value of a school planetarium program developed otherwise.

The Kansas City Museum, as one of several, stands to attest the value. This procedure of correlation has been followed for a number of years. It was severely tested recently when the Museum's financial situation forced its education department to announce it would need to discontinue this type of service or the schools would have to pay their share of the costs. The Museum's education program in all its school programs was so closely correlated with the classroom program, meeting the felt needs of the classroom teachers, that there was but one thing to do — pay; and paying they are, large school districts and small school districts.

Of course, this all presupposes one major item, *the planetarium teacher.* All the best organized plans are of little value if not augmented by a good teacher. Discriminating choice in a planetarium teacher is paramount to success.

MOTIVATING TEACHERS FOR MORE DIRECT EDUCATIONAL USE OF THE PLANETARIUM

LOUISE DAVIS
Program Director, Children's Museum, Nashville, Tennessee

Although gradual progress has been made, it has been an uphill process enlisting the cooperation of Tennessee school teachers in correlating the planetarium program with school curricula.

In our six and one-half years of experience with the Sudekum Planetarium (Spitz Model A) in Nashville, we have made gradual progress in coordinating the planetarium program with the school curriculum. We have been handicapped by the fact that the school systems in our area provide very little specific curriculum material for their teachers. Since we have not always been able to determine exactly what units will be taught in the schools, we have had difficulty in planning programs which relate directly to their curricula. In the last year or two, however, I believe we have made real progress in persuading teachers that it is desirable to correlate their field trips to the planetarium with class work and that this can be most effectively accomplished if we are told in advance exactly what they will be studying.

We have used two principal methods — a Teachers' Bulletin and various kinds of teachers' meetings — to help teachers plan for the preparation, execution and follow-up of trips to the Planetarium and the Museum. Our Teachers' Bulletin is published annually and contains suggestions of ways in which our program can be correlated with the school curriculum at various grade levels. We meet with teachers individually and in groups at individual school staff meetings, at professional meetings, at school assemblies, at special meetings held in the Museum and at in-service sessions at the schools and the Museum.

More than 2,000 school classes, or about 61,200 school children have attended our planetarium shows in the last six and one-half years. Geographically, they have been grouped as follows:

Nashville public schools: 475 classes
Davidson County public schools: 585 classes
Local private and parochial schools: 125 classes
Other public schools, within Tennessee: 735 classes
Out-of-state public schools: 122 classes

There is a very heavy load, proportionately, from public schools within Tennessee, but outside of our county. In the course of a year we deal with something over fifty counties outside of our own, including those from several surrounding states. These are not just wandering visitors; these are all school class visitors.

Our school class visitors are grouped by grade levels as follows:

Kindergarten:	3 (1952)	Seventh grade:	167
First grade:	49	Eighth grade:	206
Second grade:	121	Ninth grade:	110
Third grade:	172	Tenth grade:	37
Fourth grade:	391	Eleventh grade:	20
Fifth grade:	356	Twelfth grade:	11
Sixth grade:	369	College:	30

We served kindergartens only in the spring of our first year of operation when we were a curiosity to the general public. Since that time and up through this last school year, these figures tell the story, and you can see that grades four, five and six constitute our largest groups.

Among the college groups we have served there have been classes in astronomy, elementary education, elementary science education, human growth and development, Naval R.O.T.C., navigation, student teacher workshops, and workshops on the superior child. A large class of elementary science teachers came down from one of the Kentucky state teachers' colleges and visited our Museum, our Planetarium and Vanderbilt's Observatory and had supper in town before going back to Kentucky. This kind of combined visit we have helped to organize on request.

Most of the 2,040 school classes that have visited us have made appointments in advance for planetarium demonstrations. Once in a great while an out-of-town class will arrive without an appointment, and if it happens that the planetarium is available and the operator is there and has time to spare, we do sometimes present a show even though we have not been forewarned.

Comparatively few of the classes that have visited the planetarium have asked for specific help within the field of astronomy. It seems to me that the field of astronomy is rather large, and I have a feeling that somehow a teacher ought to know what phase of it she is teaching and ought to be able to express this in fairly simple English. I think we are gradually persuading teachers that they ought to be studying something in particular, and they ought to let us know that they are. The following figures show the number of specific subjects that have been requested by visiting groups in each year since 1952 and the number of general shows that were presented in each year.

	Specific Subject	General
Spring 1952	12	427
1952-53	31	280
1953-54	10	240
1954-55	4	281
1955-56	51	218
1956-57	132	155
1957-58	116	83

It will be noted that the situation has improved in the last three years. It was observed that in this past year most of the "general" requests came from out-of-town classes, indicating that we are beginning to make a greater impression on our Nashville and Davidson County teachers than ever before. Among the specific subjects requested were:

Seasons, day and night
Moon
Solar family, planets
Constellations
Universe, space
Christmas Star

I want to restate my conviction that we must get specific and that we must somehow reach teachers to impress on them that they must relate their field trips to their class work and only then will they be spending the taxpayer's money the way it ought to be spent. We know that it does cost money to go on trips and that a terrific amount of energy is expended by the teacher, the principal, the bus driver and everybody else involved in a field trip. It is a very serious business and I think our school systems recognize this and are trying to be cooperative in exercising some control over field trips.

I don't know whether the difficulties we have had in correlating the planetarium program with the school curriculum indicate that Tennessee is behind the times or not. I don't know whether this is a national problem or just a good southern hillbilly problem — but I know it exists in our locality and on the basis of what I have heard from some of the rest of you, I think that we're not really very different. I will conclude my remarks with these questions:

Is ours the common experience? What do you do about it?

Does the teacher feel an insecurity in the subject of astronomy?

Does the teacher trust the better judgment and superior knowledge of the planetarium operator?

Should we assume a lack of preparation of the pupils?

Is the problem due partially to inadequate discussion at the time the appointment is made? Should we ask more questions when we take appointments?

Given the existing situation, the teachers we have, and the crowded schools — what action should we take? Where do we go from here?

CORRELATING MUSEUM EXHIBITS WITH PLANETARIA

FRANK L. McCONNELL
Planetarium and Exhibits Consultant, Fountain of Youth Properties, St. Augustine, Florida

A "well-knit" museum program is achieved by imaginative use of a single broad theme correlating museum exhibits, planetarium shows and special activities.

I think all will agree that there are obvious benefits in correlating planetarium and other exhibits with the planetarium program. Yet, perhaps the real advantages are decided by the manner in which this correlation is carried on.

Perhaps the criticism which can most often be leveled justifiably at many of our museums is that many exhibits, especially those related to the planetarium, seem isolated from the overall exhibit plan of the rest of the museum. This seems a matter of particular concern to the small museum with limited resources and space. I recall very well that this was a conspicuous fault in the exhibit efforts during my first year of planetarium operation. Some kind of correlation program seemed necessary to solve this problem, and now that I work as a planetarium and exhibits consultant, such a program for each installation is mandatory.

Let's begin our discussion of a correlation program with the "obvious" benefits to be derived from such a program:

1. Many of the museum's exhibits and, of course, the planetarium area exhibits can augment and supplement the teaching program of the planetarium.
2. The planetarium area exhibits can do a great deal to put the visitor in the proper psychological mood and in a physical condition of better darkness adaptation for viewing a planetarium show.
3. At times, if not at all times, the planetarium program can serve as a focal point for seasonal short term exhibits and overall decorative schemes — for example, Christmas with the traditional "Christmas Star" show.

4. The new interest in space and space travel demands enlarged exhibit areas around the planetarium. Also, is not this new interest in the subject matter of the planetarium reason to make it more important as an exhibit area in the overall museum plan? Space is the "new frontier" and as greater advancements are made certainly interest will increase tenfold.

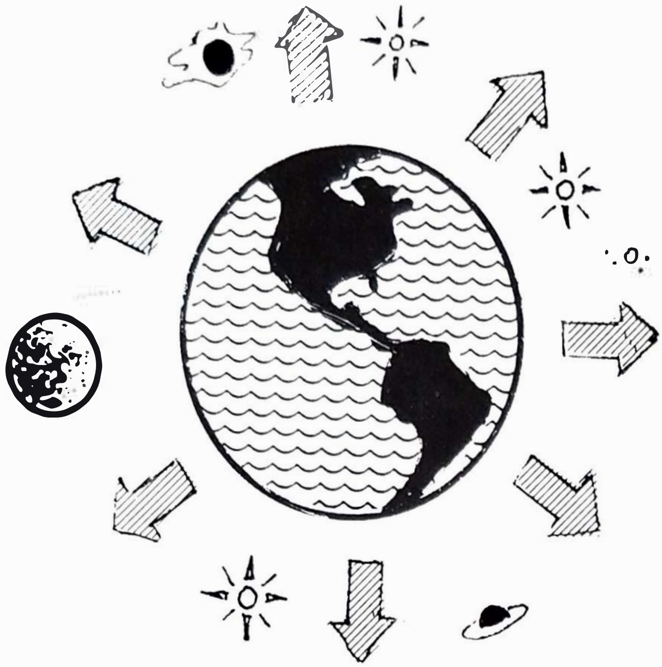
When developing a new program I like to begin with some sort of visual symbol — a kind of diagrammatic plan. Not something to follow to the letter, but rather something which stimulates my imagination and lends consistency where I might be tempted to wander. I have illustrated here two symbols and beside them listed some of the ideas stimulated by them. This method functions as a kind of "two-way" manner of mentally conceiving of the planetarium as a seeing and thinking platform for the earth in space.

Beside the first symbol, "Thinking And Seeing From Earth Outward Into Space," I listed my thoughts and discovered that they seemed to cover man's endeavors from early man's mystic interpretations of the moon, sun, planets and stars through the history of astronomy to today's research by rocket and satellite. Because of their direct connection with the subject area of the planetarium, these things seemed logically covered by exhibits in the planetarium area.

The second symbol, "Thinking And Seeing Thru Space Inwards Towards Earth," stimulated new thinking about a closer link between the planetarium and other exhibits in the museum. The obvious influences of the sun, moon, and other factors in our universe on earth have received new significance in the "Space Age," and by focusing on these influences, the planetarium can achieve a closer relationship with other exhibits in the Museum which are concerned with the earth.

New information on the sun's radiation, the atmosphere and radiation dangers to man; more precise measurements of the continents and the distances between them — all data of this kind relates to the subject matter of other exhibits. It is relevant to exhibits on sunlight and growth, the atmosphere and weather, the biology of man, geography and history. A little later I will tell you how we are using the planetarium down in St. Augustine, Florida, to introduce a part of man's history.

Also, the planetarium can lend drama and excitement to exhibits in other subject areas. For example, when introducing or featuring a rock and mineral display, the concurrent production of a brief, colorful planetarium show entitled "The Earth is Born" could add a lot to the appreciation of the great time span and the great forces



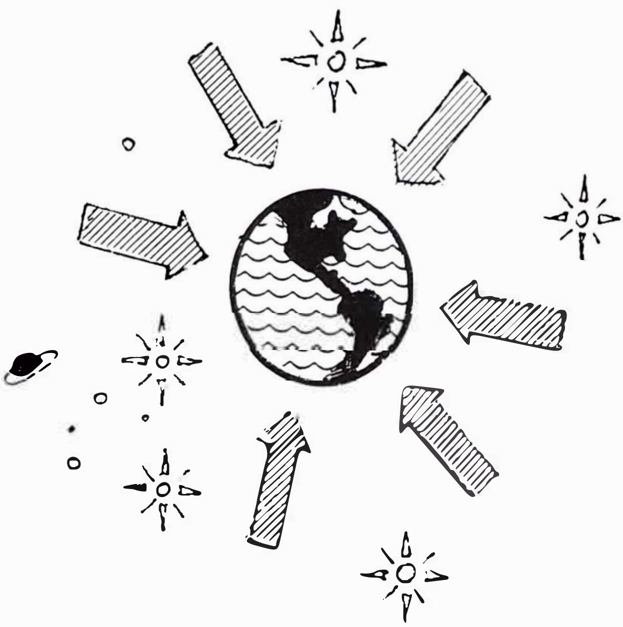
Thinking and seeing from earth outward into space

Subjects dealing mostly with man's endeavors.

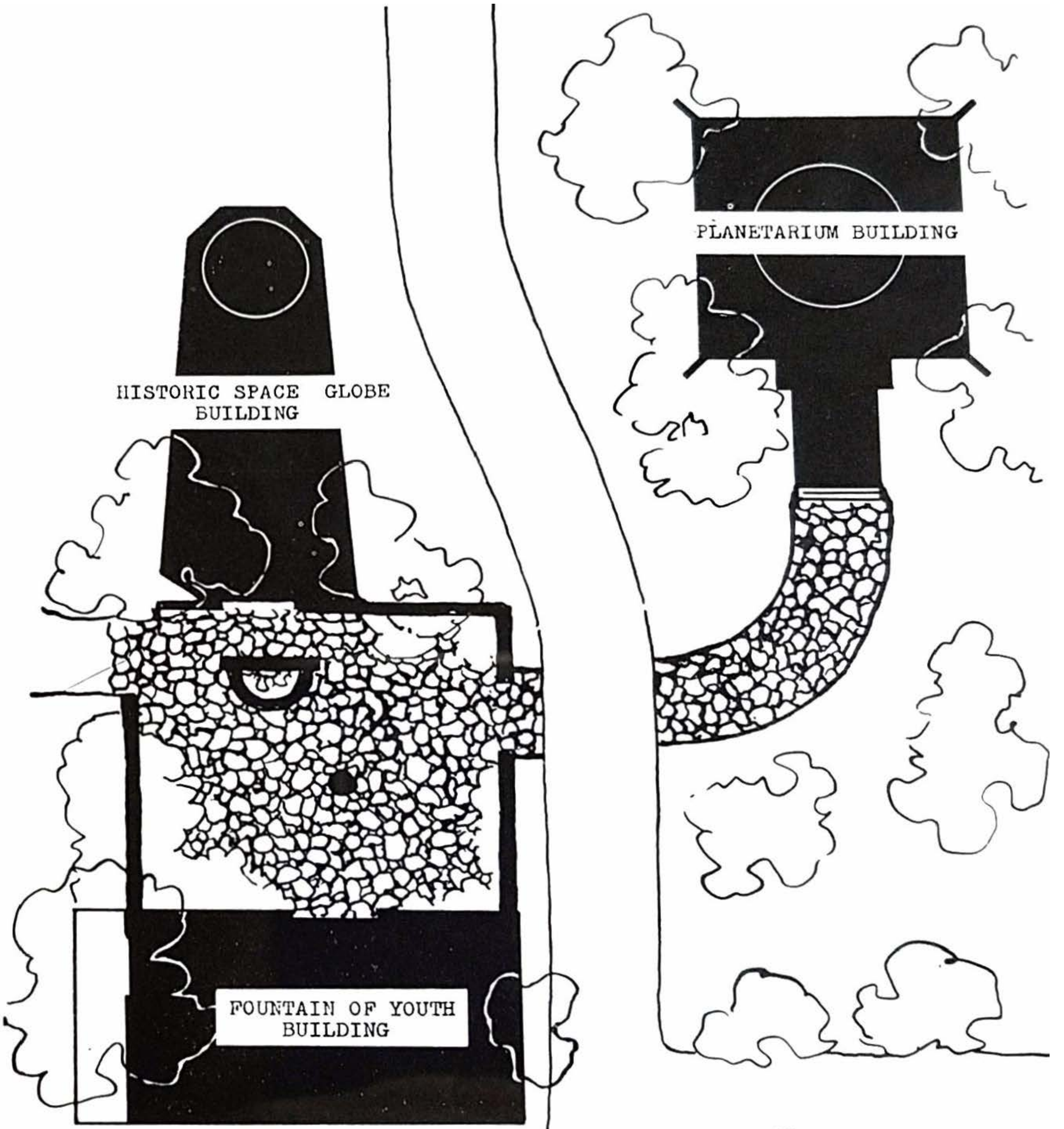
1. Early man's mystic interpretation of the moon, sun, planets and stars.
2. History of astronomy and its contributions to man.
3. Seeing into space—visual, radio, etc.
4. Satellites and rockets—research and space travel.
5. The future of our planet.

Thinking and seeing through space inward towards earth

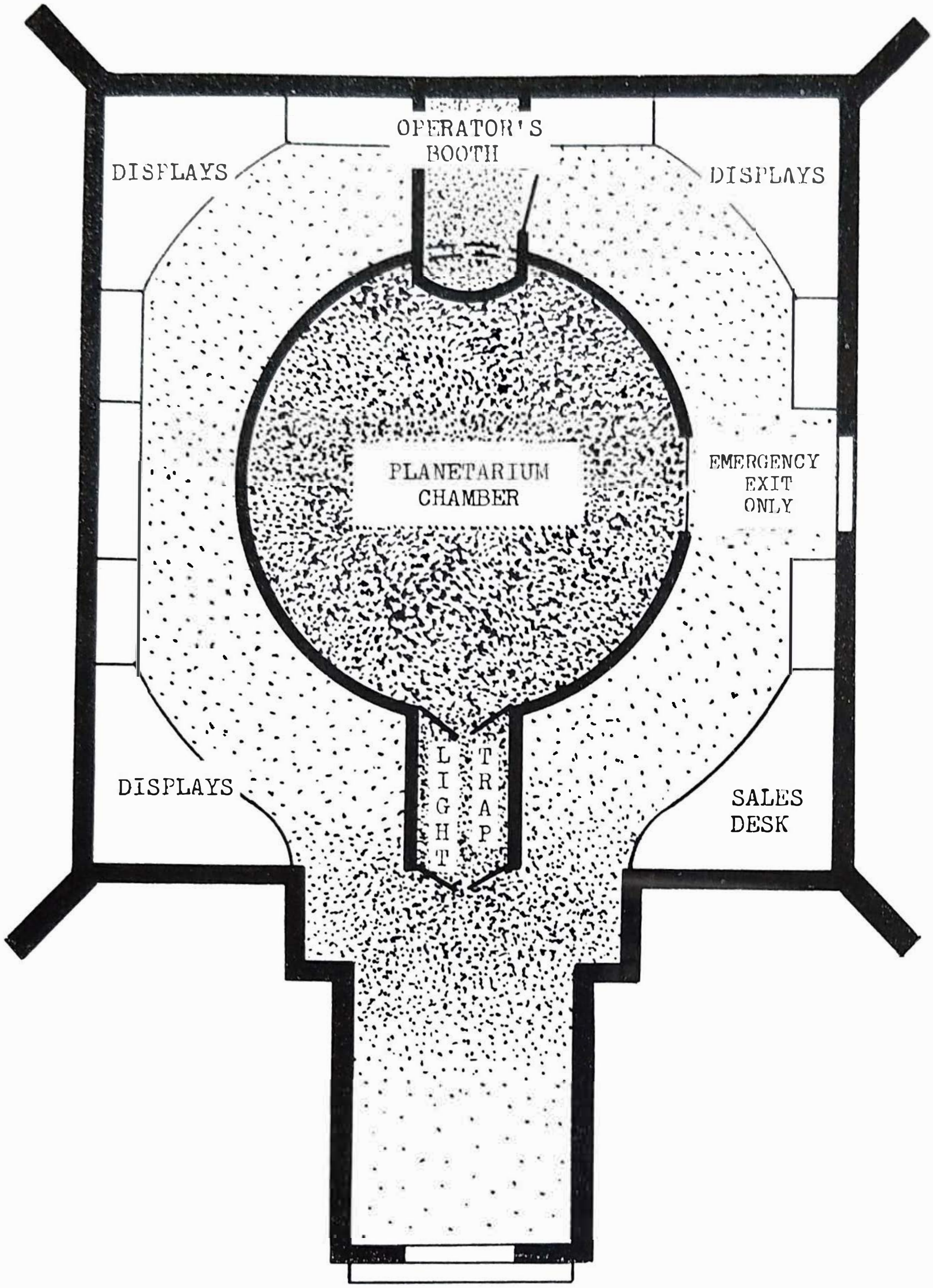
1. The sun—its benefits and dangers.
2. The atmosphere and weather.
3. Radiation and growth—influences on plants, animals and minerals. Emphasis on new atomic age research.
4. Radiation dangers to man.
5. Changes in the sun and moon.
6. Birth of the earth—geology and geography.



Subject Correlation



A section of the Fountain of Youth Park, Florida



Fountain of Youth Planetarium

involved in the formation of these rocks and minerals. Using special slides and special effect projectors with the planetarium, we produced many such shows correlated with the opening of new exhibits throughout the children's museum in Miami.

Another example is the production of a planetarium show on "Time and Travel" to run concurrently with an exhibition on transportation. A conscious effort to establish this correlation between planetarium and other museum exhibits in editorial matter on labels, brochures and exhibition and planetarium announcements will pay dividends.

I find that many of the children's museums do an excellent job of correlating planetarium shows with other exhibits and activities of the museum. Perhaps they feel that the agile minds of their younger audiences can accept more latitude and imagination in establishing this correlation.

For example, at the beginning of the fall season a planetarium show tells the story of the earth-sun relationship which brings on shorter days and colder weather causing the leaves to fall and animals to change to winter coats. This kind of show introduces and sets the scene for star gazing sessions with new constellations, field trips into the autumn woods, and all the myriad activities which take place during this wonderful season.

Children are fascinated by the fables of the constellations which are unfolded to them in the planetarium. The show is followed by art sessions where their wonderful imaginations, stimulated by what they saw and heard, help them to produce original and creative conceptions in paint or paste and colored paper.

It all seems to add up to the fact that the degree to which a correlation program succeeds is determined by the creativity and determination we put in to making it work. Nothing gives greater satisfaction then being able to feel that our entire museum program is "well-knit" — that exhibit program, planetarium shows, and all other activities of the museum flow smoothly together towards a common educational and entertainment goal.

When we think of the planetarium quite literally as a "time and space machine" we are perhaps considering the most unique way of correlating the planetarium with other museum exhibits. To illustrate, I would like to tell you about the work in which I am now engaged at the Fountain of Youth Park at St. Augustine, Florida. There, under the direction of Senator Walter B. Fraser, we are installing a Spitz model A-1 planetarium with remote controls as the third stage of a four part museum complex.

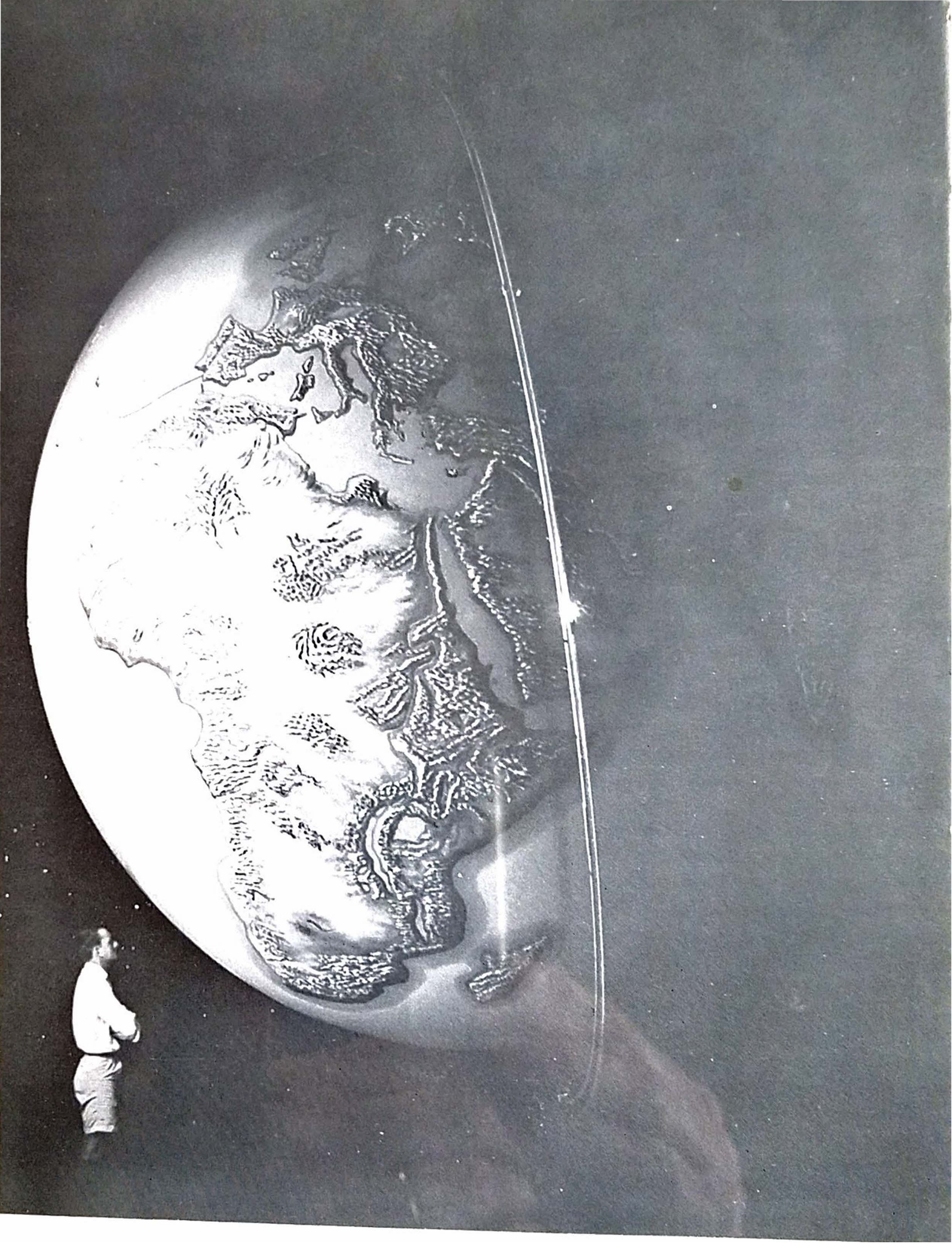
One of these buildings houses the Fountain of Youth, a memorial to Ponce de Leon, another houses an Historic Space Globe, and the third (now under construction) is for the planetarium. The physical relationship of these buildings is shown in this illustration. A fourth building to be built in the future will house a museum of Space Exploration.

Senator Fraser, a leader in Florida education, feels strongly that the act of arousing interest in learning is a major part of the education process, and he is creating here a kind of supreme example of excellent correlation between exhibits and the planetarium. For the basic purpose of both the planetarium and the Historic Space Globe is to stimulate interest and orient the visitor to this historical setting, where on April 3rd, 1513, historians believe the Spanish conquistador Ponce de Leon landed and took the first formal possession of the continental United States for a European nation. The correlating theme of the Fountain of Youth Park is " Exploration" and the Museum of Space Exploration to be built in the future will emphasize that Florida, at Cape Canaveral, again achieves another "first" with the launching of rockets and satellites for space exploration.

Upon completion of the planetarium, visitors will begin their tour of the Fountain of Youth Park in the planetarium building. They will occupy themselves here with corridor exhibits on early navigational methods and instruments and sea travel until they are called into the planetarium for the first stage of their tour. The show will be designed to take them out of their "every-day frame of mind" and to take them back in time to the period when the first one hundred years of the history of the United States took place. We will create a mood by simulating a raging storm followed by a "vast starry sky" as the storm blows away; and by illustrating the primitive navigation methods of the time, we will demonstrate to the spectators what a remarkable feat it was for these Spanish sea explorers to sail the oceans in their small ships.

The operator's booth in the planetarium will be finished like the stern of a Spanish ship, and at the appropriate moment in the show a small spotlight will reveal a seaman demonstrating the use of the astrolabe and cross staff as they were used to measure the altitude of stars in the determination of latitude.

Another function of this planetarium show will be to free the spectator of the usual inhibiting factors of our terrestrial point of reference by taking him out into space where he can look back at the earth. From this new point of reference we want him to have a new view of all the earth and the history men have made on its surface. For it is at this moment, and with this new point of view, that the visitor is whisked into the Historic Space Globe building to see what is certainly one of the most unique shows anywhere in the world.



Historic Space Globe with artificial satellite orbit in place

The Historic Space Globe building is a long hall, at one end of which is situated what we believe is the largest revolving globe in the world. It rotates on its axis and is capable of a change of latitude. Although surrounded by total darkness, one may stand in the hall and by means of black-light have the feeling that one is seeing the earth from a distance of ten thousand miles out in space.

The globe portrays the epochal events in the discovery, exploration, and colonization by Spaniards of the Western Hemisphere during the sixteenth century, the "Golden Century" of Spanish empire. By means of controlled lights, locations and events are brought to the attention of the spectators as they take place during the show. Another unique addition is a retractable satellite orbit complete with moving satellite as shown in the illustration. Under normal operating conditions, with the sunlight falling only on the left side of the globe, the orbit is not visible. The proper relationships of inclination of the orbit to period of revolution of the satellite and the rotation of the earth have been observed.

The show will begin with an animated movie, now being completed, which takes the spectators out into space. The animation moves the spectators through space, close by the moon, until the earth finally comes into view. The earth grows on the screen until it is as large as the actual globe. As this movie sequence fades into darkness, the screen curtain is pulled back and the actual globe is revealed. Later, at the point when the landing of Ponce de Leon takes place in the historical development, another movie sequence will take the spectators from their vantage point ten thousand miles out in space down to earth at the place where this epochal event took place. There are unlimited opportunities to use this technique to make history, geography, social studies, and other educational subjects relate to the total world picture — to come to life and "come down to earth" before your very eyes. Others have been planned for future production.

The show ends as the Spanish flag fades away and a waving American flag is projected on the globe. After this unique and thorough introduction to the subject, the spectator now moves to the site of the actual fountain and then on to the Indian burial ground.

I have been intensely interested in this project because of the high level of creative thinking that has gone into it. Demonstrated here is a highly imaginative and significant example of the correlation of museum exhibits with planetaria. To sum it all up: good correlation seems to be a direct product of determined effort and creative thinking.

CORRELATING A PLANETARIUM AND AN OBSERVATORY

M. T. BRACKBILL
Professor Emeritus, Astronomy, Eastern Mennonite College,
Harrisonburg, Virginia

The observatory-planetarium ensemble at Eastern Mennonite College stimulated so much interest among undergraduates, alumni and the public that a new hall was built to accommodate and instruct larger audiences.

It may be that my audience will understand a bit better the correlation of our observatory and planetarium if they know something of the origins of both our observatory and our planetarium with their associated features.

In one of the earliest and largest normal schools of Pennsylvania, I had an excellent teacher in physics, and I thought he would also be an excellent teacher of astronomy, and I think he was in many respects. However, you may find it a little difficult to believe that an excellent teacher of astronomy would not teach his class the names of any of the stars and constellations by observation, nor encourage them to learn them. But this was the case. He was a good nature teacher, well known, and taught his students the names of snakes and insects and birds and rocks, etc., but oddly, no stars. Not until five years later by my own unattended efforts with star maps and planisphere did I learn the names of the stars. By this time I was teaching at Eastern Mennonite College. Here I learned there were students who either had a start in this fascinating study or were ready to begin it; and I had quite a following of students and teachers on clear evenings while I was out learning them myself. So although I had no teacher to stimulate my interest in star study I had students who did that for me. It was, I suppose, a sort of reciprocal exercise; I got back something of what I gave. After I had purchased a small Montgomery Ward refractor telescope and a camera tripod on which to mount it and showed such objects as the moon, ringed Saturn, moon-littered Jupiter, and such, the interest increased to such an extent that we organized an astronomy club, the Astral Society, and drew up a constitution. There were only six of us at first, that February of 1930, but interest grew and soon others joined us.

Each new member was to show his interest by naming twenty-five objects in the sky, not including the sun or the moon. He was to choose a star name, pay an entrance membership fee of $1.00, and then he was assigned a star magnitude of six, a rather faint star to begin with. As he learned to identify more objects, his magnitude was increased by definite stages until he was assigned first magnitude for 85 objects. If, however, a new member reached first magnitude before Christmas, he was declared a "nova" and if he learned 200 objects before the holidays he was declared a "super nova." At the "Vernal Vespers," an outdoor program in the spring, a contest was held in which each contestant named as many stars as he could with their constellations and wrote them on paper, and then by pointing them out with a flashlight identified them to the whole group. The one who named the most stars was awarded a "silver" star called the "Astral Award."

Early it was felt that we needed a more satisfactory planisphere from which to learn the stars. Nothing that we had quite suited me, and in the summer of 1935, I designed the "Astra Guide," an adjustable planisphere, which is used by practically all the members. About this time I wrote laboratory manuals for our astronomy classes, basing many of the experiments and exercises on the "Astra Guide" and later also on the planetarium. About that time I published a little book called *Evenings with the Stars*.

Meanwhile one of our boys was reading some library books on telescopes and telescope making, and caught the fever. One day he came to me and asked whether we couldn't build a telescope. I told him that it was quite a job to grind and polish the mirror, but he knew, since he had been reading all about it. Very well, at our next meeting the Astral Society agreed to buy a kit if the boys wanted to build a telescope. They chose a Springfield model and set to work. Finally the mirror was judged to be very good and was silvered. That was in 1938. We now had a reflecting six-inch telescope and no place to put it. It happened that year that the graduating class had trouble deciding on a class gift. Quite a few of the graduates were Astralites, so I thought that maybe they would build an observatory building for the telescope, which was partly theirs anyway. I drew up a plan for it and obtained estimates of the cost, which appeared to be $1200.00. (The actual cost was somewhat more). The Shenandoah Manufacturing Corporation, a local Mennonite firm, promised me to build the 15-foot dome on a cost basis. They had some expert sheet metal workers who undertook to design and build the dome. My father, who was a tool maker, agreed to make the rollers for the top of the wall. I now presented the project to the sponsor of the class, Dr. Chester K. Lehman, who was also dean of our college. He was intrigued with the idea and presented it to the members of the class, who also were in accord with the plan. The homemade reflector was mounted in the dome January 3, 1939, and we had a going observatory ready for each and all who wished to see it. The first year we had 1200 visitors.

The purpose of the observatory from its beginning has been to popularize astronomy and through it all to honor the Creator of the heavens. It also has been a laboratory for the astronomy classes. Other instruments have been added through the years until we now have a twelve-inch reflector built by a friend of mine in Kansas City, a four-inch Zeiss refractor, a four-inch Spitz refractor (the gift of Dr. Spitz), a four-inch German binocular, a five-inch Japanese binocular, and a six-inch Mogey refractor. All of these, except the six-inch refractor, have movable mounts which can be rolled out on a large concrete observing platform, the gift of the college class of 1949.

It was in the autumn of 1947 that the Astral Society bought a Spitz planetarium, which we then mounted in the dome instead of a telescope. This turned out to be the first one sold. It was a fortunate transaction despite Pope's familiar adage, "Be not the first by whom the new is tried, nor yet the last to lay the old aside." Twenty-five to thirty people can be seated for a showing. When we saw that it was possible to have a planetarium, it did not occur to me that there would be any problem at all in correlating it with our observatory. That seemed inevitable, and so it turned out to be. It fitted into our work and experience as neatly as a punch into a die.

You all know that a telescope to the average lay person is an intriguing instrument, and almost everybody wants to see the stars through a telescope. Now, you all know also that the average person is disappointed in the appearance of a single star seen through the telescope ordinarily. It does not have points or rings or moons nearby, or at least it should not, and not even sun spots are visible. But to see the stars flash on the dome and to see the clear, star-lit sky simulated in the planetarium is a thrilling experience that anyone can enjoy whether he knows anything about astronomy or not.

So the planetarium increased the interest in the observatory tremendously; we had more guests and they came from far greater distances than before. Membership in the club increased, and it became evident that we needed another building that would seat more people and also serve as a museum and picture gallery. As a result, by soliciting the members of the Astral Society, far and near, we raised funds to build Astral Hall (cost $10,000) which has a seating capacity of 100. Incidentally, there are by now over a thousand members in this club, and during the school year about one hundred or more active members, with program meetings once a month.

With the kind help of some of my students, we built on the ceiling a simplified Copernican orrery, using model electric engines on H O track to haul the planets around the sun. A built-in screen makes possible the projection of slides and films. Numerous other teaching devices, pictures and diagrams are to be found in Astral Hall. Sometimes our visiting groups are as large as seventy or more. One way to take care of so large a group is to divide it into three or four smaller groups: one group for the planetarium, one for Astral Hall, one for the observing platform, and perhaps a fourth group for naked-eye observation of the sky. I usually take the planetarium group, my assistant takes the Astral Hall group, and astronomy students or capable Astralites take the other two groups. After the first twenty or thirty minutes the groups rotate. The number of guests and the time they can be with us determine how this is carried out.

In the dome, in addition to the planetarium, we have a small motorized orrery which demonstrates very well and at close range such phenomena as eclipse of the sun and of the moon, the phases of the moon, the configuration of the inferior planets and Mars and the apparent motion of the sun among the constellations of the zodiac.

Cur observatory-planetarium ensemble has been used not only by our astronomy classes and the Astral Society but also by the students in general, by church groups, by civic and business groups, by various schools and churches in nearby counties, and by still other groups from more or less distant places, e.g., the "Capitol Astronomers" from Washington, D. C., and the Virginia Academy of Science. A number of groups give us repeat visits, year after year. Incidentally, at the present date, 15,586 guests have signed the register, and not all have signed.

We have had a Moon Watch Station ably directed by my associate teacher, Robert Lehman. It happens that quite a few eighth and ninth graders in our community are much interested and I am planning to add a Junior Chapter to the Astral Society this fall. Also, an unusually large freshman college class has enrolled this year and I rather expect it will be necessary to have an additional section in the Astral Society, perhaps upper level for one and lower level for another.

In all these features I have tried to show you how our observatory and planetarium dovetail in an integrated and coordinated institution as we endeavor to serve our community as well as our college.

THE PLANETARIUM AS A COMMUNITY SERVICE

CHARLES G. WILDER
Chairman Museum Division, Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tennessee

Small, relatively inexpensive planetaria have been developed which are within the means of hundreds of communities; it is the responsibility of educational leaders in the "have-not" communities to see that their fellow-citizens are not denied the educational opportunities which the planetarium provides.

The American educational system — I use the term here to embrace all of those institutions, formal and informal, at work in our society educating individuals, regardless of age — has three primary functions: (1) to make people aware of social and scientific values and to evaluate these in relationship to the present and future, (2) to give the individual an opportunity to develop along the lines of his talent and to the degree of his interest, and (3) to create an attitude of responsibility, bringing about a personal behavior which contributes to a democratically changing society.

Administratively, our educational system is community centered. This means that it functions for the local group, under community supervision, and is paid for by those who live in a defined geographical area.

As I have just pointed out, the American educational system starts with the individual. Psychologists have categorized individual basic drives. These are security, recognition, response and new experiences. There is a direct connection, as I see it, between the drive for new experiences and my second function of education — that is, to give the individual an opportunity to develop along the lines of his talent and to the degree of his interest.

One of the interests which has intrigued peoples of all ages has been the exploration of the natural world. Anthropological literature dealing with primitive peoples is filled with attempts to explain natural phenomena of all kinds. This interest has not waned with the development of what is sometimes called "high cultures." In fact, the interest has greatly increased and can be found expressing itself in many ways.

There is the research scientist exploring the heart of the invisible atom with gigantic particle accelerators. There is the child who holds up a rock and asks, "What is it made of?" The scientist and the child are attempting the same thing: to find out something new. The difference in their approach is one of degree — not kind. The research scientist endeavors to push back the frontiers of verified knowledge; the child endeavors through endless questions to get answers which broaden his horizon of information and understanding of that portion of the natural world which has intrigued him.

The discovery of the empirical approach and the development of instruments for greatly increasing the effectiveness of man's poor sensory equipment have made possible a much deeper exploration of the natural world. But one does not learn to use intricate and complex equipment in a few hours. Neither is it possible to carry out elaborate experiments in a few days. Long years of training are required, and scientific work demands constant and continuous effort for achievement. Numerous scientific disciplines have come into being. The number constantly increases as the range of specialization becomes greater.

Popular interest, however, has not waned as the quest of the unknown has become more demanding. Quite the contrary is true. The wide and intense interest of the layman in space travel or nuclear energy produced by fusion are two excellent current examples.

The various papers and presentations included in this symposium cover every type of educational service planetaria can offer to a community. It would be most redundant for me to enumerate these in this presentation. I should like, however, to emphasize that planetaria, capable of presenting an exceptionally wide range of programs, have an educational contribution to make to all age groups in a community and at all interest and intensity levels. More than that, the "scope of natural" world with which they deal — ranging from nature of matter to the nature of the cosmos — encompasses a wider segment of knowledge than any other single approach. This range extends beyond the world in which we live to the larger one which sets the total environment from which ultimate goals and purposes of living itself are derived. In other words, the planetarium has a definite and distinct contribution to make to the first function of education: namely, to make people aware of values, both social and scientific -- and to give them a basis on which they can relate these to the world of the present and the future.

The organization of the solar system, its relationship to the great universe beyond, and the nature of that great cosmos are concepts which are extremely complex. Through what might be called "controlled realism," the relationships and concepts can be brought out clearly and driven home deeply. The value of well-directed planetaria in meeting existing community needs cannot be overestimated; nor does their value end there. The realism of the presentation excites the imagination to such a degree that an interest is created where none existed before. This is the goal of every true teacher. Few, if any, of the scientific disciplines have such an effective teaching aid.

Until a few years ago, planetaria, because of the cost involved, could be afforded by only a few large cities. A trip to the planetarium by the "hinterland" visitor made a deep and lasting impression. The development of a smaller and less expensive instrument has brought former "big city" opportunities to scores of communities. During the past five years I have been fortunate in being able to visit planetaria, both large and small, from coast to coast. The programming which one finds, especially in some of the smaller installations, is nothing short of amazing. More than that, a large proportion of the programs are group-orientated. Expressed in service terms, this means that they have been developed from an approach which says, "tell us what you want, and we'll see what we can do." Many of the planetaria have developed tripartite programs for groups. These programs, consisting of (1) preparation for the demonstration, (2) the demonstration itself, and (3) follow-up activities, have increased the value of the demonstration from five to six times over the so-called "excursion" type planetarium visit. Programs of this type have "sold" science teachers and skeptical administrators on the planetarium as a teaching device.

While the development of a smaller and less expensive planetarium instrument has brought wonderful opportunities to scores of communities, it has, at the same time, placed a responsibility on the educational leaders, especially those interested in science education, of hundreds of other communities. Specifically, this is the responsibility of providing the citizens of the "have not" communities with a planetarium. Such an installation, as I have endeavored to point out earlier, makes a major contribution to two of the functions of education, and gives an "assist" to the third.

In the cold scientific war of the Sputnik era, planetaria can make two important — more than that, absolutely essential — contributions to the national community. First, they can be most instrumental in kindling and developing an interest in science as a possible career for youngsters. Second, they can help in developing an appreciation by the adult population at large of the work of the science educator. In the last analysis, it is this group which determines what our youngsters will study and how much scientific equipment they will have.

Let me summarize quickly. I have endeavored to point out:

1. That our educational system is centered in the local community.
2. That it has the responsibility for providing educational opportunities for people of all ages.
3. That it should approach its task by taking care of individual and group needs.
4. That one of the fundamental individual needs is new experiences.
5. That the world of science is basically one of new experiences.
6. That the scope of science which can be treated by planetaria is the widest of any of the numerous scientific disciplines.
7. That the concepts dealt with by planetaria do not lie entirely within the range of empirically verified truth, but have large and extremely important philosophical overtones.
8. That the relationships of astronomical bodies is so complex that an effective and realistic demonstration device is essential to a clear understanding.
9. That the planetarium instrument is one of the most effective demonstration devices in the whole field of science.
10. That the development of small, relatively inexpensive planetarium instruments has brought a definite responsibility to community educational leaders.
11. That planetaria can make an important contribution to our national scientific health.

THE PLANETARIUM AND LOCAL ASTRONOMY CLUBS

RAYMOND J. STEIN
Director of Planetarium, Newark Museum, Newark, New Jersey

The planetarium can help to establish amateur astronomy clubs and to increase their membership; it can serve them further by offering courses, furnishing speakers, disseminating information in newsletters and providing space for meetings and workshops; many benefits accrue to the planetarium as a consequence of these services rendered to local clubs.

With the birth of Sputnik I, astronomy left the realm of intellectualism and became a science of interest and fascination to the man in the street, the housewife and the child. This awakened interest has greatly increased membership in existing astronomy clubs and has been instrumental in adding many new groups. In the September 1958 issue of the magazine, *Sky and Telescope*, 230 active amateur astronomical societies were listed in 46 states, Hawaii and the District of Columbia. These might well be considered the core of serious amateur astronomical clubs, but the total figure would be much larger if the hundreds of industrial, college and junior groups were included. These clubs are made up of people from all walks of life, with thousands of varied talents and capabilities, but with one common interest. In addition to serving these organizations, the planetarium can benefit from its contacts with them.

A planetarium's *service* to local clubs often begins with a regular lecture or astronomy course. Interested listeners encounter a fascinating subject which they are encouraged to pursue further. By directing them to already established astronomy clubs, or to other interested individuals in their area, the planetarium may assist the organizations in increasing their memberships and may also be instrumental in getting a club started where none had existed previously.

Another service is offered by planetarium staff members who are invited to talk at regular meetings of the societies. Extension talks most certainly make for good public relations and provide excellent groundwork for future contacts between the planetarium and the clubs.

In some instances — as with the training of moonwatch teams — the instruction and service have an even more specific purpose and obvious result. Club members benefit from, and subscribe to, astronomy courses given by the planetarium; in many cases, special courses and seminars are presented for club members only. Occasionally a local organization furnishes instructors and gives its classes in — and under the auspices of — the planetarium.

Another useful contact which some planetaria maintain with suburban astronomical societies is a newsletter which is mailed out regularly, containing data on current celestial activities and on general planetarium information. During the approach of Comet Arend-Roland in 1957, I prepared a special bulletin concerning the phenomenon and charting the comet's predicted position for several weeks. As a result, some amateurs reciprocated with excellent photographs which they had taken of the comet. Around these, a timely and popular exhibition was formed, to the gratification of the public, myself and of the contributors, particularly, who felt that their efforts had been rewarded.

Whether the planetarium is used regularly or only occasionally for club meetings, it offers the members many advantages. In addition to the planetarium itself, rooms are sometimes provided for groups to use as workshops for developing astro-photographs, making telescopes and grinding and polishing optical equipment. If an observatory is available, it not only becomes a club center for instruction and pleasurable observation, but also serves for valuable amateur research programs in special projects such as variable star work.

Today, in addition to the adult astronomy clubs, there is an ever-increasing number of both independent and museum-sponsored junior clubs of a similar nature. Although many schools are at present including astronomy instruction in their curricula, youngsters seem to derive greater satisfaction and enjoyment from learning on their own than they do from what — unfortunately, to the majority — becomes forced learning associated with classroom drudgery. Interest in a subject is, of course, the primary step to education and can be nurtured through special lectures, observation programs and workshops designed to appeal to youngsters. Certainly constellations and coordinates are more easily explained and understood in the planetarium, and the making or the use of a club telescope is both an asset and a thrill to those who may someday be choosing careers in science.

Another planetarium service to both adult and junior clubs is the provision of an information center. Whether by telephone, mail, through personal contacts or lectures, accurate factual data should be made available to club members.

Service is certainly the main function of the planetarium, but club participation in the planetarium program obviously *benefits* the planetarium by increasing its use and stimulating its growth. Besides the apparent merits of word-of-mouth publicity and increased attendance, other benefits may be derived from local astronomical organizations: many planetaria have capable volunteer or paid part-time lecturers drawn from the ranks of clubs (in a few instances, club members have been graduated to full-time staff work); by direct contact with local club members in industry, and by mail contact with organizations, planetaria have greater access to exhibit material; and through the time, skill and generosity of amateurs, even telescopes and complete observatories have been made for planetaria by local clubs.

By working with amateurs, the planetarium stimulates and aids in the educational and research efforts which constantly advance science and encourages young men and women to choose scientific careers. Thus, through cooperation, planetaria and amateur astronomy clubs will continue to provide concrete benefits as well as recreational leisure for many persons of all ages — to the advantage of the individual, the community and the nation.

ARCHITECTURE AND EQUIPMENT: INTRODUCTORY REMARKS

ROBERT SNYDER
Architect, Cranbrook Academy of Art, Bloomfield Hills, Michigan;
Chairman of Session on Architecture and Equipment

Good architecture is not the domain of professional architects alone, and I think the group that compiled this program should be complimented on its architecture. You might visualize the procedures involved as following roughly the shape of an hour glass — at one end there are big general ideas which are evolved in what we call the programming stage, they go through a phase which we call architecture, and they emerge at the other end in the form of the broad result and the facility which it provides. If you can visualize this process, I think you will agree that the sequence of subject matter at this Symposium has been quite well thought out.

The programming stage is one of the most important steps involved in reaching an architectural conclusion. It is at this stage of the game that many of the final results are determined, and I think we are quite fortunate in having someone who has been through this process here to start the present session by giving us the kind of information which the programming stage might be expected to produce for the architect.

(Following these remarks, Mr. Snyder introduced the speakers who participated in the session on Architecture and Equipment.)

EXPERIENCES WITH PLANETARIUM CONSTRUCTION

WILLIAM G. HASSLER
Executive Director, Forth Worth Children's Museum,
Fort Worth, Texas

Two installations are described; in both cases the special requirements of the planetarium are reflected in the design, construction, materials, wiring, lighting, ventilation, seating, color scheme and sound system.

In setting up two planetarium installations, one in Nashville, Tenn., and one in Fort Worth, Texas, I have encountered much the same basic problems. In Nashville the dome was built inside a room of the building, while in Fort Worth the dome was part of the original building construction.

I might say here that putting a dome inside a room is not an impossible task even should the ceiling not be as high as one would wish. Flattening the peak of the dome to some extent in no way distorts the illusion, nor is it apparent to the viewer when the stars are turned on. In Nashville the dome was built of metal lath and reinforcing rods on a heavy wooden ring suspended from the ceiling joists. Acoustical plaster was applied to the inner surface in the usual manner. Water-base white paint was sprayed on for a reflecting surface.

Since the Nashville room was rectangular in shape, the dome, twenty-one feet in diameter, was hung at one end and walls were built below it to the floor, around slightly more than half of the circumference. These were covered from seat height to dome with acoustic tile. The remaining portion was left open, except that a partition forty-two inches high was built behind the seats in that section and a gate was installed across the aisle. A speaker's booth was also included. The remaining length of the room was sufficient for exhibit cases along the wall and a comfortable walkway between them and the partition. Visitors could thus enter the room when it was not being used for a demonstration; they could see the displays, dome and projection instrument but did not have access to the latter.

The Fort Worth dome and walls were constructed entirely of metal lath inside of a reinforcing framework. Again, the inner surface of the dome was treated with acoustical plaster. The walls were of hard plaster to which acoustic tiles were glued. The concrete floor was covered with vinyl tile. This room is approximately thirty feet in diameter and the acoustics are highly satisfactory.

At Fort Worth, as at Nashville, the controls for the Spitz instrument were set up in a booth at one side of the room, with wiring running from there to the instrument and whatever other outlets we expected to use. At the instrument there are 115 volt circuits for the room lights, the motor on the star projector and for other outlets; there are also low voltage lines for the stars and various accessories. Around the room is a skyline silhouette which conceals a six inch wide trough. At the four cardinal compass points are outlet boxes from which extension wiring can be carried in the trough to various special effects. Individual switches and some dimmers are included in the booth so that these circuits may be controlled as desired. They include the compass signs, sunrise and sunset, "heat lightning" and other "gadgets" which are used at various times. There are also a few additional circuits behind the dome for other effects, such as projectors operating through small holes hidden behind the skyline. Incidentally, all switches should be of the silent type, so far as possible. Another big help to the lecturer is a variable speed motor driven control for another set of powerstats, so that the room lights can be switched over from the manual controls on the Spitz board and dimmed or brought up automatically, if desired.

Outlets for movie and slide projectors will be particularly useful, and a remotely controlled slide changer will be a big help. In a domed room there is really no ideal place to project except on to the dome itself. The curvature does not matter much but the fact that the pictures will, of necessity, be over the heads of some of the audience will be inconvenient for that reason. I know of no good solution. By all means provide a powerstat for each projector, (type 20 will do) so that the volume of light can be controlled in either instrument. (The movie projector speed will have to be constant but the light can be rewired so that it is separate and can be plugged into the variable circuit.) A convenient switch should be located near the door so that the lecturer can light up as he enters before the show, and similar convenience outlets should be included in the general wiring.

To prevent excess outside light from spilling in when the doors are opened, vestibules for light traps should be provided and should be wired for a constant dim light for anyone who leaves during a show. In order to have a brighter light in the vestibule for regular entrance and exit before and after the shows, we have wired ours with a second light, on the same dimmer circuit as those in the dome itself, from the "amber" dimmer on the Spitz control board. By way of covering emergencies when a bright light might be needed in a hurry, we have a third circuit in the reflectors with the room lights (it could be placed anywhere) and the same circuit supplies a third bulb in each vestibule. This line is on a separate emergency switch.

A "must" will be exit lights in the inner doors. These are wired into the regular exit light circuit for the building and brought into the doors themselves. They will have to be made *very* dim by the addition of many layers of colored paper sandwiched between glass. Ours show through on both sides of the door and say, "Do not enter. Lecture in progress" on the outside, and "Exit" on the inside.

The skyline or bottom of the dome should be no higher than necessary. The *ideal* would be just slightly above eye level when the viewer is seated. Since this would mean cutting doorways high into the sky part of the dome, the next alternative is to make the skyline and the door tops come as close to each other as possible and as low as practical. Our doors are nearly 7 feet high but we have carried the white of the dome down about 6 inches more on a cut-out strip, following the pattern of the skyline silhouette. This blends at each end into the cut-out silhouette on the light trough around the rest of the dome. Thus, the top of the skyline is roughly 72 to 78 inches above the floor, and the bottom of the trough itself is about 68 inches high.

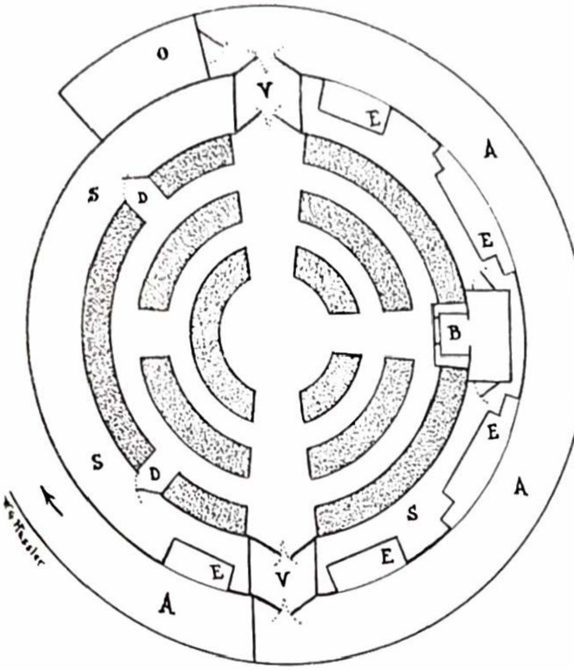
Good ventilation and air conditioning are also essential. The system must be quiet and controlled so that it can service the planetarium independently of the rest of the building. The peculiar construction of a planetarium and concentration of an audience may make it necessary to have the ventilating and cooling system completely different or perhaps even opposite from that of other areas.

We believe that the seating is of prime importance. We like our custom-made seats, designed from our own plans and specifications. The form was first developed by Mr. Philbrick Crouch and the writer in Nashville. They consist of concentric rings of bench-like units with cushioned seats and relatively high, well-padded, sloping backs. The framework was made of wood by the Museum's carpenter. The back padding and the seat parts were then made up by a local theater seat manufacturing company, using standard materials adapted to the size and shape of the forms we had constructed. At Fort Worth, almost exactly the same dimensions were used but were fabricated and installed by a local contractor who used welded iron rods for the frames, backed with wood and padded with sponge rubber. In both places the seats were covered with the best grade of artificial leather. At Nashville, the 21 foot diameter dome allowed for only two rows of seats, while at Fort Worth, with a dome diameter of nearly 30 feet, it is possible to have three concentric rings. In each case there is plenty of leg room so that visitors may slide forward, lean back and rest their heads on the back of the seat.

I feel that a planetarium can and should be colorful. The walls of our planetarium are painted a deep royal blue, as is the instrument support. The floors are a spattered design of blue and white vinyl tile and the seats are a deep red. Our vestibules are carpeted and that would be ideal for the rest of the room from the standpoint of silence, but would present too large a cleaning and wear problem.

I very strongly recommend the installation of a good "hi-fi" sound system. Good speakers may be located around the room at several points; their exact position does not seem too important. Apparatus to use both records and tapes are important. Controls for on, off and volume should be on the speaker's control board or within *easy* reach. Except for pure classroom instruction, a planetarium's main use is in arousing an interest and desire on the part of a layman to enjoy the stars. Mood, drama and genuine entertainment are essential if this aim is to be fully realized. Good music, clever sound effects and smooth performance make all the difference in the world. Of course, to this must be added a lecturer with a pleasing personality and good voice.

A planetarium incorporates many special requirements and problems, the solutions for which should be very carefully thought out in advance. Before any construction is begun, the builder would do well to examine other successful installations and consult with those who have had experience in their operation in order to avoid disappointments. A well appointed and smoothly operating installation makes the difference between an amateurish and a professional presentation.

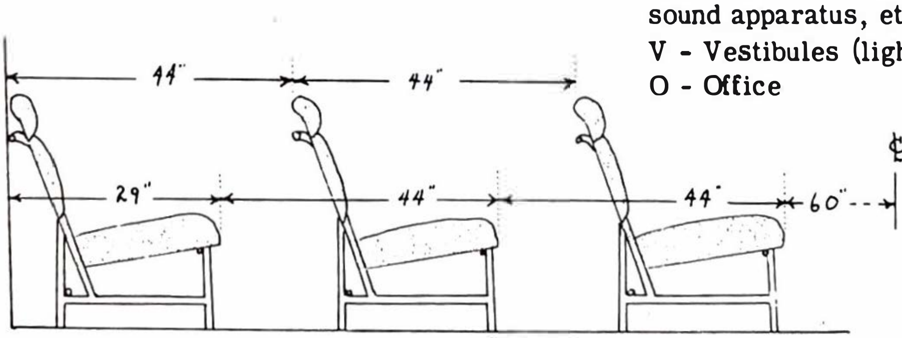


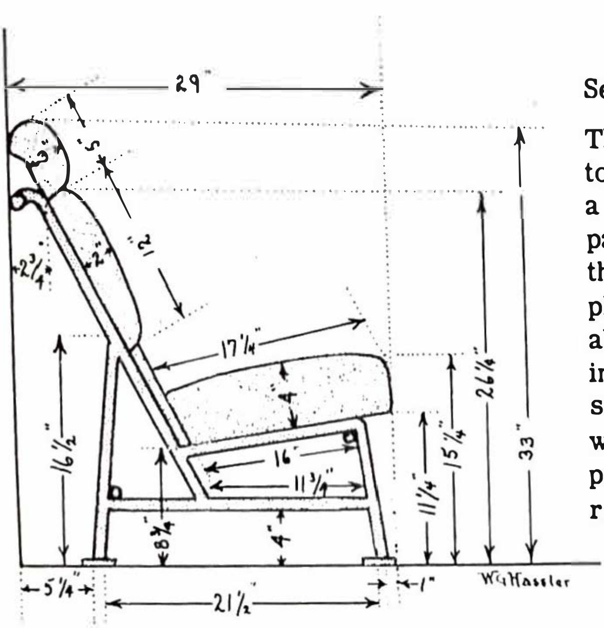
Charlie M. Noble Planetarium

Overall plan of the ambulatory, dome and seating.

Dome is 29-1/2-feet in diameter, with three concentric rings of custom made seats. Between the dome and an ambulatory, which encircles somewhat over half of the total circumference, is a space for storage and in which are located air conditioning apparatus and five exhibit cases. The contents of the latter are seen through windows in the wall of the ambulatory. The planetarium projector is operated from a booth at the side of the dome. Since the planetarium is located on the second floor, over a large circular rotunda, it is reached by a semicircular ramp, which becomes the ambulatory around the dome.

A - Ambulatory which slopes down to main floor of rotunda.
S - Area for storage, air conditioning machinery and exhibit cases.
E - Exhibit cases which roll back from windows along ambulatory.
D - Doorways.
B - Booth and control console, with small room behind for additional projectors, sound apparatus, etc.
V - Vestibules (light traps)
O - Office





Seating for the planetarium.

The framework is of 5/8-inch rods, welded together. Back and bottom of the seats is a double thickness of 1/4-inch plywood, padded with foam rubber and covered with the best grade of "artificial leather" or plastic. The welded frame units are spaced about 33 inches apart on the back and 22 inches on the front circumference of each semi-circular seat. Horizontal rods are welded to the upright frames on three places. Units are bolted to the floor. Top rod forms a hand rail.

ARCHITECTURAL PROBLEMS OF THE SMALL PLANETARIUM

WILLIAM EDWARD KAPP
Architect, F.A.I.A.; Trustee of the Cranbrook Institute of Science

The small planetarium with limited funds gains economic and educational advantages in being attached to or built within a larger institution; the effectiveness of the planetarium instrument depends on the design of the room in which it is housed, and if plans and materials for this room were standardized it would help new planetaria to secure the best use of the instrument.

A planetarium building is a unique structure with many unusual problems entirely its own. This gathering of specialists in planetarium operation knows that inadequate or improper building facilities can seriously interfere with planetarium demonstrations. The instrument and the building function as a single unit during a demonstration. The instrument design is accepted as proper for its purpose. The building design must provide for the most effective use of the instrument and for the convenience and comfort of the spectators; it must, of course, comply with building codes and regulations.

The problems involved in building a planetarium can be simply solved if all of the building requirements and their elements are properly studied before actual construction begins; but they may become complex if the building committee and the architect fail to recognize and solve them on paper where mistakes can be easily corrected with an eraser.

Let us assume that the building problems of a small planetarium with a thirty-foot dome will be similar to those studied and solved here at Cranbrook. Let us also assume that the need and desire for a planetarium exist and that the funds are available for the site, the building and the instrument.

If I have any qualifications to discuss the architectural problems of planetaria, it is because of the combined advice and directions of Dr. Robert R. McMath, who honors this planetarium with his name, and Dr. Robert T. Hatt, Dr. Armand Spitz, Mr. Herbert Williams, Mr. William Schultz and the directors of the eight public planetaria I have visited and studied in detail.

To these people I am indebted for their assistance. From this practical knowledge my office has developed studies for four proposed midwest planetaria, of which Cranbrook is the first to be built.

These studies of large and small planetaria indicate their common needs regardless of size. In the large existing planetaria, which usually have been financed with munificent gifts, both the exterior and interior design is monumental in scale. They are complete with vestibuled entrances, lobbies, galleries for educational exhibits, as well as staff offices, minor service rooms for public and operating conveniences, mechanical plants for heating and cooling, and parking facilities. The small planetarium requires all of these facilities, but seldom can afford them. This problem may be a blessing in disguise for it usually means that the planetarium must become a part of an existing school, museum or institution. It is not only a physical addition to another institution, but also an extension of that institution's educational program. For the small planetarium with a limited budget, there are great economic advantages to be gained in being incorporated in an institution equipped with public facilities. As an example, here at the Cranbrook Institute of Science we have available an administrative and maintenance staff, a sheltered entrance, a display lobby, exhibit areas, check rooms, toilet facilities, heating and electrical services, and parking facilities. All these facilities were available at the Institute and are used by our small planetarium. These related building elements would require more floor space in a separate building than the planetarium itself. Although it first appears to be a handicap, attaching to or building within another building actually makes it possible to economize in building and operating costs and has some educational advantages.

A building program should be as complete as possible. It should list all the things that the committee considers desirable and everything that is considered undesirable as well. This will enable directors to avoid many problems which would otherwise be thrust upon them.

The interior facilities and finish of the planetarium building must be designed to provide for complete optical disappearance. At the beginning of a planetarium demonstration, as the general illumination gradually disappears, so does our visual perception of the room's finish and size. Otherwise the necessary illusion of the vast spaces of the night sky would be destroyed. Hence, the architect must design first for an invisible room and second for a background that will be suitable for the uses to which the room will be put preceding and following the demonstration.

The exterior design of the planetarium building, in contrast to the disappearing interior design, is usually required to be a conspicuous indication of its function at all times. In other words, it should look the way the public expects a planetarium to look, with circular or polygonal walls and a dome.

When the small planetarium provides all of its own auxiliary services, instead of sharing those provided by an existing institution, its design problems become like those of a large planetarium with an entrance, lobby, exhibition area, utilities and public conveniences — all of which effect the exterior design but not the planetarium interior.

When the small planetarium is attached to another institution and does not have to provide a number of auxiliary services for itself, the exterior building design remains a simple and pleasing form.

Once the funds have been secured for the planetarium instrument and building, several basic steps must be taken. A qualified building committee must be formed and it must secure the advice of the designer of the instrument for guidance. After the instrument size has been determined, the selection of an architect must be considered. The architect should be a well-qualified designer who is interested in, or better still, enthusiastic about tackling the problems of planetarium construction.

The building committee must plan for adequate space in a new or available building. The size and position of the instrument and the operating space for the lecturer are fixed in our assumed area thirty feet in diameter. The usual desire for obtaining maximum seating capacity results in crowding the spectators in upon the instrument and the lecturer, interfering with the effectiveness of the demonstration and other uses of the room when illuminated. Obviously an area forty feet in diameter would be better, but not if the extra space is filled with more seats around the instrument, nor if the larger reflecting dome is beyond the instrument's proper projections.

The forms of the enclosure may vary. One of the simplest forms is a cylindrical or polygonal drum with a flat roof like that of the old Dusseldorf Planetarium. The dome in most cases is simply hung on the interior, and that's probably the least expensive type of structure. However, most people, including committees, want to have the dome showing, so an alternative form is the cylindrical or polygonal drum with a dome on the exterior. Few exterior domes are what they seem to be, because they are not used for the interior dome. The space between the inner and outer domes is amazing and expensive. For example, in the Adler Planetarium, in Chicago, there is more void space between the twenty meter reflecting dome and the exterior dome than there is in the planetarium below it.

At Flint, the exterior dome is of steel and is not the dome of the planetarium. Here, again, there is a tremendous space between a hung reflecting dome and the roof, with stairways going around and up through to a hole in the roof.

If you are planning a small planetarium you can't afford a double dome with all that waste space. There are ways of making less expensive structures, and the architect for a small planetarium should find them. At Cranbrook, by various means we were able to get our costs down, not as low as we had hoped, but to a figure that permitted the award of a construction contract.

Materials for the interior and exterior of the planetarium building are evaluated in terms of their suitability, cost and appearance. Exteriors are usually built of masonry to comply with building code requirements or because masonry is the best material to use for the place where the planetarium is being built.

The form of the planetarium building should be simple and free of extraneous devices unless they have purposeful meaning such as the signs of the Zodiac. The exterior should express the purpose of the planetarium, as the exterior of the small planetarium does here at Cranbrook. Our original building was designed by Mr. Eliel Saarinen, and our task was to take the rectilinear design and add a circular structure with a dome.

For our Board of Trustees, we studied seven different proposals for attaching the planetarium to the existing building. We considered their advantages in relation to operation, to appearance— inside and out, and to future museum expansion. In several of these proposed plans, the planetarium would not have been seen from the front of the main building. It was finally decided to make the new addition a feature of the exterior near the museum entrance, with an exposed dome, horizontal lines at the base of the drum, and copings determined by the adjacent structure. The resultant form is a simple solution in harmony with the Institute design.

The exposed dome and the limited funds available necessitated a careful study of concrete domes and steel domes. We found that it would be relatively expensive to build a concrete dome if we followed the usual procedure which requires special form work for proper shaping. This was the procedure that had been followed at the Boston Museum of Science, and we obtained data from them that led to the development of exposed concrete in our dome. The metal dome is probably better from the standpoint of weather tightness, but it's a more expensive job.

No matter whether you build with a concrete or steel structure, the problem of building the inner dome remains. Two domes necessitate the extra space referred to before, and our problem was to find a way to avoid that useless and costly space. We finally devised a combined steel and concrete dome design wherein there are only four inches of space between an inner plaster dome and the concrete outer dome. It was done without providing any form work for the concrete or the plaster. The design idea consists of an umbrella-like frame without a center stick, but with a circular base around the ends of the ribs. The ribs are little four-inch I-beams, bent cold to a true circle in a shop. The umbrella was formed in several sections, brought down the highways with a special police escort, assembled at the site and lifted into place by a crane, and bolted together and anchored on top of the circular brick wall drum which encloses the planetarium.

On the top of the umbrella ribs, 3/4-inch round rods were added in a series of concentric horizontal circles, tack welded to the ribs. Across the rods, a paper-backed wire mesh was secured to retain and reinforce the concrete cover. Concrete was placed by pneumatic guns in two layers, including the exterior finish. That was treated with a waterproofing compound, and there was the external dome with no form work of any sort.

To do the interior plaster work, it is customary to have suspension wires 4 feet on centers over the entire area, and from the suspension wires two-inch steel channels bent to the circles are run 4 feet on centers, then 3/4-inch channels, also bent to the circles, are wired 16 inches on center to receive metal lath and the plaster over all.

In place of all of this bending and forming of a suspension system, the inside of the umbrella ribs offered a hemispherical form ready to receive furring channels directly by tack welding, followed by metal lath and plaster. This simple solution provided an accurate form and saved the labor of hanger calculations and templates.

After the concrete dome was complete and before the lath was put on the interior, the underside of the concrete and the steel ribs were sprayed with two inches of insulating material.

The inner dome was plastered with acoustical plaster — wood float finish — and painted with acoustical paint.

The total thickness — exterior to interior — was 7 inches.

The acoustical plaster was the lightest available color, but it dried out with an uneven color and it has been given a coat of acoustical paint.

In place of the economical plaster reflecting dome, a better solution is a perforated metal ceiling with acoustical felt behind, to absorb sound. This permits handling exhaust air through the multitude of holes — a pretty good way to handle the air, except for one difficulty. That is the accumulation of dust on the top of the suspended dome, which, if neglected, becomes a dangerous dust fire hazard. There are modern methods of putting in perforated metal or plastic ceilings in modern office buildings where the air is thoroughly washed and cleaned, but these require removal to get rid of that dust and dirt, although the primary cleaning purpose is to get better light transmission.

Some day when more planetaria are built, something better than a metal ceiling will be used. In fact our good friend, Doctor Spitz, is working on a development of that sort.

Now to the walls in the small planetarium. In the large planetarium you can do several things, assuming adequate funds. The problem here was to provide walls hard enough to take abuse by children. Here an ordinary commercial perforated board was bent to the curved wall and fastened over the entire area on two-inch furring strips. The space between the wall and the board was filled with two-inch padding.

At the top of the wall at the base of the reflecting dome is a projecting device — a black ledge that does a multitude of things. Above it is the silhouette of the neighborhood sky line which is visible; back of it are lights for general illumination and receptacles for eight small speakers for our sound projection. It also serves as support for the illuminated compass points. Most important, it conceals the air supply inlets for all ventilation needs. There are no holes, no grilles in the reflecting dome. The problem here was to move air into and out of the room without discomfort — to make sure that no air would blow on the heads of spectators and that grilles would not be visible. The solution was this: where the dome comes down within the upper part of the exterior brick walls, air ducts were placed back of some of these spaces round about, with ten or twelve small branches leading to flattened nozzles blowing air up into the top of the room. To remove the air there are grilles in the wall behind the seats. There are no grilles spotted visibly around the room, no drafts to bother the occupants, and it's a fairly simple system.

Planetarium ventilation systems should eliminate noise. Many air systems push the air around too fast, create whistling noises and carry fan noises through the ducts. In this system there are no grilles where the air comes in, only nozzles pushing the air into the room without noise. You can't hear air noises coming in, and of course you can't hear the air going out at a lower velocity. In fact the only noise I can hear now, I think, is the revolving tape recorder. Any noise is distracting and undesirable. Low noise level is very important at planetarium demonstrations where the audience as a rule is very, very quiet.

The planetarium floor requires comment. Obviously it should be dark and dull to avoid reflected light, easy to maintain, and reasonably priced. This floor is a black vinyl tile with an admixture of white spots or chips in it and, though it is laid in nine-inch square tiles, it gives the illusion of a continuous material.

There are numerous devices about the room to which I call your attention in case you have not noticed them.

Theoretically these vestibule doors are not to be opened from the outside during a demonstration, but there are little peek holes in them fitted with a magnifying glass so the whole vestibule can be seen when you get up to the door.

The vestibule is illuminated by a tiny recessed light in the ceiling that lights the black floor, not the walls, so that if one comes in or out that light does not shine in and disturb the demonstration.

These theater-type seats have back legs about an inch and a half lower than regular theater seats. You may not be conscious of it, but they are tipped and you can note the fact by the extra leg room between the rows.

Ideal seating for a sixty-foot planetarium would be to omit the seats and lie on the floor. I'm serious about this. On many of my Maine vacations, I go up on Mount Cadillac on Mount Desert Island. It's about 1600 feet high and bare on the top. I like to go up there on nights when there is no moon and lie on the bare rock and look in wonder at the heavens.

In a planetarium you look here and there and you get kinks in your neck. The next best thing for chairs would be steamer chairs so you could tip back. Special high back chairs with head rests were considered very carefully by our committee. Head rests were rejected because of the very thing you see here where the wall is soiled and damaged at the head line.

There are secret doors on both sides of the room here that open in to triangular shaped closets designed for the storage of special equipment. A motion picture projector could be rolled in and out of these spaces. These doors are made accessible by having the seats immediately in front of them fastened not to the floor but to a group slip, so they can be pushed out of the way.

To summarize my comments, I would say that the architectural problems of a small planetarium, while unusual, are not difficult, provided there is a complete understanding of what a planetarium is and what it is not, and provided there is time for adequate consultation with the manufacturers of the instrument, the building committee, the donor or the fund raising group, and the architect, before any preliminary studies are made.

As a result of our experience here at the Cranbrook Institute of Science and our studies for three other planetaria, and on the basis of reports on a number of schools and institutions which are considering the building of planetaria, I believe that the interior designs of small planetaria should be standardized because of the direct relationship between the design of the room and the proper use of the instrument.

It's a wonderful instrument. If you build a poor room, whose fault is it? The committee's and the architect's fault. The instrument is there; its needs are known. Why not give it a proper background and facilities. Similarly, the interior wall and dome materials and details could be standardized along with accompanying recommendations and directions on related mechanical and electrical services.

If a committee buys a Spitz instrument, I think there should be some method whereby they could buy plans and specifications for the interior finish and design of the room in which the instrument is to be used and then install the room in the kind of building that suits their local conditions. Why should each building committee and each architect sit down and go through this problem of deciding what they are going to put on the walls, how they are going to build the ceiling, how they are going to build the dome, how they are going to bring in the air and how they are going to take it out, and all of the other items which must be considered apart from the instrument?

The hundred or more small and large planetaria in the United States have by now undoubtedly made nearly all of the mistakes that should be avoided in the future. A plan to secure and correlate this data for the future builders of small planetaria could be one of the beneficial results of this first symposium here at Cranbrook. I believe that you members of the new association can do more than educate the public with your demonstrations. I believe you can help yourselves and your present and future planetaria by assembling and distributing material on planetarium design.

I have finished my comments and would like to close with a little story of what happened here at our planetarium, as it illustrates so well the marvels of the projector, the educational value of the demonstration and the combined effects on the spectators.

It concerns a group of Boy Scouts assembled here for a group demonstration. Like all youngsters, they were awed and thrilled by the experience and after it was over they dashed – as all boys do – outdoors into the clear cold winter night. But one of them stopped still on the open terrace, looked up at the sky and shouted "Look, fellows – it's just like the Planetarium."

Site steel assembly; prefabricated base and ribs

Lift of one-half assembly

Dome assembly complete

Rod reinforcement and paper-backed wire mesh

Applying concrete by pressure gun

Integral float finish for appearance and sealing

Stages in the construction of the Robert R. McMath Planetarium of Cranbrook Institute of Science

PLANETARIUM BUILDINGS – DESIGN AND CONSTRUCTION

HERBERT N. WILLIAMS
Sales Manager, Spitz Laboratories, Yorklyn, Delaware

The first consideration in planetarium design should be to secure the best use of the instrumentation as recommended by people who have had experience with planetaria over a number of years; new planetaria can profit from the experience of others and incorporate many specific improvements in their plans.

One of the main problems facing any institution considering a planetarium program is the most efficient use of space. Most of you have successfully met this problem at least for the time being.

Prior to 1952 the majority of our smaller installations were made by museums and colleges which had, or could make available, space adequate to house the dome and equipment. In colleges many older buildings with high vaulted ceilings were commandeered by science departments and a planetarium became part of their educational and public relations programs. This involved minimum expense and fairly good use of the planetarium, although in many cases the space available presented limitations to a full utilization of the installation.

Several things have happened recently to change the emphasis of good space requirements or conditions. You are all aware of these factors and many of you have experienced increases in planetarium attendance of 50, 60, 70% and even more, in the past two or three years.

Perhaps the most important factor in this increase was the announcement made only a short time ago that led us spectacularly into the space age. A new dimension was added to our thinking and fascinating new words became part of our everyday vocabulary. More and more people became interested in the skies and the demand for interesting and informative planetarium programs increased. The need for technically trained and scientifically oriented people at various professional levels increased the importance of the planetarium's position in the college or university program and in the community.

This increased demand and the resultant increase in the desirability of a planetarium has created a problem involving architects, contractors and personnel. Evidence of this growing demand has been experienced by Spitz laboratories perhaps most spectacularly in the field of high schools, colleges and universities where building programs for new science facilities are making it possible to include planetaria. More important, perhaps, from the public point of view, but fewer in numbers, are the new museums and museum additions which are being built and in which planetaria, both large and small, are becoming focal points for entire museum programs. Many of the questions which come up regarding construction and design in the college field are similar to those which must be considered by the museum. In both cases the increased interest and importance of this type of facility demands greater seating capacity, better shows, and better planning of the physical installation including such features as double entrances (light traps), complete soundproofing, adequate air-conditioning, inner acoustical treatment, additional circuitry, auxiliary exhibit and lobby areas, comfortable seating, and perhaps more important than ever before, that which might come under the heading of cosmetics.

I think all of us agree that any planetarium show should begin with all the aspects of good theater brought into play the moment a person enters the planetarium area. It is obvious that adequate existing space for a modern planetarium installation is very difficult to find. There is still space on the campuses of some of our older colleges and in some of our older museums which can be used with a certain amount of inner reconstruction for the planetarium.

Dickinson College in Carlisle, Pa., is making use of an old, old building, with high, vaulted ceilings and stained glass windows, which I think had run the gamut from dining hall to library and to science laboratories. Since a new modern science building is being constructed, the planetarium will go into the old space and when they are finished, the interior will be completely face-lifted and modernized while still maintaining the architectural flavor of the campus.

The Charleston Museum has just installed a planetarium in its building. Those of you who saw the Charleston Museum at the American Association of Museums convention at Charleston this spring remember the tremendously high ceilings, some fifty feet, which made it possible in this case to build a planetarium building within a building, complete with roof and rain gutters, should one of the heavy storms or hurricanes damage the museum structure.

The New York State Maritime College at Fort Schuyler was able to install a planetarium when space long since forgotten was unearthed— literally. One of the cells of the fortress had been filled with sand as additional protection years and years ago and was discovered through the detective work of Meir Degani. The sand was removed and flooring installed so as to provide a very nice planetarium and small exhibit area for use by the cadets.

Once the decision to have a planetarium has been made, the problem of design and location comes up. This question, Medusa-like, rears a many serpented head. Ossification, however, need not be the only reward for facing it. Should the planetarium be buried architecturally within a large science building or museum, or should it be a separate building with separate entrances? Perhaps it might better be attached to a present structure so that a duplication of facilities can result. Should it be centrally located or perhaps built as part of an observatory where its access might be somewhat limited? Should it be upstairs near the roof so that observation of the real sky could become part of the program, or might it be located near the front entrance to provide accessibility? Could it be so constructed as to provide space not only for the planetarium show, but also for lectures or class rooms? Answers to these questions can be justified from two points of view. One, which is perhaps most practical, is based on the use to which the planetarium facility is to be put and the function it is to fulfill, and the other is based on aesthetics as I will demonstrate later on. The perplexing problem of a donor's personal preference I will leave to your diplomatic resources.

Here at Cranbrook the planetarium is attached to the main building and I believe the choice has been an extremely fortunate one. The planetarium can be open for special showings while the rest of the museum can be closed off to the public. It is accessible to toilet facilities and washrooms, to the sales desk, and to the exhibits in the immediate lobby vicinity, including the excellent orrery which has operated for years as a focus of attention as one enters the museum proper. Being located adjacent to the front entrance, its external design attracts the attention of the visitor the moment he approaches the building. Someone once said that there is nothing more intriguing than a dome on a building, especially in a building dedicated to science. It gives promise of things mysterious, scientific and perhaps astronomical. As a youngster who grew up in this area, I can look back on the fascination with which I would regard the observatory dome at the other end of the building. Now there are two.

There is one basic and inviolate point which cannot be forgotten no matter where the planetarium is to be placed, or in what type of structure. It is for all of us a statement of the obvious but unfortunately not so for those who have perhaps only a vague notion of what a planetarium is. *A planetarium structure must be designed with the realization that the best use of the planetarium instrumentation,* *based upon the experience of planetarium people over a number of years, must be paramount in importance.* Beyond that, the architects and designers need be limited only by the amount of money they can spend. This in itself can be astronomical.

We have tried, in most cases successfully, to help acquaint architects with the problem and to guide them toward the most effective use of space. Our suggestions come from what has been done before in installations across the country and our experience has involved, unfortunately, sins of omission and commission, sins which all of us should hope to see eliminated in any planetarium to be built in the future.

You can easily imagine the immediate situation when the president of a college or the director of a museum (the former situation is perhaps a little more extreme) calls in his architects and announces that they are going to build a planetarium. In the eastern part of the country perhaps this situation need not arise, but in areas where the word "planetarium" is generally believed to be from another language, I can well imagine the reaction. I can see the architect running to the dictionary to find out what a planetarium might possibly be and eventually writing to us for advice. We can, with our brochures and physical installation requirements, supply enough information so that the architects and designers can go ahead. We request that they submit drawings of their ideas to us for comment and for suggestions concerning wiring, seating, air conditioning, the handling of entrances, and so on. Much of this can be handled quickly by our engineers. At the same time we look over the situation to see that nothing has been done which would ruin the whole thing. Only on one or two occasions have we had to go beyond the architect for powers of veto, and only when a designer has decided to get fancy in the areas where the functional use of the planetarium must rule supreme. I can remember one instance where the architect wanted to place under our hanging Model B a large plastic bubble under which colored lights would continually play on the instrumentation during the sky show. An actual verbal battle ensued between the Laboratories and the architects, with final assistance from the donor himself before the matter was dropped.

Other problems arise, and these remarks are not being made to point out any inadequacies within the architectural profession although sometimes I marvel at their assumed omniscience. It is more, I think, a matter of degree in some cases. We specify that the planetarium chamber should be completely isolated acoustically from the rest of the museum and that the chamber itself should be capable of complete and utter blackout. Here again we in the profession know exactly what this means. I have seen on specifications this statement, "98.8% of stygian blackness." That would certainly sound dark to me — even darker than Ivory soap is pure. However, after dark adaptation in many places, I have found it quite easy to see the instrument and other people standing around. We have specified that the noise level in the planetarium chamber should not exceed that of a quiet suburban living room at midnight. There is nothing more ruinous to the philosophy of a good planetarium show than the sound of the flushing of restroom facilities. Humbling, yes, to the lecturer, but certainly not conducive to an illusion of space and quiet and order.

The greatest difficulty seems to arise from the operation of air conditioning units — both for cooling and warming the area. We specify that all compressors and motor driven equipment be far enough away from the chamber so that vibration and rumble is not transferred to the chamber itself and that metal duct work be interrupted with fabric or insulated so as to cut down transfer through the ducts. We also recommend that ducts be large enough so that the volume of air passing through them creates no hiss or roar. At one of our new planetaria, unless they have corrected the situation, the blowers must be turned off before the lecture begins.

The Charleston Museum, working closely with an excellent contractor, has done a magnificent job in all respects but I would like to comment particularly on one point. It has as quiet an air conditioning situation as possible. No noise, no hiss, no draft, and yet in ten minutes you can experience a noticeable drop in temperature. In Charleston this is a definite asset. It is also the type of unit which can be used in the winter time on occasional cold days to keep the planetarium comfortable. This and the lecture hall next door are the only two rooms so blessed in the museum.

Light tightness seems also to be a hurdle. It is not generally recognized at first that a person's eyes, when completely dark adapted, are capable of seeing even the tiniest amount of light. It is, after all, on this principle that the projection planetarium has been developed. All doors that are not light trapped should fit perfectly in their frames and if the dome is perforated or translucent, extreme care should be taken that no light from another room or from behind the dome encroaches on the chamber area. It is not possible, as has been suggested once or twice, to paint the dome black to kill extraneous reflection, and it is not a good idea, as it has also been suggested, to turn the dome on its side so that people can look at the sky without craning their necks. Comfortable seating is the answer to that problem and under no circumstances would we ever advocate that dentist's chairs be considered.

Some recent developments in the design of the planetarium chamber merit, I think, some consideration. Just a few years ago we spoke of the Model A-1 planetarium and 20-foot diameter projection dome as optimum for use by museums and colleges. The increased interest and participation by the public has changed our thinking to a point where we recommend a 24-foot dome, if the use is to be predominately for classes in astronomy, and a 30-foot dome if an active public program is being considered. We do not recommend anything larger than a 30-foot dome simply because the projection techniques used do not produce what we feel to be an acceptable illusion. I might mention, however, one very excellent and extremely active planetarium at Lancaster, Pa., at the North Museum on the campus of Franklin and Marshall College. One of our Model A-1 instruments, which admittedly has been reworked optically, is operating under a dome 40 feet in diameter. It is an extremely good installation but we feel honestly that a larger instrument capable of additional projection should be considered.

The University of Nebraska State Museum has filled in a corner of its T-shaped structure with a simple, cubed structure some fifty feet square. In this area they have installed a Model A-1 planetarium and 30-foot dome with future plans to install a 40-foot dome and our Model C projector to take care of the increasing interest. The smaller planetarium will be moved to the University's branch museum in the western part of the state. As it now stands, their present installation provides for excellent exhibit space through which visitors pass on their way to the chamber itself. There are several others who are developing planetarium facilities on this basis — beginning with the A-1 installation but providing for the ultimate possibility of a major program.

In several recently constructed planetaria, the radius of the planetarium chamber is several feet greater than the radius of the dome. This provides a rather interesting cosmetic situation and in several cases has improved both the acoustics and the air conditioning situation. It also promotes, I have found, the creation of an illusion of space. A walk-around area beyond the last row of seats also helps in traffic control and offers an opportunity to provide transparency box exhibits and/or very shallow three-dimensional cases to increase the educational value of the installation. Ultraviolet exhibits can create a three-dimensional surface and can be used very decoratively. All of this lighting must be controlled from the console so that only before and after the demonstration can the exhibits be seen. The Franklin and Marshall planetarium had fairly large exhibit cases in the planetarium chamber but has eliminated them because of a problem of policing the equipment during the time visitors were viewing them between demonstrations. This is a point to consider, and it is our general feeling that exhibit areas in the chamber, if they are used at all, should be used decoratively or only to augment the planetarium program. Generalized exhibits on astronomy requiring study should be left to the lobby area or to the area outside of the planetarium theater.

In the past few years the museum sales counter has been found to perform a real educational service and, of course, an economic service for the museum. Neither should be regarded lightly. If the museum makes an honest attempt to screen the material to be offered and to make well founded recommendations to those who seek additional information, the educational value of a sales desk can be high. The Hayden Planetarium has a wide range of books, charts, telescopes, etc. priced from 50¢ to $50.00. Their annual gross is up in the $60,000 bracket. To be effective, any sales desk should be located where it will stop the greatest number of potential customers. Notice the situation here at Cranbrook. The sales desk at Fort Worth is directly opposite the ramp leading up to the chamber.

Realizing that man has at last gained his toe-hold in space, with the result that the wild west is no longer the only frontier open to man, we of the planetarium profession have a definite responsibility. The planetarium in many, many cases will be the only medium available through which those who are interested can learn about their sky surroundings. The standards of our planetarium shows should be constantly revised and set higher. The quality of our presentations should be under constant scrutiny and we should act as one when our advice is sought so that no planetarium now under consideration need operate with unnecessary limitations created by misunderstanding or ignorance or above all, misinformation. They say that experience is a good teacher. She is expensive enough, at any rate, and some of us have had to pay the bill. As with most pioneers, this experience has created a debt, and this debt is something we should all keep in mind. We, as a professional group, should dedicate ourselves through our work in the field and through meetings such as this, to the over-all excellence of the profession and to the further service of science, philosophy and mankind. It is most gratifying to know that in the small planetarium field this has always been the case.

REFERENCE AND SALES MATERIALS; EXHIBITS:

THE ROLE OF REFERENCE AND SALES MATERIALS IN A PLANETARIUM

MAXINE B. HAARSTICK
Director of Planetarium, Minneapolis Public Library, Minneapolis, Minnesota

If they are provided with an adequate staff and sufficient space, the reference library and the sales desk should both function as valuable educational services; the sales desk may be a lucrative source of income, but the material to be sold should be carefully selected on the basis of its educational value.

Reference and sales material play an important part in the educational use of planetaria. A reference library for staff use is essential. For members and the general public, a reference and lending library is desirable despite the problems encountered in its operation. Through careful selection, sales materials can represent an excellent selection of books, pamphlets, and star charts for interested persons in astronomy.

A review of materials in a reference library at a planetarium includes books for all ages and levels of interest. *Exploring the Universe* by R. A. Gallant, *Pictorial Astronomy* co-authored by Dinsmore Alter and Clarence H. Cleminshaw, *An Introduction to Astronomy* by Robert H. Baker and *Vistas in Astronomy* by A. Beer reflect the scope of reference books. Depending on the development of the programming in a planetarium, a reference library becomes strong in special areas. The proximity of the public library in a city to the planetarium determines in part the scope of a reference library. Very few planetaria have lending libraries.

A reference library in a planetarium for the general public is valuable in that a collection of books is assembled and can be perused by the interested persons who might later want to purchase these books for their own library or borrow them from a public library. The collection at a planetarium might be more complete since the purchase of expensive volumes may be justifiable or forthcoming as a gift. It is often difficult to see a complete selection of astronomy books on the open shelf of a public library at one time.

Telescope lending is a popular feature of several planetaria and is in the future plans of many. Small reflecting telescopes and binoculars are loaned on a weekly basis. Usually this service is related to an astronomy club activity. Staffing the reference and lending libraries is a problem. The collection of reference materials and purchase of telescopes is also limited by the budget.

The sales counter is a part of the educational services of many planetaria. Stocked with recommended books, pamphlets, star charts and photographs, the sales counter can be a profitable enterprise. Generally, if there is a profit in the operation it goes into the general fund for equipment not easily purchased within the annual budget.

Selection of reference and sales materials is usually the responsibility of the director or staff member in charge. One of the most pressing problems involved in the operation of a sales counter is staffing it adequately in rush periods which usually follow the planetarium shows. This problem has limited the stocking of items which would require special help from the sales person. Large maps and other items requiring space are not suitable for the space usually given to sales counters. Storage of stock is another problem.

Where the sales counter serves as an information center, the sales personnel often have difficulty referring technical questions to the proper authorities. Getting personnel with sufficient interest in the subject of astronomy to work in the sales counter is another problem, although the use of volunteers has worked successfully.

Telescopes have not been stocked in sales counters because of the individual attention which would have to be given in explaining the merits of the instrument and its use. Junk souvenirs are considered in poor taste, and for the most part all items are selected for their educational value.

Sources of sales counter materials are made available through museum supply houses and publishing companies. The market is flooded with literature and "gadgets" related to the space age. Careful selection of these items for the sales counter is important in view of the dual role of the sales counter as an educational service and a profitable enterprise.

Little effort is made to talk about literature in planetarium shows. However, special exhibits of literature in planetaria gives the visitor a sample of recommended books on the market. Some planetaria publish lists of books and items sold in their sales counter.

A reference library with some lending materials and a sales counter are considered educational features of a planetarium. Selection of materials, adequate staffing, and space for this service are important aspects of planetarium administration.

A SUGGESTED LIST OF REFERENCES ON ASTRONOMY

TITLE	AUTHOR	PUBLISHER	PRICE
A Guide to the Constellations	Samuel Barton	McGraw-Hill, 1943	$ 5.00
A Primer for Star Gazers	Henry M. Neely	Harper & Bros., 1946	5.00
Across the Space Frontier	Edited by C. Ryan	Viking, 1952	4.50
An Introduction to Astronomy 5th edition	Robert H. Baker	B. Van Nostrand, 1957	4.85
Arizona's Meteorite Crater	H. H. Nininger	World Press, Inc., 1957	3.75
Astronomy	John C. Duncan	Harper & Bros., 1955	6.00
Astronomy	Henry N. Russell Raymond S. Dugan John Q. Stewart	Ginn & Company, 1955	6.50
Astronomy Made Simple	Meir H. Degani	Doubleday, 1955	1.00
Between the Planets	Fletcher G. Watson	Harvard Univ. Press, 1956	5.00
Conquest of the Moon	Edited by C. Ryan	Viking, 1953	4.50
Elements of Astronomy	Edward A. Fath William Olcott & others	McGraw-Hill, 1954	5.00
Field Book of the Skies	R. N. Mayhall and Margaret Mayhall	Putman's Sons	5.00
Galactic Neulae and Interstellar Matter	Jean DuFay	Hutchinson's Scientific & Tech. Pub., 1957	8.40
Galaxies	Harlow Shapley	Harvard, 1943	3.50
Guide to Mars	Patrick Moore	Muller, 1956	2.75
Introducing Astronomy	J. B. Sidgwick	MacMillan	3.50
Making Your Own Telescope	Allyn J. Thompson	Sky Pub. Corp., 1947	3.50
Meteor Astronomy	A. C. B. Lovell	Oxford Univ. Press, 1954	10.40
Handbook of the Heavens	Hubert J. Bernard Dorothy A. Bennett Hugh S. Rice	McGraw-Hill	4.95
Observational Astronomy for Amateurs	J. B. Sidgwick	MacMillan, 1955	10.00
Of Stars and Men	Harlow Shapley	Beacon, 1958	3.50
Pictorial Astronomy	Dinsmore Alter & Clarence H. Cleminshaw	Thomas Y. Crowell Co., 1956	5.95
Radio Astronomy	J. L. Pawsey & R. N. Bracewell	Oxford, 1955	8.80
Realities of Space Travel	Edited by L. J. Carter	McGraw-Hill, 1957	8.75

TITLE	AUTHOR	PUBLISHER	PRICE
Rockets, Missiles & Moons	Charles Coombs	William Morrow, 1957	3.75
Rockets, Missiles & Space Flight	Willy Ley	Viking, 1951	5.95
Rocket Power & Space Flight	G. Harry Stine	Henry Holt, 1957	3.75
Scientific Uses of Earth Satellites	Edited by James A. Van Allen	U. of Mich. Press, 1956	10.00
Skyrocketing into the Unknown	Charles Coombs	Wm. Morrow, 1954	4.00
Stars in the Making	Cecilia Payne-Gaposchkin	Harvard Univ. Press, 1952	4.25
The Amateur Astronomer	Patrick Moore	Norton, 1957	4.50
The Changing Universe	John Pfeiffer	Random House, 1956	$ 4.75
The Comets and Their Origin	R. A. Lyttleton	Cambridge Univ. Press, 1953	5.50
The Earth as a Planet (The Solar System Vol. 2)	Edited by Gerald Kuiper	U. of Chicago Press, 1954	12.50
The Elements of Astronomy	Edward A. Fath	McGraw-Hill	5.50
The History of the Telescope	Henry C. King	Sky Pub. Corp., 1955	12.50
The Galactic Novae	C. Payne-Gaposchkin	Interscience Pub., 1957	8.50
The Mars Project	W. Von Braun	U. of Ill. Press, 1953	3.95
The Milky Way (3rd Ed.)	B. J. Bok & P. F. Bok	Blakiston, 1957	5.50
The Nature of the Universe	Fred Hoyle	Harper & Bros., 1951	2.50
The Planets, Their Origin & Development	Harold C. Urey	Yale Univ. Press, 1952	5.00
The Planet Jupiter	Bertrand M. Peek	MacMillan, 1958	8.50
The Planet Venus	Patrick Moore	MacMillan, 1957	3.00
The Story of Astronomy	Arthur L. Draper & Marian Lockwood	Dial Press, 1939	3.00
Space Encyclopaedia	Sir Harold Spencer Jones & others	Dutton	6.95
The Stars in Myth and Fact	Oral E. Scott	Caxton Printers, 1942	4.00
The Sun (The Solar System I) Vol. I	Edited by Gerald Kuiper	Univ. of Chicago Press	12.50
Theories of the Universe	Edited by Milton K. Munitz	Free Press, 1957	6.50
Through Space and Time	Sir James Jeans	Cambridge Univ. Press, 1934	4.25
Through the Telescope	Edward A. Fath	McGraw-Hill	2.75
When the Stars Come Out	R. H. Baker	Viking, 1954	3.50

TITLE	AUTHOR	PUBLISHER	PRICE
Vistas in Astronomy (Volume I)	Edited by Arthur Beer	Pergamon Press, 1955	28.00
Vistas in Astronomy (Volume II)	Edited by Arthur Beer	Pergamon Press, 1955	44.00

A SUGGESTED LIST OF CHILDREN'S BOOKS ON ASTRONOMY

TITLE	AUTHOR	PUBLISHER	PRICE
A Dipper Full of Stars	Lou Williams	Follett	$ 2.50
Beyond the Solar System	Bertha Parker	Row, Peterson	.40
Book of the Stars	Louis Sutherland	Bernard Ackerman, 1944	3.00
Book of the Stars	Wm. Tyler Olcott	Putnam	3.75
Comets	Herbert S. Zim	Wm. Morrow, 1957	2.50
Cosmic View	Kees Boeke	John Day	3.25
Experiments in the Principles of Space Travel	Franklyn M. Branley	Crowell	2.00
Exploring Mars	Roy A. Gallant	Doubleday, 1956	2.50
Exploring the Moon	Roy A. Gallant	Doubleday, 1955	2.50
Exploring the Universe	Roy A. Gallant	Doubleday, 1956	2.50
Fun with Astronomy	Mae & Ira Freeman	Random House	$ 1.50
Introducing the Constellations	Robert H. Baker	Viking Press, 1937	4.00
Let's Read About Stars	Lucille Sutherland	Webster, 1957	
Man-Made Moons	Irving Adler	John Day, 1958	3.50
Mars	Franklyn M. Branley	T. Crowell, 1955	2.50
Man-Made Satellites	Willy Ley	Guild Press, 1958	1.00
Orbit	Hy Ruchlis	Harper & Bros., 1958	2.75
Our Starland	C. C. Wylie	Lyons & Carnahan	
Patterns in the Sky	W. Maxwell Reed	Wm. Morrow, 1951	2.75
Picture Book of Astronomy	Jerome S. Meyer	Lothrop, Lee & Shepard	2.75
Space Pilots	Willy Ley	Guild Press	1.00
Space Stations	Willy Ley	Guild Press, 1958	1.00
Sun and Its Family	Bertha Parker	Row, Peterson	.40
The First Book of Space Travel	Jeanne Bendick	Franklin Watts, 1953	1.95
The Golden Book of Astronomy	Rose Wyler & Gerald Ames	Simon & Schuster, 1955	3.95
The Real Book About Stars	Hal Goodin	Garden City	1.25
The Stars	Irving Adler	John Day	

TITLE	AUTHOR	PUBLISHER	PRICE
The Stars	H. A. Rey	Houghton, Mifflin, 1952	5.00
The Stars by Clock & Fist	Henry M. Neely	Viking, 1956	4.00
The Stars for Sam	W. Maxwell Reed	Harcourt, Brace	4.00
The Stars: Stepping-Stones into Space	Irving Adler	John Day, 1956	2.95
The Sun	Herbert S. Zim	Wm. Morrow, 1953	2.50
The Sun & Its Family	Irving Adler	John Day, 1958	3.00
The Wonderful World of Mathematics	Lancelot Hogben	Garden City, 1955	2.95
This Way to the Stars	John Schealer	E. P. Dutton	2.95
Worlds in the Sky	C. L. Fenton & M. A. Fenton	John Day	2.50

SOURCES FOR FILMS, SLIDES, CHARTS, PUBLICATIONS, ETC.

Adler Planetarium & Astronomical Museum	Chicago 5, Ill.
Astronomical Society of the Pacific	675 18th Ave., San Francisco, Calif.
Astro Murals, Inc.	231 West 59th Street New York 19, N. Y.
Astronomy Charted	33 Winfield Street Worcester 10, Mass.
California Academy of Sciences	Morrison Planetarium Golden Gate Park, San Francisco, Calif.
Encyclopedia Britannica	1150 Wilmette Ave. Wilmette, Ill.
Faucett Books	Dept. 367, Greenwich, Conn.
International Screen Organization	1445 18th Ave. North St. Petersburg, Fla.
Life (Filmstrip Division)	480 Lexington Ave. New York 17, N. Y.
Maco Magazine Corporation	480 Lexington Ave. New York 17, N. Y.
Maxton Publishers, Inc.	15 East 26th Street New York 10, N. Y.
Museum Supply Service	P.O. Box 2122 Madison 5, Wisconsin
New American Library of World Literature, Inc.	501 Madison Ave. New York 22, N. Y.
Society for Visual Education	1345 Diversey Parkway Chicago 14, Ill.

Sky Publishing Corporation	Harvard College Observatory Cambridge 38, Mass.
The American Museum - Hayden Planetarium	81st Street & Central Park West New York 24, N. Y.
Whitestone	1100 West Broadway Louisville, Kentucky

MAGAZINES, PERIODICALS, PAMPHLETS AND CHARTS

Bulletin for Visual Observers of Satellites	Smithsonian Astrophysical Observatory, 60 Garden Street Cambridge 38, Mass.
Griffith Observer	Griffith Observatory P.O. Box 27787 Los Angeles, Calif.
Monthly Evening Sky Map	Published quarterly by Maria Barritt, Box 3, Pike County, Shohola, Penna.
National Geographic Magazine	Published by National Geographic Society Washington 25, D. C.
Nature Magazine	Nature Magazine 1214 16th Street Washington 6, D. C.
The Observer's Handbook	Royal Astronomical Society of Canada, 252 College Street, Toronto 2B, Ontario
Sky Reporter	Monthly insert, Natural History Magazine, Central Park West at 79th St., New York 24, N. Y.
Sky and Telescope	Sky Publishing Corporation 60 Garden Street Cambridge, Mass.
Scientific American	Scientific American Inc. 415 Madison Avenue New York 17, N. Y.
Space	Published by Ben Adelman 4211 Colie Drive Silver Springs, Md.
Splendors of the Sky	Sky Publishing Corporation 60 Garden Street Cambridge, Mass.
Stars of Summer	The Adler Planetarium & Astronomical Museum, No. 2 of a Series of booklets on Astronomy
Strolling Astronomer	Association of Lunar & Planetary Observers, Las Cruces, New Mexico

PLANETARIUM EXHIBITS

MAURICE G. MOORE
Director, Longway Planetarium, Flint, Michigan

Exhibits should be temporary, topical and pertinent to the current demonstration; fresh material for display may be found in student-built exhibits, exhibits exchanged among planetaria and exhibits provided by companies engaged in the manufacture of items related to astronomy.

The phrase "planetarium illusion" is often used to indicate that section of time when the lines of the dome melt into an artificially created evening sky. And yet, in a broader sense the "planetarium illusion" must apply to everything the audience sees, feels, and thinks. A planetarium is a composite of impressions, and each of these impressions must be artistically related, culminating in a satisfactory and informative experience.

Every demonstration has its beginning long before the star switches are pressed by the lecturer. When the visitor enters the planetarium, the exhibits must be of such quality that they will whet the appetite of the visitor, thereby making him a more appreciative audience when ushered into the circular sanctum.

Planetarium people are not a particularly unusual breed of people — they, too, tend to follow the line of least resistance. This means that all too often exhibits are left up longer than desirable. One planetarium director with whom I corresponded said that most of their exhibits had been on display over twenty years. I think all of us realize that some displays do have a degree of permanency, but in order to avoid the fallacy of believing that all displays have this quality, many planetaria keep several cases marked for monthly change. These changes are made in accordance with recent astronomical news or with the current public presentation of the planetarium. Dr. Linsley has managed to change the exhibits at the Bishop Museum regularly and pertinently by simply projecting colored slides onto a flat wall surface. Such a method certainly fulfills the requirements of good exhibition, and it's inexpensive too.

Planetaria that function as units in general science museums will find it impossible to keep all exhibits in line with the proposed objectives of the planetarium, but certainly demonstrations can be arranged within the physical plant so that astronomical displays are clustered in and around the projection chamber. Such an arrangement would lend immediacy and impetus to the demonstration itself.

The planetarium exhibits and the planetarium demonstration tend to reinforce each other when handled properly. This means that the people who have been assigned to work in the display area should call attention to those exhibits which augment the current sky show. Likewise, the lecturer can reinforce the effectiveness of the exhibits by weaving mention of them into his lecture. Even in the brief time we have been in operation in Flint we have found that the exhibits that have been the subject of this mutual promotion have been very popular with our visitors.

As you know, Buhl Planetarium has done an outstanding job in relating its presentations to the public school program. Part of this school program is presented graphically in exhibits that are created by the students themselves. If they lack anything in quality, they make up for this deficiency by building good will and good public relations for the planetarium. And these exhibits also have the desirable quality of being temporary, since they are displayed in the galleries for only three weeks.

But suppose you haven't developed your school program to this point. And suppose you're not an artist like Tom Voter and can't make your own spectacular exhibits every month. Where do you go from this point? I'm a novice in this planetarium business, but I do ask questions, and this is one of the questions I have often asked of my more experienced colleagues. Their reply has been simple and direct: "Write letters." Write to each and every company engaged in manufacturing items related to astronomy. Many of these letters will go unanswered, but a few will result in new centers of interest. For example, Griffith has been promised a nose-cone as a result of a letter sent to Lockheed Company, and Hayden Planetarium set up two new exhibits this week — one from IBM dealing with computers used in astronomy and one from Republic Aviation dealing with the progress of space vehicles.

One idea that has appeal, but no formal planning behind it, is that of the interplanetary loans of exhibits. Of course, several planetaria have exchanged exhibits but this has been a personal sort of horse-trading. It may be that in a short time we will see exchanges of exhibits becoming more and more prevalent. Perhaps each of us could make an inventory of displays we would be willing to exchange. Information such as subject, height, weight, and width could be mimeographed and sent to other planetaria, probably in geographic proximity. Such a procedure might prove an effective safeguard against exhibition stagnation.

One thing on which I'm sure we can all agree is that planetarium displays are not stepchildren that can be treated lightly. Interesting and meaningful exhibits cannot be dispensed with any more than we can dispense with the music which also heightens the planetarium illusion. Three points seem to summarize the use of planetarium exhibits quite well: (1) keep them meaningful, (2) keep them fresh, and (3) keep them closely oriented in terms of space and subject material. And above all, we must all remember that we are engaged not in a competitive business but in a cooperative enterprise. And this cooperation should extend beyond the idea level sharing that we are doing here at Cranbrook. It should apply to exhibit exchanges as well, whenever such an exchange seems to be mutually advantageous.

PRESENTATION METHODS AND SPECIAL EFFECT TECHNIQUES: INTRODUCTORY REMARKS

JAMES A. FOWLER
Curator of Education, Cranbrook Institute of Science, Bloomfield Hills, Michigan; Chairman of Session on Presentation Methods and Special Effect Techniques

A planetarium is of itself a remarkable instrument with which it is possible to recreate the appearance and motion of the heavens. However, the impact of the planetarium can be greatly enhanced by different methods of presentation and the use of special effect techniques. This morning our session will be devoted to a consideration of these two aspects of planetarium programming.

There are two schools of thought when it comes to presentation methods. The first includes those planetarium demonstrators who believe it is imperative to present a "live" demonstration. The second embraces those demonstrators who feel that a recorded lecture-demonstration is just as effective. Likewise, there are those who hold that factual demonstrations are far more desirable than illusionary trips to the moon, Mars or some other point in outer space; in other words, science fact versus science fiction.

Our first speaker is associated with a planetarium installed at a military establishment. This planetarium serves as a teaching aid in the training of engineers but is also used to entertain the military personnel at large and the general public in the immediate vicinity. I am sure that the approach employed under such circumstances should be most enlightening.

Our second speaker, Mr. William Schultz of the Cranbrook School, will describe an inexpensive planetarium made with "do-it-yourself" materials. In view of the cost of the larger professional models, this home-made planetarium should have great popular appeal. Such a small "model" of a planetarium might well be used to stimulate community support for a full-scale planetarium by those seeking to raise funds for this purpose.

The third speaker, who has constructed and who operates his own planetarium, and who trains high school students to present the demonstration, will show how effectively a recorded planetarium lecture can be utilized by these students.

Although different methods of presentation are vital to a successful planetarium demonstration, the use of special effect techniques is probably even more important since through these techniques astronomical phenomena can be simulated which could not otherwise be achieved with the standard projector and its accessories.

Of these special effect techniques, one of the most impressive is the use of sound effects. These have a two-fold application. One really belongs to the realm of presentation methods since it concerns the use of music to dramatize the presentation.

In many planetaria, "coming in " music is provided while the audience is being seated and waiting for the program to begin. This music need only be pleasing but can be more effective if it is tied in with the season of the year. Music is also valuable as a background for such portions of the demonstration as the sunset and sunrise. If, in addition to the music, a variety of suitable sounds, such as bird songs, insect and frog calls, are added, the effect is even more dramatic.

Music for planetarium programs should be selected with great care. If you are not musically inclined, it would be wise to seek assistance since inappropriate music is much worse than no music at all.

There are an infinite number of ways in which sound can be employed in the planetarium other than to provide music. The fourth speaker has been experimenting for some time with the use of sound and will describe and let us hear some of the ways in which music and other sound effects can be applied and how they can be achieved with conventional equipment.

Perhaps the most interesting aspect of special effect techniques is the ingenuity shown by many persons responsible for planetarium demonstrations in the construction of devices which produce an amazing array of effects from simple, inexpensive and easily obtainable materials. Needless to say, most of the devices used with the large planetarium projectors are far more elaborate and must be made with much greater precision. One such device is described in the paper by George W. Bunton of the Morrison Planetarium in California. But we are much more concerned with those devices which can be made by almost anyone who has a bit of mechanical skill or an aptitude for gadgetry. Perhaps this Symposium may provide the incentive for someone to prepare a book devoted to a description of these "home-made" devices. Certainly among our speakers on special effects there is someone eminently qualified to write this book It is conceivable that in order to be complete a book of this type should be compiled in cooperation with planetaria throughout the country where such devices have been made and are in use.

Even this book would not be a "panacea" for all planetarium operators. There are many planetaria which do not have anyone on their staff with the necessary degree of mechanical skill to design and construct these accessory devices. For this reason, when planning your planetarium it would be wise to explore your community for someone with an aptitude for this type of construction and an interest in assuming this responsibility.

The final speaker this morning will present a vivid demonstration of the way an old technique is being employed with refreshing effectiveness to show astronomical phenomena with authenticity and aesthetic appeal. This will be a demonstration of "black light" techniques for achieving unusually realistic effects especially in connection with accessory exhibits and displays.

PRESENTATION OF PLANETARIUM PROGRAM

JAMES H. HARNDEN
U. S. Army Engineer School, Fort Belvoir, Virginia

Lacking a personal touch, the recorded lecture fails to hold the attention of the average audience as effectively as the "live" lecture; recorded lectures should only be used for demonstrations which require very precise synchronization of sound effects and narration.

Demonstrations are presented at the Fort Belvoir Planetarium by five military personnel who are topographic surveyors. Generally, the available personnel have not had practical experience in surveying, but have successfully completed the Topographic Surveying Course at the Engineer School. Although a background in astronomy would be helpful to the demonstrators, it is not a necessity because the average planetarium program is composed of statements of simple facts which are easily verified. Military service requirements and obligations cause a rapid turnover of personnel with the result that within a year and a half a completely new planetarium staff exists. This requires the newly assigned replacements to make tremendous initial efforts to take on their full share of planetarium duties.

Upon being assigned to the planetarium our personnel are sent to a two-week Instructor Training Course, better known to us as "Charm School". After completion of this course, they come back to us no more charming than before but with the fundamental skills which will enable them to become effective instructors. Their primary mission is to teach astronomy and azimuth determination. They must begin preparation of these lessons and concurrently learn, by practice and by observation of other instructors, to manipulate the controls of the planetarium console so that they can simply and quickly, without the aid of light, illustrate any principle the equipment is capable of demonstrating. They then may help the experienced demonstrators by showing slides or operating a pre-recorded program. This training is not brief or simple with personnel inexperienced both in public speaking and astronomy; and yet the success of our demonstrations has been attributed to the diligent and constant study and preparation of these industrious men who actually enjoy their work even though it is obligated military service. The fact that we have increased the number of programs from one to over ten is further testimony to their outstanding attitudes and efforts.

The use of the recorded lecture has been one of our most extensive projects, and through its use we have found that it is a medium which can be used very effectively, and yet it is one which can be misused. A pre-recorded program lends itself to the more imaginative type of presentation. An example of this is a program such as our "Lunar Excursion" or "Trip to Mars" where a great deal of coordination and precision is needed to achieve certain effects such as rocket blast-offs. This type of program also minimizes the number of personnel required to present it each time. This is an important aspect with our small staff.

Our recorded programs have been made possible through the combined imagination and ingenuity of our present and departed staff members. From *Life* magazine and others we have obtained film strips which we have used to mount our own slides for use in conjunction with recordings. At times it has been necessary to recognize copyright laws by writing for permission to photograph appropriate paintings from certain books. We have received assistance from the Martin Company in the form of a tape recording of the Vanguard launching which we used in the process of making our latest program, "Project Satellite".

Initially our planetarium was equipped with a wire recorder, but we have since changed to a tape recorder; the sound quality is improved tremendously and the tapes are much more durable.

Our first attempt to use a pre-recorded program was in connection with a Christmas presentation entitled "The Star of Bethlehem". This was a simple narration of some of the facts and theories of what the Star of Bethlehem was. This was recorded against a background of seasonal music, and a number of slides were shown as the story progressed. This program is still presented each Christmas season, although we have seen fit to alter some of the subject matter. Of course, we have transferred it to a tape recording.

Our next venture with a recorded program was our first "spectacular" called "Trip to the Moon". A great deal of research and ingenuity went into its make-up, and the result was a well received and enjoyable program. This was our first experience with sound effects and the precise coordination which they require. We obtained slides, and with permission photographed some of the fine paintings of Chesley Bonestell. After much experimentation we decided on certain selections for the musical background and eventually found that an effective "blast-off" can be attained by holding the microphone near a fan. This became our most popular program for all age groups; and, except for a few minor changes and its transfer to tape, it remains essentially the same today. With the conception of our "Trip to Mars" program, which has surpassed the "Moon Trip" in popularity, we have renamed the "Trip to the Moon" program "The Lunar Excursion". The Mars program was made in much the same way as the "Moon Trip" but we were fortunate to obtain all colored slides, which seems to add to its success.

Although we have many other programs available to the public, they are not recorded. We have found that the recorded program can become an escape mechanism if used merely to avoid a seemingly monotonous task of repeating a certain program over and over again. Regardless of the quality of the narrator, this type of program lacks the "personal touch" that is needed and except for rare instances will not hold the attention of the audience.

With the development of new and better recorders, tapes and accessories, we believe that the quality of the recorded program should be outstanding and last for a period of years. We shall continue to be successful with them, however, only if we use them for the distinctive type of program for which they are suited.

A 45-CENT PLANETARIUM PROJECTOR

WILLIAM SCHULTZ, JR.
Head, Science Department, Cranbrook School,
Bloomfield Hills, Michigan

A small, home-made planetarium, constructed by seventh grade science students, provides an inexpensive "substitute sky" on nights when observation of the real sky is impossible and helps to build public support for the construction of a full scale planetarium.

This project was undertaken for two reasons: to provide a "sky" for visitors to our observatory on cloudy nights and as a class project in seventh grade general science. This planetarium was developed before the appearance of the small $15.00 Spitz instrument which would now eliminate the first reason for construction.

The 45-cent expenditure was for two sheets of 22-inch by 28-inch black light-weight cardboard and a 6-volt light bulb for a battery type lantern. The bulb must have a concentrated filament — not the crescent-shaped type — otherwise the star images will appear as tiny arcs of circles.

The ideal shape for a pin-hole type star projector would be a sphere. A more easily constructed shape is either the dodecahedron (12 sides), or an icosahedron (20 sides). The latter was used for this instrument. Notice that the dodecahedron faces are pentagons, while the icosahedron faces are equilateral triangles.

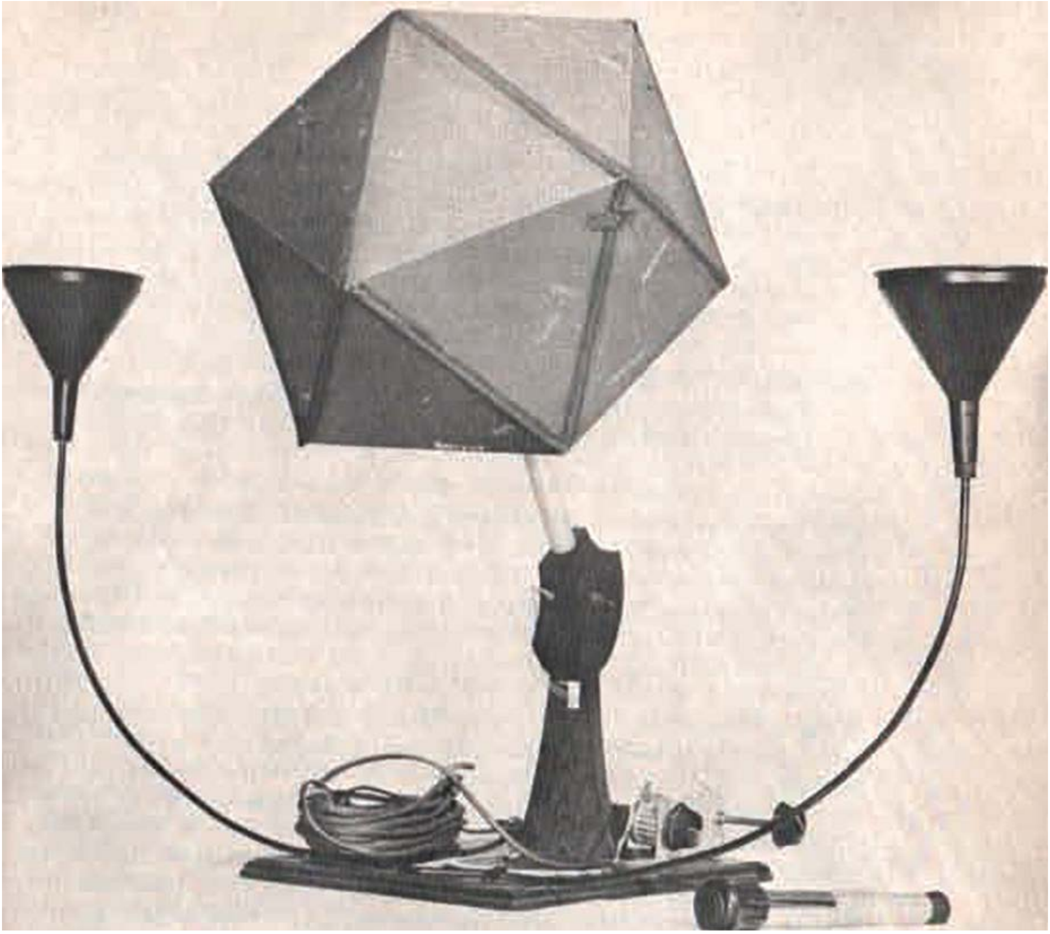
After the icosahedron was made and suitable bearings designed, the pinholes for the star images were located and burned in with red-hot needles of various sizes to represent the various magnitudes. Burning makes a clean hole and insures against the "filling in" which occurs if holes are merely punched.

Only the main stars in each of the constellations were put in, thus the appearance of the planetarium sky is similar to that seen in a large city. The projector shows all twelve of the constellations of the zodiac as well as Ursa Major and Minor, Cassiopeia, Cygnus, Bootes, Pegasus, Andromeda, Aquila, Orion, Canis Major and Auriga.

The projector can rotate to show diurnal motion and is adjustable in latitude from 0 to 90 degrees.

A small 6-volt transformer salvaged from an old radio lights the bulb. The socket for the bulb came from the same source. A year or so after construction other refinements were added. Reflectors for the dome lights are dime-store aluminum funnels and the pointer projects an image of a flying saucer instead of the customary arrow. Rheostats are now used on the dome lights and on the star projector.

I feel that in addition to meeting the needs stated in the first paragraph, this little instrument generated an enthusiasm among some of our trustees and among visitors to the observatory that helped in no small way to provide the incentive for the present beautiful installation of the Spitz instrument in our McMath Planetarium.



The 45¢ star projector

A REPORT ON THE NORTH CANTON PLANETARIUM

RICHARD H. EMMONS
Project Engineer, Interplanetary Midcourse Guidance Study Project, Goodyear Aircraft Corporation, Akron, Ohio

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This experiment shows that a small, relatively inexpensive planetarium can be a practical and profitable investment as well as a valuable educational resource; recorded lectures eliminate the need for trained speakers, make repeat performances virtually effortless and are accepted by audiences as an appropriate and economic expediency.

This is an interim report on a continuing experiment in astronomy education which the writer has been conducting at his home, in the village of North Canton, Ohio, since 1953. There, in what appears to be a private garage, the writer has constructed and profitably operated a semi-public planetarium on an investment figured only in hundreds, and not the usual thousands, of dollars. The importance of the experiment lies in the demonstration of the practicality which is inherent in a small planetarium, and the implication for accelerated growth in the number and distribution of small planetaria.

The North Canton Planetarium, as the facility is called, has a 14-foot diameter, 27-pound portable dome and a home-made star projector, which make it possible to give customary planetarium demonstrations for as many as 40 persons at a time. Diurnal motion is accomplished by motor drive, while manual adjustments permit showing the effect of changes in latitude and procession. The sun, planets, and the moon in its proper phase can be portrayed for any particular date. Auxiliary projectors are used for twilights, solar eclipse, the outlines of constellations, and to simulate an artificial satellite. Photographic slide projections are also used, as is customary, to enrich the program. By combining various capabilities of the projection equipment, the Southern Cross can be shown drifting in the sky over Australia, processed to 10,000 A.D., the midnight sun can be seen from the north pole, or the triple conjunction of Jupiter and Saturn in Pisces in 7 B.C. can be reproduced. The four programs which have been offered during the calendar year are:

"The Autumn Stars", "The Christmas Star", "The Winter Stars", and "The Spring Stars".

Since 1953 more than 10,000 persons have attended these programs at The North Canton Planetarium in capacity groups from virtually every community within a radius of twenty-five miles, including the cities of Akron, Canton, Massillon and Alliance. The residential situation makes it unfeasible to schedule programs on a public, individual admission basis, and therefore the planetarium is operated semi-publicly for groups by reservation. A charge of ten dollars per group has tended to professionalize the service, and through bringing a return on the investment has contributed to the permanence, if not also the dignity, of the service.

The building which accommodates The North Canton Planetarium is 22 feet long and 16 feet wide. Built at a cost of about one thousand dollars, the structure is light-proofed for daytime demonstrations, is insulated and has forced air ventilation and gas heat. The interior is finished with wallboard and is painted dark green. The projection dome, made at a cost of about one hundred dollars, consists of 20 aluminum ribs, a base ring, and a fabric cover complete with skyline silhouette. The dome is easily disassembled and made portable by automobile, and on two occasions has been temporarily installed in other cities as a traveling planetarium. During one of these installations the paid attendance totaled 1500 persons in a period of three weeks. The planetarium projector, which can be duplicated commercially for less than one hundred dollars, provides adequate realism and high positional accuracy in representing about 500 of the brightest stars, the Orion nebula, the galaxy of Andromeda, and the Magellanic Clouds.

The North Canton Planetarium has been operated by each of five local high school science students who were excused from their classes for this educational employment at times of scheduled programs. The planetarium lecture was tape-recorded from a script the writer had carefully prepared, and the young operators had only to practice coordinating the various planetarium controls with the recordings. Three practice sessions usually sufficed to ready them to operate the planetarium. Uniformly successful programs were thus economically achieved, regardless of the frequency of the presentations or the astronomical backgrounds or speaking abilities of the several operators. The use of recorded commentary in the small planetarium is accepted by the audience as an appropriate expediency, just as in the case of educational sound films.

Through the use of recorded commentary, the small planetarium becomes remarkably more practical, overcoming capacity limitations through virtually effortless repeat performances. As planetaria demonstrate inherent practicality, more of them will appear. The small planetarium and recorded commentary combine naturally to form an audio-visual educational medium which can contribute greatly to fulfilling a recognized need for the dissemination of astronomical information. This need exists throughout the United States and the world, and far exceeds the number of qualified planetarium lecturers. There should be at least a small planetarium in service to every school system and community!

"AUTUMN STARS" — A RECORDED PLANETARIUM LECTURE

RICHARD H. EMMONS
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Project, Goodyear Aircraft Corporation, Akron, Ohio

A recorded lecture used in demonstrations at the North Canton Planetarium described in the preceding paper (page 170).

Hello and welcome to the North Canton Planetarium where you have come to see our make-believe stars in our make-believe sky. We will try to make you think you are outdoors on a clear, dark fall evening while we talk about many wonders of the heavens which can be seen from Ohio this time of year.

To make it seem more real we shall fade this dim light slowly as though it were twilight fading after sunset. Then as it grows dark we will slowly turn on the star projector in the center of the room which will make spots of light on the dome above our heads. You will find it easy to imagine these spots of light are the distant stars for they are arranged in the same patterns or constellations as are seen in the outdoor sky. During our program it will help if you try to forget there is a dome overhead. The real sky outdoors may look like a dome to you but the real sky is not a surface. It is instead our view of endless space. The stars, planets and other bodies which make us aware of space are at vast and different distances from us. Two objects may appear side by side in the real sky although one may be millions of times farther away from us than the other. The study of the stars and planets and other bodies in space is called astronomy. Astronomy should never be miscalled astrology which is the foolish attempt to foretell our personal future or character from the positions of the planets. Astronomy is a true science but astrology is an old superstition. Today scientists pay no attention to astrology but they are eager to learn all they can about astronomy. What scientists learn about astronomy with telescopes in places called observatories is best taught to others in a special theater like this called a planetarium.

Learning about astronomy in a planetarium is easier than in a classroom or even outdoors. In a planetarium you can see the stars in comfort at any time you choose without such outdoor problems as having to wait for nighttime or clear weather. Outdoors, as you know, we can't see the stars in the daytime because the sun's bright light is scattered across the sky by the moisture and dust in the air above us, making a curtain of daylight which hides the stars from our view. If we were to travel out into space in daytime beyond the thin layer of air that surrounds our earth, the sun would be seen shining intensely from a dark starless sky. You have noticed that our twilight is fading. We have purposely allowed time for our eyes to get used to the dim light so that when the faint stars appear we would be able to see them.

Now let us watch quietly as night approaches, as the curtain of daylight slowly withdraws after sunset and the starry universe far beyond our reach unfolds before our eyes. If the stars would appear only one night in a thousand years few people would sleep that night away. The little lights in the heavens would be described so that others could read about them for centuries to come. It is fortunate for us that our world is not like the planet Venus from where the stars could never be seen. Venus is wrapped in a blanket of thick clouds which never clear away. We on earth do have the opportunity to look out upon the universe and thereby have learned many important truths which have helped free our minds from ignorance, superstition and fear. And as Ralph Waldo Emerson said, "What we see teaches us to trust the Creator for all that we have not seen". Can you imagine what the first men thought when they looked up at night and saw the stars. They soon recognized that the stars were above the highest mountains and were more lasting than human life. They thought if they could solve the mystery of the heavens it would somehow help them live better lives. The mystery of a little light in the night was so ever present and so challenging that some story of the sky had to be found even if only in their imagination. And so it came about that some of these lights were first believed to be man-like gods looking down on the world, interested in the affairs of the world and with power to control man's fortunes. This old superstition called astrology still lingers in our world today. The child-like people of long ago imagined pictures among the stars just as you may have at some time imagined pictures formed by clouds. The sky pictures formed by stars are called constellations. After early men had filled their night sky with constellations and had made up fairy tales or myths about them, they were able to give entertaining answers when their children asked honest questions about the stars. The constellations and the fairy tales about them have been handed down from parent to child for thousands of years. Anything enjoyed by so many people for so long a time is worth knowing. Also we find the constellations very useful in describing directions in space. They serve to divide the sky into regions just as states divide our great country. Today astronomers and navigators must know the constellations, and many others just enjoy knowing them. So let's look at some of the important constellations we can see on fall evenings.

The most famous constellation is the Big Dipper. A dipper, as you know, consists of a cup or bowl and a long handle. The Big Dipper of the sky consists of seven stars which we will now point out in the planetarium sky with the help of our arrow of light. If we connect these four stars by imaginary straight lines, we trace the bowl, and these three, the handle of the Big Dipper. Although visible from Ohio on any clear evening of the year, since it never quite sets beneath our horizon, it is probably most easily recognized in the fall when it looms large near the northwestern horizon, exactly as we see it here. Large telescopes reveal more than a half million very faint distant stars within the Big Dipper's bowl. Where the Dipper's handle bends you can see a double star. The brighter star is named Mizar; the fainter star is Alcore. Although Mizar and Alcore appear side by side, the distance between them actually measures two trillion miles. These stars are at a distance of 75 light years from us, which means that the light by which we now see them left the stars 75 years ago. Light travels 186,000 miles each second or 670,000,000 miles per hour or about 6 trillion miles each year. The stars of the Big Dipper are all moving through space at speeds of thousands of miles per hour. From the direction and speed each individual star is now moving we can tell where it must have been 50,000 years ago and where it will be 50,000 years from now. Here we see a slide showing how the Big Dipper changes its shape in a period of 100,000 years. All the constellations are changing slowly, but in a human lifetime the changes are too small to be noticed by naked eye. No wonder we call them fixed stars. Have you heard of the Great Bear in the sky? The stars of the Big Dipper are part of the Great Bear who strides along the northwestern horizon in the early evening during fall. These faint stars mark the bear's head. His back stretches over the Dipper's bowl. Here are his hind legs and paws. His front legs are marked by these stars and his front paws are here. The Dipper's handle forms a long tail on the Great Bear. The American Indians before Columbus came knew bears well enough to know they had short tails and although they, like their European neighbors, saw a Great Bear in the sky, they imagined the three stars in the Dipper's handle were three Indians who followed the Great Bear. The first Indian had a bow and arrow with which to kill the Bear. The second Indian carried a pot in which to cook the bear meat and the third Indian carried fire wood.

The last two stars in the Big Dipper's bowl are called the pointers. They form a line which always points to the famous North Star. Watch the arrow and you will see how the pointers are used. The North Star is no brighter than many other stars. Its fame comes from its position, not its brightness. It is almost directly over the earth's North Pole in line with the earth's axis of rotation and shows us the north direction from wherever it is seen. It is sometimes called the Pole Star or Polaris.

The earth spins around on its axis like a huge top, carrying us with it as it makes one full turn every 24 hours. We in Ohio are being carried eastward by the turning earth about 700 miles per hour. We find it hard to realize we are moving since everything around us is moving with us, even the ground and air, but by watching changes in the sky we can prove we are moving. All the objects in the sky seem to move in circles around the North Star once every 24 hours. In our planetarium sky we can show this same effect speeded hundreds of times faster than in the outdoor sky by simply switching on the projector's motor. Remember, as you watch our planetarium stars drift as real stars appear to drift throughout the night, that we have speeded the passing of time so that we see in ten seconds the change that requires an hour to see outdoors.

In the next few minutes we will watch the Big Dipper, the Great Bear and all the other stars appear to wheel once completely around the star Polaris as the turning earth makes them appear to do in the outdoor sky. Since we have removed the sun from our planetarium sky we can watch this effect as though it were a 24-hour night without the interruption of sunrise and daytime. Notice the stars keep their fixed distance from Polaris as they appear to move around it. They also keep their same relation to one another. The pointer stars in the Big Dipper's bowl faithfully keep pointing to Polaris. In watching the Big Dipper appear to move you are learning that constellations can appear in different parts of the sky while their stars keep the same pattern. You recognize the Big Dipper and each of the constellations by its shape or pattern, not by its tilt or direction, no matter in what part of its daily apparent circle around Polaris it is seen.

Stars that are so near Polaris that they appear to pass under it without setting are called circumpolar stars. The stars of the Big Dipper are circumpolar. All the clocks of the world are set and regulated to the turning of the earth. Time is first found by the astronomers who carefully observe the instant stars appear to pass overhead. You may set your watch to time announced over the radio, but the radio station first set its clock to time obtained by the astronomers. The brightness of stars is measured by what is called their magnitude. The very brightest stars are called first magnitude stars. The faintest that can be seen by naked eye are sixth magnitude. Giant telescopes have revealed stars down to the twenty-third magnitude and no doubt there are many times as many beyond the reach of our telescopes, unseen and unknown to us. A star's brightness depends on its temperature, its size and its distance. A faint star may be actually larger in size than a brighter star which is nearer to us. Stars are giant balls of hot gas, too hot to burn in the ordinary sense and which produce their heat and light in a manner known to us only in an exploding hydrogen bomb. Our sun is a typical star, appearing larger and brighter than all the rest because it is so much nearer. The stars we see at night are 250,000 or more times farther away than our daytime star, the sun. The sun is only 93,000,000 miles from us. Although there are countless billions of stars in the universe, we know of only 9 planets. Planets are cool solid balls like our earth which travel around the sun. The other stars are too far away to see if they have planets going around them. While telescopes permit close study of the nearby sun and planets, they show the stars only as brightened points of light.

The North Star marks the end of the handle of the Little Dipper. Seven stars again form a bowl and handle, but the shape is a little different from that of the Big Dipper. Outdoors the Little Dipper is difficult to see unless the night is quite clear and dark. These same stars form the constellation of the Little Bear. Winding between the Big and Little Dippers we see a chain of stars known as Draco, the dragon. These four stars mark the dragon's head and winding through here we see his snake-like body. In the northeastern sky during fall evenings is the constellation Cassiopeia, known to many as the broken chair. Here we see the legs of the chair. Here, the seat. And its back appears broken at a point where a star seems out of place. Men of long ago thought of it as a throne on which Queen Cassiopeia was sitting. It may look to you like the letter W or at other times, the letter M. Queen Cassiopeia's husband, King Cepheus, is at her side among these stars. The daughter of Queen Cassiopeia and King Cepheus, the Princess Andromeda, is nearby, completing the royal family. These chains of stars were said to be wrapped around the princess. There is a story or myth about these chains which we will tell in a few minutes. But now, notice this faint blur of light in the constellation Andromeda, for it is the farthest object that can be seen without a telescope. Through the telescope, as shown here, it is seen to be a galaxy or vast cloud of about one hundred billion suns, so deep in space that its light travelling six trillion miles a year takes about one million six hundred thousand years to reach our eyes. We see the galaxy of Andromeda by antique light as it was about one million six hundred thousand years ago.

The gallant hero Perseus appears as an inverted letter Y northeast of Andromeda. The star known as Algol in the constellation Perseus is a variable star whose light fades from second to third magnitude about every third night. Early men believed this star was a demon's eye which winked at them from above. Now astronomers know that this happens because a dark star is moving around Algol and regularly comes almost in front of Algol, cutting off some of its light to earth. The Perseid meteor shower radiates from this constellation in August each year as the earth crosses the path of a former comet and collides with many small particles moving in the comet's wake. These stars southwest of Andromeda represent the faithful flying horse on which Perseus rode called Pegasus. You might find it easier to remember them together with a star from Andromeda forming a great square, or as a baseball field with home plate, first, second, third bases, and even the catcher's box.

One of the largest constellations is Cetus, the monster of the sea. On fall evenings it is seen in the southeastern portion of the sky. Five stars mark the monster's head. A long neck joins the head to the body. The star, Mira, midway down the monster's neck, is one of the largest known stars, twenty-seven million times larger than our sun, but six and a half million times farther. An ancient Greek myth tells of Cassiopeia, Cepheus, Andromeda, Perseus, Pegasus and Cetus. It seems that Queen Cassiopeia had boasted that she was the most beautiful woman in the world. This made the mermaids of the sea angry for they believed that they were more beautiful. They asked King Neptune of the sea to punish Cassiopeia for her vanity and he sent a sea monster, Cetus by name, to terrify all the people who lived along the seashore where Queen Cassiopeia and King Cepheus ruled. King Cepheus learned that the only way to save his country from Cetus was to give his daughter, the Princess Andromeda, to the monster, which he then decided must be done. So poor Andromeda was wrapped in chains and left on the shore to await the coming of Cetus. Just then Perseus happened to come by on the back of his flying horse, Pegasus, returning from a trip in which he had slain the hideous gorgon named Medusa. He was carrying with him the gorgon's head which had a strange power. Any creature that looked at the gorgon's head, with its snakes for hair, immediately changed to stone. Perseus saw Andromeda chained at the seashore and decided to try to help her. Just as he arrived, Cetus rose out of the water and Perseus, while shielding himself and Andromeda, held out the gorgon's head and the monster then looked upon it and immediately turned to stone. He then took the chains from Andromeda and returned her happily to King Cepheus and Queen Cassiopeia.

High above us during the autumn evening is the constellation

Cygnus the Swan, better known as the Northern Cross. Here is the mainstay and here is the cross piece. The first magnitude star at the head of the Northern Cross is called Deneb. The star Albireo is at the foot of the cross and is a beautiful double star when seen even in a small telescope. The two stars which together make Albireo to the naked eye are colored blue and gold which shows they are of different temperature.

West of the Cross is the constellation Lyra, the Harp. It is a small constellation but its star, Vega, is one of the brightest stars in the entire sky. The star Beta Lyra is actually a double star consisting of two giant suns separated from each other by only six million miles, across which great streams of hot gasses flow from one to the other and into space at the rate of three million billion billion tons each year.

There is a faint object in the constellation Lyra unseen by the naked eye known as the Ring Nebula. It is the result of a star having exploded long ago. Through the telescope it looks like a ring of smoke. A number of stars have been known to explode, blowing off their outer shells which become smoke rings in space. Here is a picture of one of these objects taken with the largest telescope in the world on Mount Palomar. Here the ring is ten thousand billion miles across and still growing larger at the tremendous speed of several thousand miles each second centuries after the original explosion. When a star explodes and the light of that explosion finally reaches earth after many, many years of travel through space, we first see what appears to be a new star, or Nova. The star may have been too faint to have been noticed before the explosion, but now it may become temporarily the brightest star in the sky, possibly visible during broad daylight.

Now if you will search our planetarium sky like a true astronomer, looking closely at the constellations you have learned, you may be the first to discover our so-called Nova, or new star. As you study each star pattern we have talked about, you are sharing with scientists the thrill of patrolling the heavens. Discovery of a Nova usually gets into newspaper headlines like the discovery of a new comet. Watch carefully now, for our Nova is appearing in one of the northern constellations and is rapidly growing brighter. After remaining bright for several weeks the Nova fades. Soon it can be seen only by telescope. Years later through the telescope we may begin to see the unfolding of the giant smoke ring like the one we saw in the photograph. Since some stars have been seen to explode, we wonder whether our sun will ever explode. Astronomers assure us that we have nothing to worry about. It is possible they say, but not likely to happen in the next few billion years.

West of Lyra we see the constellation Hercules, recognized by four stars in the shape of a keystone. These stars and others nearby suggested to people of long ago the figure of mighty Hercules in a kneeling position. The sun and all its planets are drifting through space twelve miles per second in the general direction of Hercules.

There is a beautiful cluster of about fifty thousand suns seen by telescope at a point along the western edge of the keystone. Here is a photograph of the Hercules cluster taken through a large telescope. Observers have compared this object to a heap of diamonds on black velvet. Even at the center of this cluster the stars are spaced billions of miles apart. Two such clusters could pass through one another without any of their member stars colliding. There are several hundred clusters known, each about one hundred light years across and about forty thousand light years distant.

A group of stars south of the Northern Cross suggested the figure of a giant eagle in full flight. Persians, Hebrews, Arabs, Greeks and Romans all agreed the constellation looked like a soaring bird of prey and it is still known as Aquila, the Eagle. The star, Altair, marks the eye of the Eagle and together with two other first magnitude stars, Vega and Deneb, form a bright triangle overhead. Between Aquila and Pegasus lies the small constellation, Delphinus, which Boy Scouts call Job's Coffin, but which looks like a kite and tail.

In the southern sky far below the western edge of the great square we come upon the first magnitude star, Fomalhaut, the southernmost of the fifteen first magnitude stars that can ever be seen from Ohio. Fomalhaut rises during the twilight as fall begins each year.

We have talked about the main constellations and other wonders of the fall evening sky. Look for them outdoors some clear evening soon.

Now let's quietly watch our new friends, the autumn constellations, as they drift throughout the night and strange winter stars appear and fade in tomorrow's dawn.

SOUND EFFECTS IN THE PLANETARIUM

DAN SNOW
Planetarium Director, Cleveland Museum of Natural History, Cleveland, Ohio

Recorded lectures are unsatisfactory because they cannot be adjusted to different audiences, but recorded sound effects and recorded music are highly effective used in conjunction with "live" lectures; a boundless variety of sound effects can be obtained with a tape recorder and simple household equipment.

There is no doubt that a good sound system can add tremendously to the effectiveness of planetarium programs, but there is room for discussion about the appropriateness of its use in certain areas. For instance, it is often suggested that planetarium speakers could save a great deal of wear on their vocal chords by taping their programs, and after one has given three or four school programs in a single day it is a very tempting thought. However, it seems unwise to fall back on taped programs. Any perceptive person is bound to feel slighted if the planetarium management does not care enough to provide a live speaker; and in public programs, the varying proportion of children and adults demands a corresponding variation in emphasis which is impossible with a taped presentation. With school classes it would obviously be necessary to have tapes for different grades but even this would not be adequate, for it is well known that there is a considerable variation in the receptiveness of classes on the same grade level. In short, a taped program forbids any adjustment to the audience.

However, there still remains a field of usefulness for tape recorders that is limited only by the ingenuity that is brought to bear. It is unnecessary to point out that music is a great mood-setter and can begin its work at the very beginning of a planetarium program. Twenty or thirty minutes of music before a program begins can make the waiting period more pleasant for the adults and seems to inhibit, to some extent, the restlessness of the children. The choice of this music is not very critical, the main requirement being that it have a pleasant sound.

The first really effective use of music comes with the sunset. Some speakers like to talk their stars out, some like to use only music, and others mix the two. In any event, there are two possible approaches to a sunset. The first, which might be called "The heavens proclaim their glory" approach, makes use of music of high emotional content such as the finale of Strauss' "Don Juan." If the stars are made to appear at full brilliance rather suddenly at the climactic moment, the dramatic impact is considerable. The second approach might be called "The darkness falls from the wings of night" approach and requires a soft eerie type of music such as Griffes' "White Peacock," or the final part of the Neptune movement of Holst's suite, "The Planets." This sort of sunset can be enhanced by the addition of a few birds, crickets, or frogs — sounds which may be obtained from the records produced by Cornell University. If your recorder will play for a whole hour it is pleasant to have appropriate night sounds occurring from time to time all through the program. Be sure, though, that the birds are native and the season proper or there will be complaints.

Some programs, or parts of programs, are made more effective if the speaker talks above a musical background. Much impact can be added to the appearance of a side of the moon, for instance, if it is accompanied by some cold airless-sounding music. Some special effects seem to demand music. As an example, there seems to be no selection that adds so much to a good auroral display as the latter part of Dukas' "Sorcerer's Apprentice." They seem to be made for each other.

The most important of all is the sunrise music, for, properly chosen and presented, it can send your audience on its way with a fine feeling of completion. In this case, there seems to be no doubt that music with a triumphant lift is the best. A few of the many possibilities are: the seventeenth variation of Rachmaninov's "Rhapsody on a Theme of Paganini," the finale of Wagner's "Liebestode," the latter part of Addensell's "Warsaw Concerto," and many others. Obviously the compositions mentioned are only a very few of the many appropriate ones that exist.

In the realm of sound effects, use of the tape recorder is limited only by the amount of imagination and inventiveness available, and for this very reason, it is impossible to go into details here. However, some idea of the possibilities can be gained from a detailed description of a particular production — a blast-off into space for instance. Some planetarium directors are a little embarrassed by this type of program but at this time there is simply too much interest in space travel to neglect it.

It is assumed that the good offices of the chief engineer of a rocket propulsion laboratory are not available to provide the authentic sounds of a rocket exhaust. If they are, so much the better, but if not, a very respectable collection of appropriate noises can be collected from quite ordinary sources.

What is needed is some indication of the approach of blast-off time, the noise of the rocket motors when fired, and appropriate space ship noises when things quiet down.

Traditionally the first of these takes the form of a count down, but there is much to be said for just the ticking of a clock. It seems to be more suspenseful and also gives the lecturer an opportunity to describe to his audience in a pitch black chamber how they are strapped to their acceleration couches and to build up a little suspense with a graphic description of the horrors of rapid acceleration. Just placing a clock next to the microphone gives a pretty thin sound, but if the noisy type of kitchen timer is placed, with the microphone, under a metal wastebasket, the ghostly resonance that results is quite astonishing.

A very fine rocket motor noise can be obtained by playing a stream of water from a rinsing hose with a spray head onto the bottom of a stainless steel sink. This is converted from the sound of water spraying into a sink to the uproar of a blast-off by recording it at a tape speed of fifteen inches per second and playing it back at seven and a half. This drops the pitch of the sound and draws it out into something quite unrecognizable. This is used at a volume just below the threshold of discomfort and a great deal of variety can be added to the effect by twiddling the volume control with one hand and the tone control with the other. It may be remarked in passing that this does not scare the children; on the contrary, most of them seem to love it. This racket may be continued as long as seems desirable and then cut off suddenly with the explanation that the noise can no longer keep up with the space ship which has far exceeded the speed of sound. However, absolute quiet is unrealistic and it helps the effect if the speaker makes his remarks over a background of noises that indicate the presence in the ship of strange and exotic machinery. This type of noise can be found in an infinite variety by a careful exploration of the short wave radio bands. These noises are the by-products of electrical machinery, high speed code transmission, and the like. Some of these sounds are weird enough in themselves but they can be improved by mixing them up. Many tape recorders are so designed that the erase head can be by-passed so that sound can be recorded on sound until the desired effect is obtained.

Other elaborations are possible. For instance, perhaps it turns out that some simple-minded electronic computer has picked a launching date that has landed the space ship in the middle of a meteor shower. A completely ominous sound of meteors striking the outside of the space ship can be obtained by putting the microphone under that metal waste-basket again and drumming at random on the outside with one's fingers. Again, the effect is improved by recording at a high speed and playing back at a slower one.

One final word. It seems unlikely that many planetarium space trips will end up on an inhabited planet, but there is the possibility that some poor shipwrecked creature may be rescued from an asteriod. The immediate problem is how does he communicate, what sort of a noise does he make. Thought transference seems like the cowardly way out and playing speech at the wrong speed won't fool a six year old, but playing ordinary speech backwards produces a wonderful effect that partakes of the quality of double-talk in that it always seems that in another instant it will make sense but never does. Some pretty strange native music can be obtained in this way too. Obviously this is too extreme, but it is worth trying for oneself if only to discover one more example of what is possible.

To summarize, the greatest usefulness of sound equipment is in doing things that the lecturer cannot do and its limitations are the same as his.

THE DEVELOPMENT AND USE OF AUXILIARY DEVICES IN THE PLANETARIUM

GEORGE W. BUNTON
Morrison Planetarium, California Academy of Sciences,
San Francisco, California

The special effects obtained with auxiliary projectors contribute to both the educational value and the dramatic value of the planetarium program; many obscure phenomena are simply and ingeniously reproduced with specially constructed projectors or modified lantern slide projectors.

As must be expected, a great variety of opinion exists among planetarium people regarding the use of the planetarium. This variety is probably greater among the operators of the smaller installations than among those who use the major instruments. This difference arises partly from the fact that the number of smaller planetaria is nearly ten times that of the larger in the United States. But it also comes partly from the fact that all of the larger planetaria are necessarily dedicated to the attraction of large numbers of people. With such a common aim, the philosophy of programming and presentation is very much the same. It may be described as the consideration of the planetarium as a *theater*, and, accordingly, a demonstration within the theater takes on the nature of a drama.

Many of the smaller planetaria are installed as part of educational institutions offering formal courses of study, such as colleges or universities. It is natural under such conditions that the planetarium becomes a teaching aid. It is not to be denied, however, that pedagogy can often profit by the application of a little histrionics.

The planetarium, whether large or small, should be thought of as a "projection theater." It is a unique chamber within which all sorts of magic can be wrought. When the stars are on the dome, the spectator is outdoors viewing the real sky. Regardless of the imperfections of the facilities, the tiny spots of light which appear overhead are at once identified with the stars. The operator should never call attention to an imperfection unless he wishes to make use of it for its own incongruity.

Auxiliary projection devices can contribute greatly to a planetarium demonstration. Some devices may only lend a bit more drama to the performance, such as a sunrise or sunset, while others are of value as teaching aids, such as a projected model of a cepheid variable or the appearance of a nova. The use of lantern slides will be reserved for later discussion.

The development of projectors for special effects would appear to be a task beyond the capacities of all but a few of the smaller planetarium installations. This is not true, however, for very effective projection devices can be fabricated from tin cans, plywood, and mailing tubes. It is not difficult to motorize the operation if it is required. A standard lantern slide projector can be modified to produce special projection effects. The larger size, for $3\frac{1}{4}$-inch by 4-inch slides, particularly, has great possibilities, for ~~when the~~ slide holder is removed there is room to insert considerable mechanism. For a long while at Morrison Planetarium we used such a projector with a special mechanical slide to show the motion of the earth and moon about their barycenter. A large "tubing bearing", a simple ball bearing with very thin walls about two inches inside dimension, was mounted in a wooden slide holder, and an arrangement was provided for mounting a circular glass slide inside the bearing. A pulley was provided and was driven by a small clock-type electric motor to produce rotation of the slide. The slide was made from a drawing showing two white discs representing the earth and moon, the larger one bearing a small black dot at the proper location to represent the barycenter. The slide was mounted so that it would rotate about the small black dot. The same mechanism was used to represent the simultaneous rotation and revolution of the moon. A slide showing two discs, the earth and moon, with an arrow pointing earthward on the side of the moon toward the earth, was mounted and rotated to show that the arrow, which pointed always toward the earth, actually rotated completely with each revolution. Further uses of such a device are readily found. An image of a spiral galaxy rotating slowly is most effective when discussing this phase of astronomy.

It should be pointed out that the slide need not be cut into a circular form as almost any shape can be adapted to the space available within the bearing. An entirely different way of rotating the image is to mount the slide in a fixed position and rotate a dove prism in front of the projection lens. The image will rotate at twice the speed of the dove prism. In this case, care must be taken that the dove prism rotates precisely about the optic axis. Some very strange motions can result if this is not done.

The aurora is one of the most pleasing effects which can be added to the planetarium repertoire. This requires wide angle projection.

A special projector must be constructed for this — a small lantern slide projector containing a slide of the aurora and equipped with a wide angle projection lens. The war surplus $1\frac{1}{4}$-inch Erfle eyepiece serves very well as a projection lens. The aurora slide is made from a charcoal drawing of auroral curtains or bands, is then tinted (ordinary food coloring used in the kitchen works very well to tint the gelatin) and is projected on the dome. A plastic disc of about 1/8-inch thickness is mounted so that it will rotate in front of the projection lens. The plastic is deformed by heating and pressing with large steel ball bearings or some similar device, and as it rotates in the projection beam, the curtains wave and shimmer in a very aurora-like manner. A little black paint placed at random over the plastic disc adds to the mysterious ebb and flow of light.

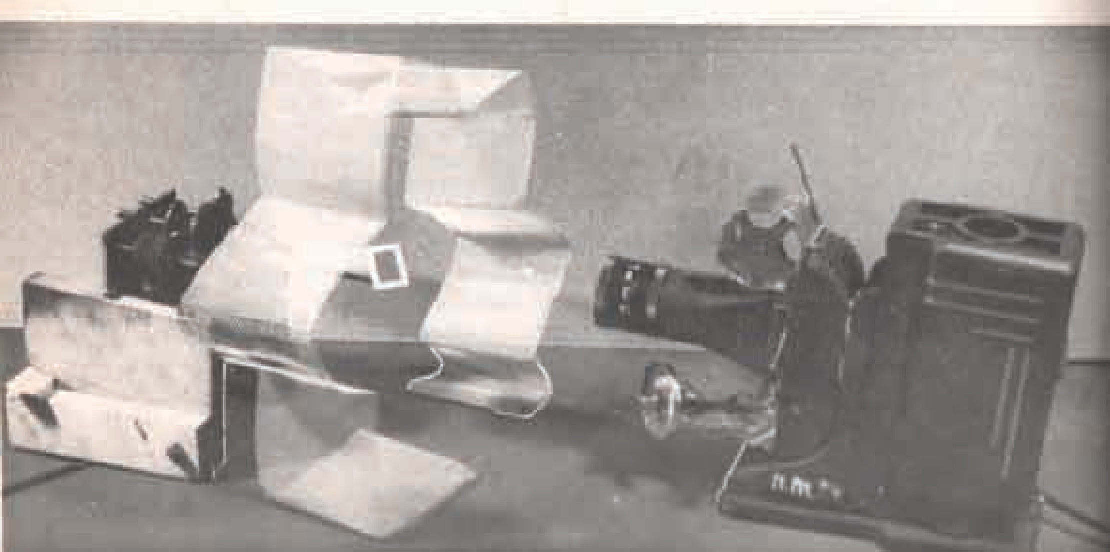
Economy of material and effort is always acceptable, and the application of the same projector to various uses is certainly economical. Two tricks for increasing the versatility of special projectors have evolved at our planetarium.

One of these is particularly applicable to mechanized devices. A metal box, about 10 inches square and 6 inches high, equipped with a hinged lid, is used as the projection case for a number of different devices. A projection lamp socket for the small bayonet type lamps is mounted toward one side of the box, and a tube for a projection lens is mounted opposite the lamp. The projection axis is not centered but is displaced to one side of the box. Provision is then made to mount a metal plate vertically between the lamp and the projection lens. This plate carries a small condenser system and any mechanism needed to produce the desired action. The plate can be removed from the box simply by disconnecting the motor wires and lifting the plate out of its guides.

Two examples of devices used in one of these boxes are the projection model of a cepheid variable star and a stellar evolution model. Both of these use an iris diaphragm activated by a small motor. The cepheid model, when in operation, causes the iris to open and close by a small amount and a rheostat to oscillate in the proper phase to brighten the lamp when the diaphragm is increasing. The image, slightly out of focus, is projected upward by a diagonal mirror in front of the projection lens. This plate can be removed and another with a similar mechanism can be inserted. This one shows a star coming into being from a very large size and shrinking to its stable, main sequence size. Simultaneous color change takes place by the addition of a rotating plastic disc placed in front of the projection lens. The disc carries segments of colored gelatin, running from deep, almost invisible red to a light straw to represent the sun. The mechanism is stopped while the lecturer describes the thermo-

Aurora projector

A simple satellite projector. A needle hole light beam is projected to a slowly rotating mirror, set at a 45 degree angle. A strip of screening bent in a wavy form will cause the projected satellite to fluctuate in brightness as it traverses the dome.



nuclear process that maintains the sun's energy. Then the mechanism can be run through the remainder of its cycle, which is first a slight shrinking with a simultaneous change to a white color, followed by an increase in size and a reddening of the image. When the image reaches its maximum size, it is abruptly turned off and squarely in the center of the former image there appears a tiny white star. This latter episode is intended to represent the ultimate collapse of a star to the white dwarf stage.

The second economy plan for projectors consists of a lamp house and condenser system designed for $3\frac{1}{4}$-inch by 4-inch slide size. This is mounted on a wooden base which extends about 15 inches in front of the lamp house. On this extended base is mounted a rail to carry lens holders which can be moved along the rail to any position, very much like an optical bench. This system allows for the use of any sort of slide or mechanized device to be projected with any lens combination. By combining positive and negative lens elements, extremely long equivalent focal lengths can be obtained by the telephoto system. Mirrors or rotating color discs can also be mounted on this rail.

Illustrative devices such as have been discussed are most valuable in depicting astronomical phenomena which would otherwise be obscure. The main purpose of the planetarium is to interpret science for the layman or the student. It is not in keeping with this purpose to present material that is complex unless it is thoroughly clarified. In speaking to a lay audience, the lecturer must be careful never to present a new idea without first laying a good foundation. In every show, at the first mention of a planet, a brief definition of a planet should be given, the stars should be described, and the difference between a star and a planet should be pointed out. A projection orrery is an excellent addition for this purpose, but unfortunately, such a device is complicated and expensive. The best substitute is a lantern slide of the solar system.

Diagrammatic slides should be used as little as possible. They should always be white lines on a black background with enough contrast so that the diagram seems to float among the stars. The lecturer can even refer to the "drawing on the heavenly blackboard." Pictorial slides may be treated variously. Astronomical objects may be framed in circular masks to suggest a telescopic view. The superimposition of the image upon the object or the part of the sky where the object is located adds to the presentation. Slides should not be projected with so much brilliance as to reduce the sensitivity of the eye to the stars when the slide image is removed. A dimmer on the slide projector makes it possible to fade in an image to the desired brightness. One way of controlling brightness is by the use of an iris diaphragm mounted in front of the projection lens. But the use of slides should be kept to a minimum. Remember that a lantern slide lecture can be given as well in a conventional auditorium and gains nothing by being delivered within the planetarium dome.

While one will admit the truth of the statement that the show is no better than the lecturer makes it, we must also admit that the ability of the lecturer is not the only limitation upon the show. The equipment and the way it is used is at least of equal importance. The time and money invested in the development of special effects devices is well spent, and once a device is built, it is available for further use and even for modification from that time forward. For a man with ideas and a small workshop, the planetarium can become a gadgeteer's paradise.

SPECIAL EFFECTS EASILY PRODUCED

JOHN M. CAVANAUGH
Curator of Astronomy, North Museum and Planetarium,
Franklin and Marshall College, Lancaster, Pennsylvania

A description of devices simply constructed to simulate comets, satellite motion, rotation of objects in space and the approach and recession of objects.

To maintain continuing interest in planetarium shows, as well as to present astronomical concepts in convincing demonstrations, requires an endless source of inventiveness and boundless enthusiasm. Of course an adequate budget helps too.

Motion, color and a sense of realism play an immeasurable part in the successful presentation of a planetarium show. Music, sound effects and the speaker's flair for showmanship build up a crescendo of excitement that makes each presentation a memorable experience for the audience.

While effective demonstrations are the practical way of showing, for example, the changing form and motion of a comet, not every planetarium has the funds or means to have the necessary mechanism engineered and built commercially. Confronted by just such problems, North Museum and Planetarium began building demonstration models for each monthly show. These are used in conjunction with and to supplement the regular Model A Spitz instrument.

Through the generosity of Franklin and Marshall College, under whose authority the Planetarium operates, and through the interest and cooperation of local industries – Hamilton Watch, Armstrong Cork Co., R.C.A., – we were equipped to give free rein to imagination and ingenuity.

A well equipped shop was included in the original Museum building, and this has been the "sine qua non" of all our works; other essentials, many of them donated, are slide projectors, a variety of lenses, small advertising motors, old electric clocks, rheostats, gold fish bowls and pieces of broken mirror.

Satellite Motion: Among the simplest of planetarium effects is to show one of the satellites crossing the sky. This is an especially good ending for a show that closes with sunrise.

Drill a fine needle hole in the center of a 2-inch by 2-inch piece of sheet copper; this will take the place of a regular 2-inch by 2-inch slide. Cut a short piece of dowel rod at 45 degrees and drill a hole in the flat end to fit tightly over the motor shaft, and cement a piece of mirror on the slant end. Push the dowel on the slow speed shaft and with the copper plate in a slide projector, beam the needle hole onto the mirror. The turning mirror will reflect the point of light as a moving object traversing the dome.

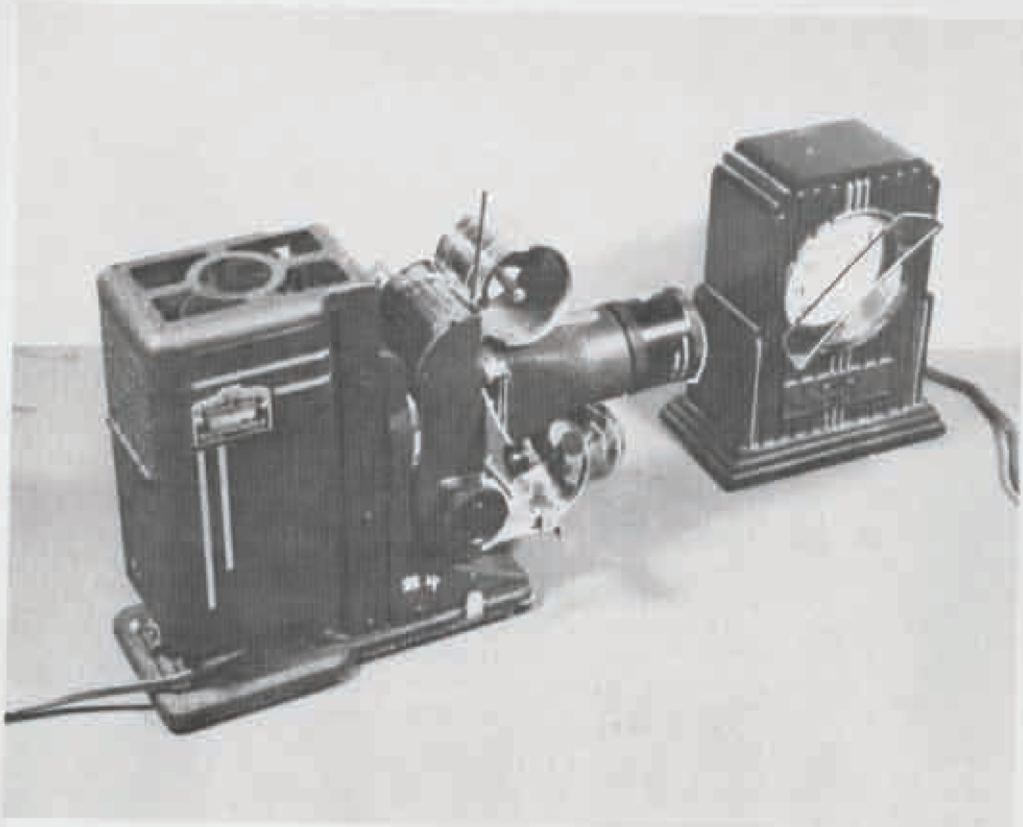
For variations on this, use an old motor that has developed a vibration in the shaft; this will project a periodically lengthened image, demonstrating the tumbling motion of the satellite. The fading and brightening of the image can be effected by projecting through a wavy piece of window screen.

Rotation: Rotation, that universal attribute of things in space, is easily presented. Mount the lens tube of a projector in the center of a wood disc or pulley, so that the tube becomes the shaft on which the disc rotates. Fasten a slide — the earth, the moon, a galaxy, a star cluster, etc. — on the tube opposite the lens and at such a distance that it will focus at the desired projection distance. While a motor turns the disc, beam the projector lamp on the slide and the image will rotate on the dome. Projected images of small opaque objects, space ships, models of the earth and planets may be rotated also by flooding the model with the light of two or three projectors. The changing appearance of Saturn's rings is well demonstrated this way.

Approach and Recession: The expanding and contracting effect, so useful in showing the approach or recession of objects in the sky, is easily and economically produced, and the same process may be used to show the sun's movement in relation to the other stars. A 12-inch copper cylinder, preferably having a hemispherical end and about 6 inches in diameter, is pierced by numerous fine needle holes. A small bulb with point filament is mounted on a sliding shaft which moves in the axis of the cylinder. A reversible motor or reciprocating shaft moving the light axially in the cylinder will cause the simulated stars (projected through the needle holes) to approach, spread out and brighten as we apparently pass through them. The action is reversed by withdrawing the shaft.

Because of continuous shows, demonstrations and exhibits along the walls within the planetarium room seldom receive adequate attention. Aside from this, the value of maintaining the space and sky illusion precludes the use of distracting elements within the same room.

We hope the accompanying photographs will enable planetarium operators throughout the country to build these and other, as yet unthought of, effects to enrich and enliven all our shows.



An easily assembled comet demonstrator. A piece of mirror is attached to the minute hand shaft of an electric clock. A 2- by 2-inch slide is made from a large air-brushed drawing of a comet and projected from the mirror to the dome. During the lecture the comet will be seen slowly moving through the stars. By increasing the projection voltage as it nears the sunrise point, the tail will lengthen and the comet become brighter.

SPECIAL EFFECTS AND ACCESSORY PROJECTORS

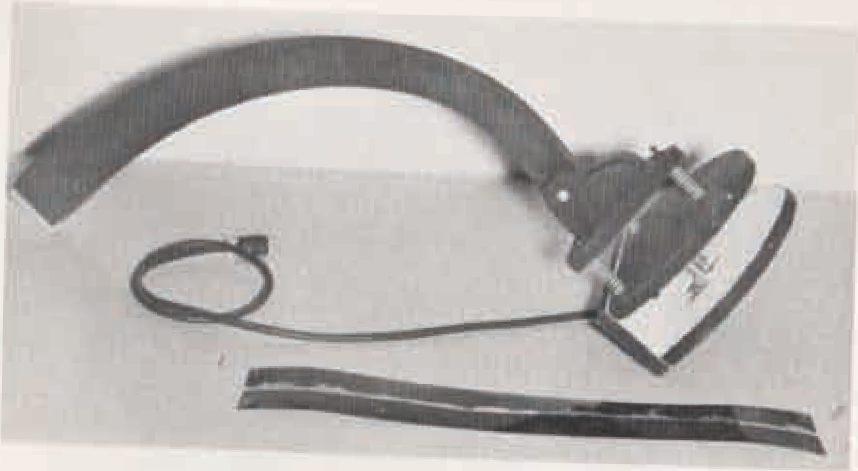
MEARL F. CARSON
Curator of Natural History, Forth Worth Children's Museum,
Fort Worth, Texas

A description of four easy-to-make devices: a lunar landscape projector, a space ship cabin projector, a constellation outline projector and a device for varying the size of the projected image.

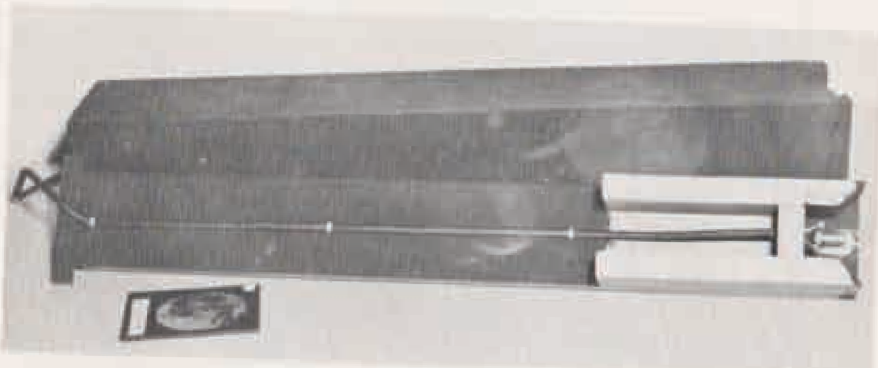
At the Charlie M. Noble Planetarium in the Fort Worth Children's Museum, Fort Worth, Texas, we have learned it is desirable to construct auxiliary projectors to be used during regular public programs, as well as special equipment to be used for teaching purposes. We have found that many complex astronomical phenomena (such as retrograde motion) can be easily explained and demonstrated by the use of simple equipment. Because our museum, like most small museums, is without machine and optical shops, all of these devices are of very uncomplex nature. The construction and uses of several of these devices are described in the following paragraphs.

Lunar landscape projector: On a strip of clear acetate $15\frac{1}{2}$ inches long and $2\frac{1}{2}$ inches wide a negative painting of a lunar landscape is painted with black rubber base paint. This is placed over a semicircular light-box of 3/8-inch wood in which there is a regular # 605 bulb (the projector uses the same power supply as the meridian). It is necessary that the bulk be placed so that it is an equal distance from the acetate strip at all points in order to focus properly. A curved wooden arm and metal shoe attach the projector to the Spitz planetarium projector in the place of the meridian projector, or one of the other projectors. A spring-loaded threepoint suspension system makes it possible to position the lunar landscape image on the dome above the skyline. Two projectors, each covering 180 degrees, are necessary to create the illusion that the audience has landed on the moon and that they are surrounded on all sides by lunar mountains and craters.

Projector for varying the size of the projected image: A wooden tube 24 inches long is constructed so that a standard $3\frac{1}{4}$-inch by 4-



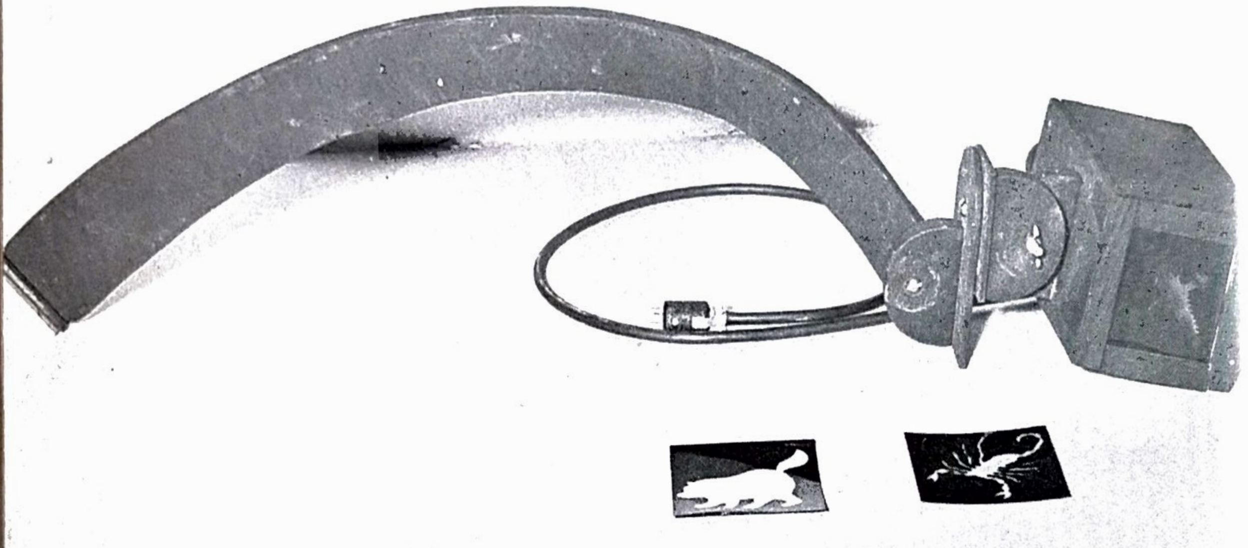
Lunar landscape projector



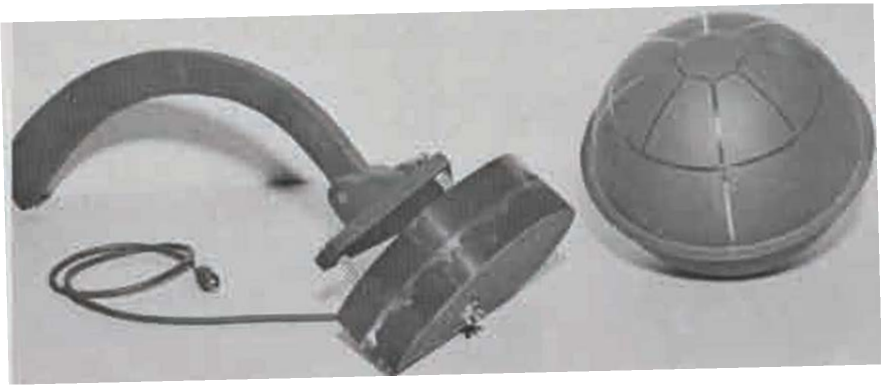
Projector for varying the size of the projected image inch lantern slide can be placed in one end. A wooden plunger is made to slide freely inside the tube. A #605 bulb is positioned on one end of the plunger so that it centers on the image on the lantern slide. A crosspiece on the opposite end of the plunger prevents the bulb from touching the slide leaving a 1/8-inch clearance. Another stop on the end of the tube prevents the plunger from being pulled completely out of the tube. The size of the projected image can be varied by moving the plunger in and out. The nearer the bulb is to the slide the larger the projected image.

Space ship cabin projector: A plastic sphere is first covered with a network of thin strips of masking tape to represent the nose section of a space ship. The sphere is then painted with black rubber base paint. When the paint is dry the masking tape is carefully peeled off leaving a grid of clear plastic. The under side of the sphere has a hole cut in it and two bolts fitted to it so that it can use the light source that is ordinarily used for the geocentric earth. These plastic spheres are usually available at local display houses.

Constellation outline projector: Negative paintings of the mythical figures outlining the constellations are painted on $3\frac{1}{2}$-inch by 4-inch sheets of clear acetate with black rubber base paint. A rectangular, open-end light-box about $3\frac{1}{2}$ inches by 4 inches by 7 inches is constructed of 1/4-inch plywood. The negative-painted constellation outline is placed over one end of the light-box. A #605 bulb is placed at the center of a wooden block cut to slide into the light-box opposite the negative painting. The size of the projected image can be altered slightly so it matches the stars in the constellation by moving the block in and out. An arm and shoe attaches the projector to the Spitz planetarium projector.

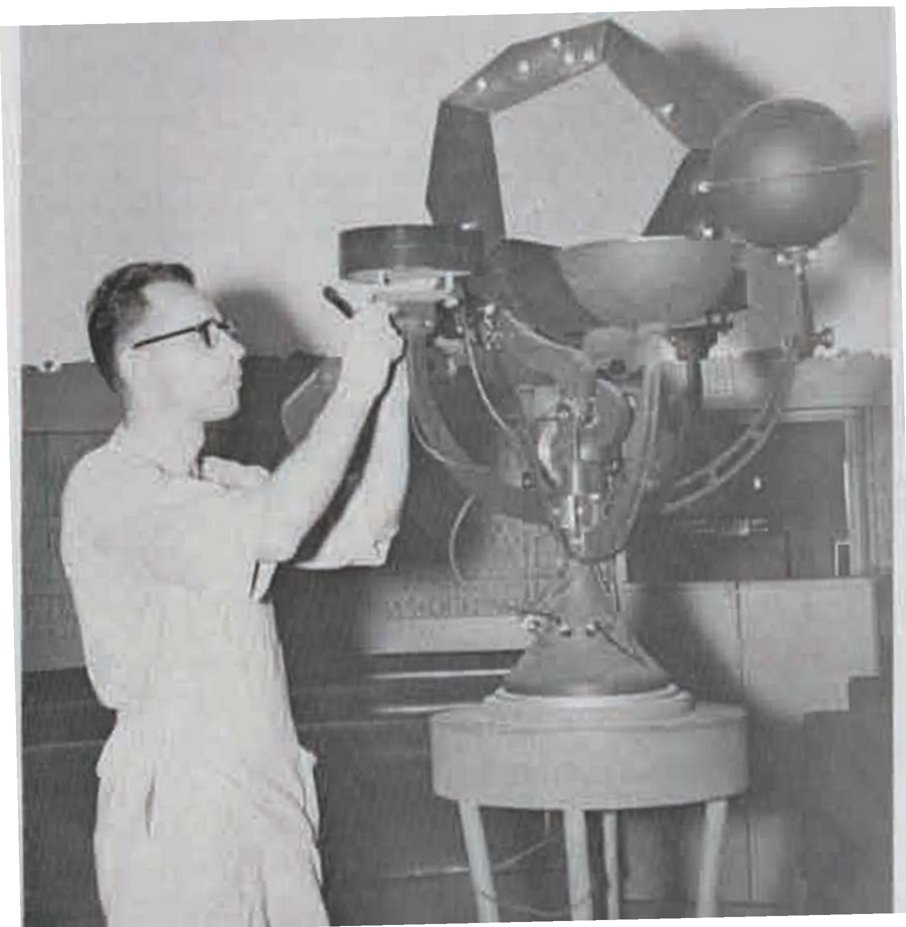


Constellation outline projector



Space ship cabin projector

Lunar landscape projectors and space ship cabin projector in position on instrument



THE USE OF BLACK LIGHT IN THE PLANETARIUM

THOMAS W. VOTER
Director, Hudson River Museum, Yonkers, New York

If it is used correctly, the "black light" produced when fluorescent pigments are exposed to ultraviolet radiation lends dramatic intensity and translucency to planetarium exhibits.

Nearly everyone is acquainted with the use of ultraviolet light and fluorescent paint. Today it is used in industry, crime detection, advertising and as a decorative medium of many uses. The armed forces are using it extensively in their various training programs. As a visual teaching aid, it has unlimited applications.

In the museum and planetarium field the potential value of black light as a dramatic medium for use in astronomical and other natural science exhibits has hardly been explored except by a few artists and technicians.

Fluorescent painting has suffered in the past from frivolous, often garish, application of pure color in large masses lacking any feeling of light and shade. Because the medium has fallen into inexperienced hands, many unhappy and costly mistakes have been made.

There has been very little written about the technique of fluorescent painting and most of us who use the medium have learned by experimentation. In all astronomical paintings the artist is interpreting the light in nature, and he has always been limited by his medium, for the conventional pigments are incapable of duplicating light. They lack intensity and translucency. At best they are a poor imitation of nature's radiance.

Fluorescence is the emission of light which occurs when certain natural or synthetic materials are exposed to ultraviolet radiation. With fluorescent pigments the artist is actually "painting with light." In other words, fluorescent pigments are not just ordinary coloring materials but are really lights — billions of tiny lights spread uniformly over the area covered.

The brightness is controlled by the intensity of the black light and the amount of pigment in the finished paint. There is no secret formula for mixing the various fluorescent pigments or mysterious technique for getting some of the effects we want. However, the conventional practice of mixing two colors to get a third does not always work. For instance, mixing fluorescent yellow with blue does not produce green but a dirty grey.

Time does not allow me to go into the techniques of fluorescent painting with any thoroughness here today, but keep in mind a few of these points if you use the medium. Be sure your surface underpainting contains no lead — a chemical action will dull the paints in time. Use a good brand of colors. They are expensive but worth it in the long run. A four-ounce tube costs about five dollars. Your middle tones are secured by conventional methods; the fluorescent pigments mix well with non-fluorescent paint to produce the darker tones.

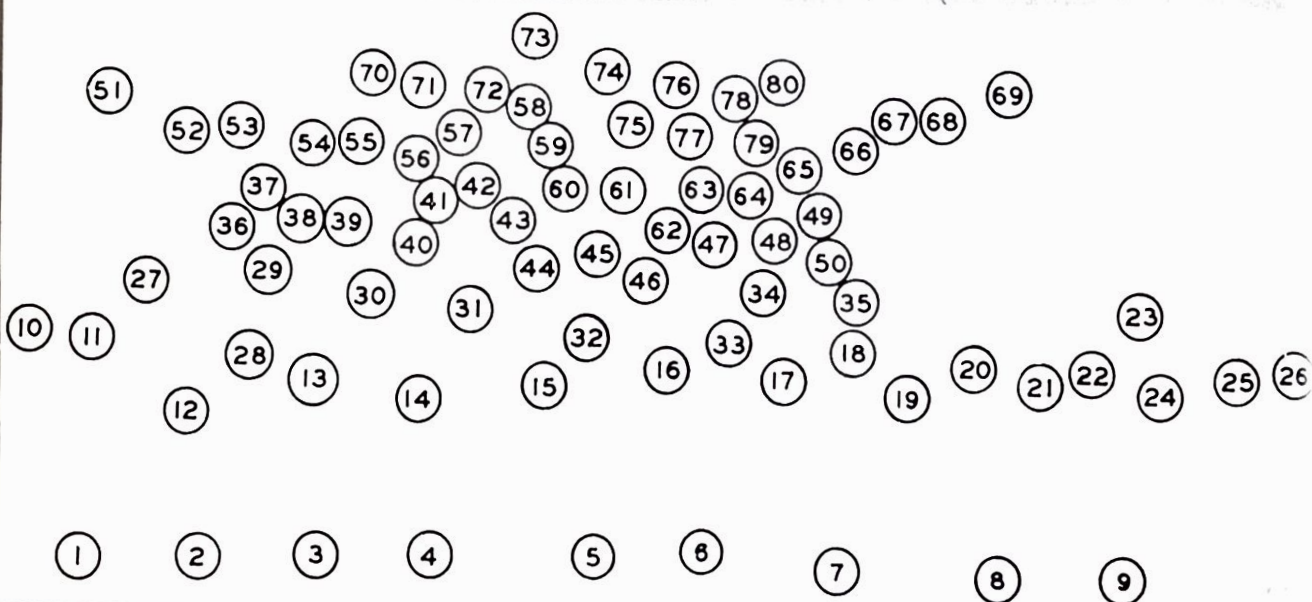
Underpainting, glazes and scumbles are used to get various effects and in astronomical subjects the air brush can be used to good advantage.

In all cases the work should be done under the same lighting conditions in which the final exhibit is going to be seen. That means painting under black light which bothers your eyes but does them no damage I'm told.

Because there have been a few unhappy experiences with black light installation, its permanence has been questioned. However, if a good quality of paint is used on a properly sized and painted background, fluorescent painting should be as permanent as any oil painting.

The efficiency of the black light fixture and its reflector is also important. The best fixtures have a lifetime of 6,000 to 8,000 hours.

Last and most important, get a competent artist with a knowledge of painting — because all our exhibits are only as good as the man who plans and creates them.



Some participants in the symposium

KEY TO PHOTOGRAPH

1. R. Howe, Museum, Kansas City, Mo.
2. N. Cole, Children's Museum, Ft. Worth, Tex.
3. M. Carson, Spitz Labs., Yorklyn, Del.
4. W. Frankforter, Sanford Museum, Cherokee, Iowa
5. C. Smith, State College, San Diego, Calif.
6. C. Wilder, American Museum of Atomic Energy, Oak Ridge, Tenn.
7. J. Spoehr, Spitz Labs., Yorklyn, Del.
8. H. Williams, Spitz Labs., Yorklyn, Del.
9. J. Howe, Mueller Planetarium, Lincoln, Neb.
10. R. Hatt, Cranbrook Institute, Bloomfield Hills, Mich.
11. E. Koestner, Museum of Natural History, Dayton, Ohio
12. H. Owens, County Board of Education, Adelphi, Md.

13. Mrs. R. Howe, Museum, Kansas City, Mo.
14. Elizabeth Simons, Museum, Charleston, S. C.
15. Mrs. Mae Bell, Children's Museum, Rocky Mount, N. C.
16. J. Forbes, National Foundation for Junior Museums, New York, N. Y.
17. Jacqueline Avent, Children's Museum, Nashville, Tenn.
18. Mrs. Maxine Haarstick, Public Library, Minneapolis, Minn.
19. Mrs. W. Hassler, Children's Museum, Ft. Worth, Tex.
20. W. Hassler, Children's Museum, Ft. Worth, Tex.
21. Mrs. T. Robinson, Planetarium, Dallas, Tex.
22. S. Menke, St. Ambrose College, Davenport, Iowa
23. R. Stein, Museum, Newark, N. J.
24. R. Emmons, Goodyear Aircraft Corp., Akron, Ohio
25. C. Gebler, U. S. Dept. of the Interior, Washington, D. C.
26. J. Fowler, Cranbrook Institute, Bloomfield Hills, Mich.
27. C. Starrett, Buhl Planetarium, Pittsburgh, Pa.
28. Ruth Howard, Museum, Kalamazoo, Mich.
29. L. Howland, County Board of Education, Laurel, Md.
30. H. Brown, Public Schools, Oklahoma City, Okla.
31. C. Cochran, West Virginia Univ., Morgantown, W. Va.
32. Mrs. G. Smith, Goodman Planetarium, Atlanta, Ga.
33. Mrs. Devra Portoulas, Children's Museum, Brooklyn, N. Y.
34. S. Hruska, Children's Museum, Detroit, Mich.
35. R. Pfrang, U. S. Air Force Academy, Colorado Springs, Colo.
36. Margaret Noble, Public Schools, Washington, D. C.
37. Mrs. D. Moyer, Junior League, Dayton, Ohio
38. E. Stackpole, Marine Historical Ass'n., Mystic, Conn.
39. A. Praus, Museum, Kalamazoo, Mich.
40. J. Pearson, Museum, Hastings, Neb.
41. C. Brooks, Marine Historical Ass'n., Mystic, Conn.
42. Doris McMillan, Cranbrook Institute, Bloomfield Hills, Mich.
43. J. Rosemergy, High School, Ann Arbor, Mich.
44. O. Peterson, State Teachers College, Emporia, Kans.
45. M. Deusing, Museum, Milwaukee, Wisc.
46. T. Gangl, Museum of Health and Science, Dallas, Tex.
47. R. Miller, Henry Ford Community College, Dearborn, Mich.
48. Mrs. L. Kelly, Children's Nature Museum, Charlotte, N. C.
49. Mrs. M. Brackbill, Eastern Mennonite College, Harrisonburg, Va.
50. F. McGouldrick, U. S. Air Force Academy, Colorado Springs, Colo.
51. J. MacMahon, Museum of Natural History, Dayton, Ohio
52. Mrs. J. Cavanaugh, Franklin and Marshall College, Lancaster, Pa.
53. J. Cavanaugh, Franklin and Marshall College, Lancaster, Pa.
54. Jean Russell, Museum of Science, Buffalo, N. Y.
55. Mrs. J. Marsh, Museum, Fairfield, Conn.
56. J. Harnden, U. S. Army Engineer School, Ft. Belvoir, Va.
57. J. Bowen, Chicago Teachers College, Chicago, Ill.
58. C. Rice, St. Ambrose College, Davenport, Iowa
59. J. Harris, U. S. Army Engineer School, Ft. Belvoir, Va.
60. E. Linsley, Bishop Museum, Honolulu, Hawaii
61. M. Moore, Longway Planetarium, Flint, Mich.
62. W. MacBriar, Museum, Milwaukee, Wisc.
63. Heather Thorpe, Univ. of Michigan, Ann Arbor, Mich.
64. M. Brackbill, Eastern Mennonite College, Harrisonburg, Va.
65. Mrs. A. James, Junior College, St. Petersburg, Fla.
66. T. Voter, Hudson River Museum, Yonkers, N. Y.
67. H. Cornell, Milwaukee Astronomical Society, Milwaukee, Wisc.
68. F. McConnell, Fountain of Youth Properties, St. Augustine, Fla.
69. L. Roberts, Univ. of Florida, Gainesville, Fla.
70. R. Adler, Chicago Planetarium Society, Chicago, Ill.
71. Louise Davis, Children's Museum, Nashville, Tenn.
72. Martha Schaefer, Cranbrook Institute, Bloomfield Hills, Mich.
73. W. Schultz, Jr., Cranbrook Institute, Bloomfield Hills, Mich.
74. R. Levin, Chicago Planetarium Society, Chicago, Ill.
75. D. Snow, Museum of Natural History, Cleveland, Ohio
76. A. Spitz, Spitz Labs., Yorklyn, Del.
77. L. Durrance, Children's Museum, Jacksonville, Fla.
78. Mrs. R. Sullivan, Children's Museum, Charleston, W. Va.
79. J. Wells, Madison College, Harrisonburg, Va.
80. M. Degani, State Univ. Maritime College, Ft. Schuyler, N. Y.

CRANBROOK INSTITUTE OF SCIENCE

Cranbrook Institute of Science was established in 1930 as an instrument for education and research in the natural sciences. It has operated chiefly in the natural sciences; and in this field, has served the end of education by providing the major natural history museum of the metropolitan Detroit area, an astronomical observatory and the first planetarium in Michigan to be accessible to the public. Its publications enjoy world-wide distribution.

The Institute building is located in Bloomfield Hills, Michigan, some twenty miles from downtown Detroit. It shares a 300 acre campus with five other institutions, each founded by George G. and Ellen Scripps Booth. These are Brookside School, a primary day school for boys and girls; Kingswood School, a secondary boarding and day school for girls; Cranbrook School, the equivalent school for boys; Cranbrook Academy of Art, a college level school for talented students in architecture, sculpture, painting, and allied arts; and Christ Church, a Protestant Episcopal church serving the community.