SPACE JOURNAL

DEDICATED TO THE ASTRO-SCIENCES

MARCH-MAY

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- LAWS OF PROBABILITY SHOW BEINGS ON OTHER PLANETS!
- HOW SPACE TRAVEL WILL ANSWER THE RIDDLE OF LIFE!
- WHAT ARE MENTAL QUALIFICATIONS FOR SPACE PIONEERS?


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Photographs on p. 39, 40, Yerkes Observatory; p. 37, 38, National Geographic Society; photograph of Dr. Shockey by Keith Barrette;

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STATEMENT OF POLICY

The immediate and eager acceptance of SPACE Journal by scientists and technicians, business and industrial leaders, students and educators, as well as the general public, has brought into focus the wide recognition by the American people of the total challenge presented by the problem of Space exploration. Such general acceptance has placed SPACE Journal in the unique position of interpreter of ideas in all fields even remotely related to Space travel. It is the interpreter which translates the individual languages of the various specialists into a universally understood "layman's English"—this role is vital, since in this highly specialized age even the scientists are often laymen in fields other than their own.

SPACE Journal is rapidly becoming the forum wherein the exchange of ideas among industry, science, education, and the public can be made. It is bringing to view the resources of all the arts and sciences bearing on the problem of Space exploration.

Thus SPACE Journal as a universal medium of communication promotes the overall objective of the exploration of Space by helping the specialists to understand each other, the scientists, engineers, businessmen, and educators to understand each other, and the taxpaying layman to understand them all.

In such a role, so greatly expanded in scope from that of its beginning, and so vital to an uninformed public, SPACE Journal has deemed it advisable to disavow any connection with the Army, Navy, Air Force, or other military and civilian segments of the government and to terminate its affiliation wih the Rocket City Astronomical Association. In pursuit of our broader aims, we announce that, beginning with the next issue, this magazine will no longer be published as an official organ of the Rocket City Astronomical Association.

We believe that this action will afford us the liberty of presenting all views without the restrictions that exist when a publication is acting as the voice of any type of organization. SPACE Journal will continue as an independent publication "dedicated to the Astro-sciences" and to the peaceful exploration of Space for the benefit of all mankind.

MECHTA AND OPERATION SCORE

The year 1958 closed with a significant advance in Space technology, but the year 1959 opened with an even more significant one. The old year closed with the successful launching of the United States Air Force's Atlas in Operation Score; and the new year began with Mechta, the spectacular Lunar probe of the Soviet Union, which is now in orbit around the Sun. However, more lies between the two events than a mere two weeks.

Both Operation Score and Mechta bring up a question about the direction in which American Space technology is advancing. While we know relatively little about the technical details of Mechta (and there is no reason to assume that we will ever know the complete details), we know at least one thing about the Atlas and Operation Score. It worked. It was successful. The magnitude of its success was made all the greater because of the faith the Air Force had in its product. In the not too remote past, there were rumors that the Atlas guided missile, still having its growing pains, would be cancelled in favor of a more "sophisticated" missile system. This attitude toward sophistication in our present missile and satellite design bears closer scrutiny. Project Vanguard is not so recently dead that one cannot remember the reason given for accepting it over the Jupiter-C was that it was more sophisticated.

Webster's New Collegiate Dictionary defines *sophisticated* as "Deprived of original simplicity; made artificial, or, more narrowly, highly complicated, refined, subtilized, etc. . . ." Surely the very definition, when applied to our present position in Space technology, begs the question: What price reliability?

Without belaboring the obvious, it does seem that there is more than a trace of *sophistry* in such views of *sophistication* when the term is used as the last word and final criterion for judging the absolute value of a guided missile or a satellite vehicle. And Mechta should make us wonder, too, just how sophisticated it and the Sputnik vehicles are.


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OTHER BEINGS ON OTHER PLANETS?*

Today man is looking out at the star-filled heavens with new curiosity, asking if tomorrow's space explorers may find other beings on other worlds. Based on science's rapidly expanding knowledge, the answer is "Yes." Eminent astronomers are sure conditions suitable for life exist elsewhere.

Our galaxy, called the Milky Way galaxy, contains roughly 400 billion stars and Dr. Gerard Kuiper, director of the Yerkes Observatory, believes that about 10 billion of the stars do have sets of planets orbiting around them. These are invisible to terrestrial telescopes because planets are cold masses emitting no light of their own. Assuming that our planetary solar system is typical, Dr. Kuiper estimates that there are about 100 billion planets in our own galaxy alone. In the entire universe there may be over 100 billion galaxies like ours and Andromeda.

If other solar systems are like ours, about 10% or 10 billion planets in our galaxy are orbiting in a temperate "life zone," at just the right distance from their sun where liquid water, air and vital chemicals could exist. Where these ingredients do exist, so may living cells. "Life is probably the inevitable consequence of chemical evolution wherever physics, chemistry and climatology are right," Harlow Shapley of the Harvard University Observatory maintains.

To support their conclusions, astronomers turn to the mathematical theory of probability which holds it inconceivable that out of 10 billion "inhabitable" planets in the galaxy our earth is the only one where conditions are right for the evolution of life. In fact, though man's 5½ billion-year-old earth is actually middle-aged by celestial standards, there may well be a multitude of other planets on which life has been evolving millions of years longer than on earth. If spaceships which approach the speed of light could be built and if man ever reaches distant planets, he may, on arriving, find himself to be just a primitive Johnny-come-lately compared to the local inhabitants.

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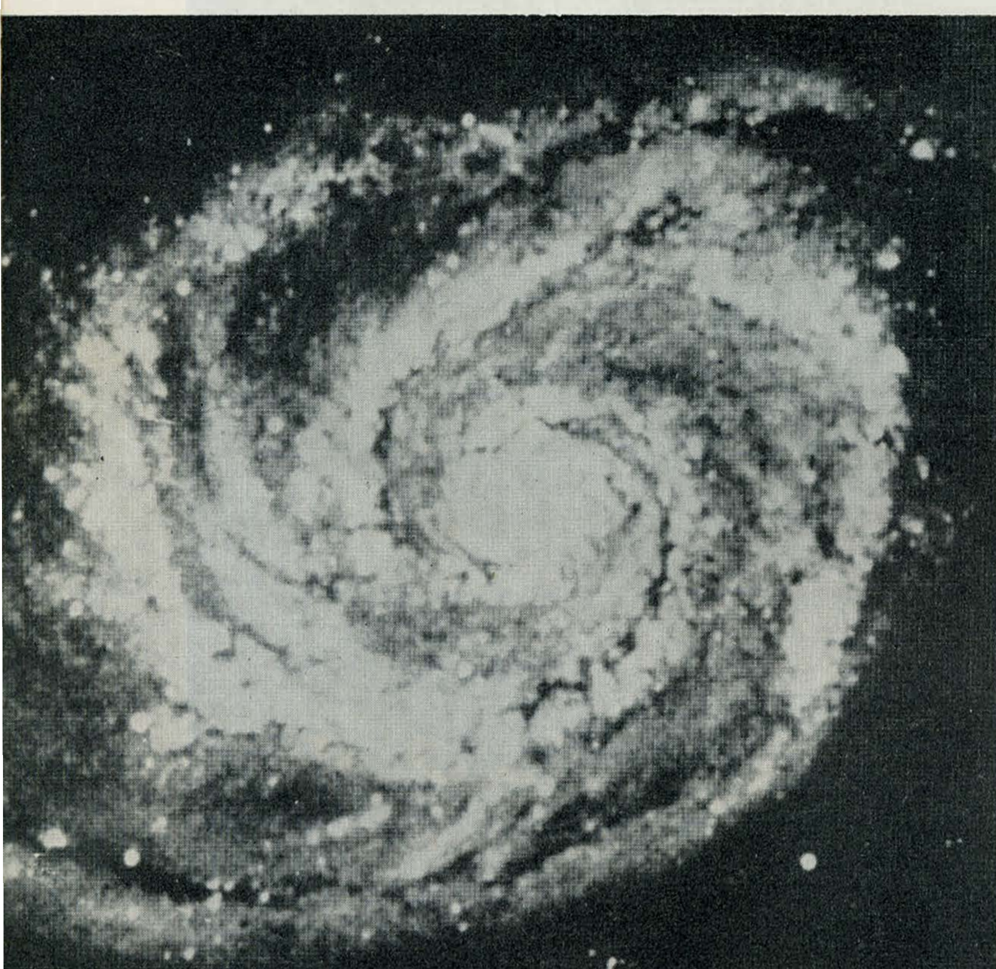
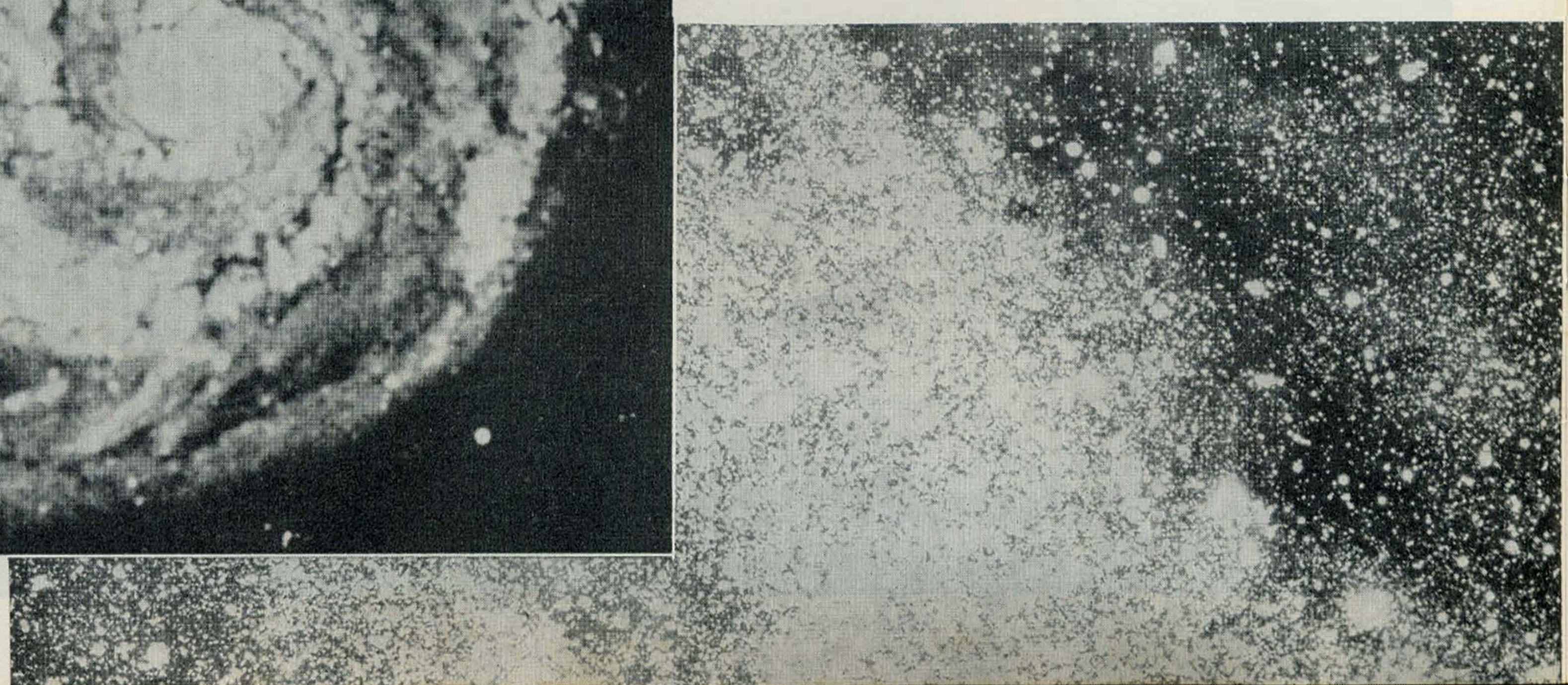




the ultimate necessity of space travel

BY PHILIP N. SHOCKEY

Philip N. Shockey was born in 1931 and attended secondary schools in Pittsburgh, Pennsylvania. After receiving his BA and MS degrees in geology from West Virginia University, he attended Cornell University and earned his doctorate at that institution in geology. He has taught at both of these colleges. A former field geologist for the West Virginia Geologic and Economic Survey, he has also been an assistant geological consultant for the South Pennsylvania Gas Company. He has also worked as a geologist for the United States Geological Survey. A member of the Geological Society of America and the Society of Sigma Xi, he is presently the chief geologist and vice president of the Penn-Idaho Mines, Inc. He lives in Salmon, Idaho, the western location for Penn-Idaho Mines, Inc.

News reports concerning this country's efforts toward the conquest of Space are alarming in several respects. The most alarming fact, however, is not that we may be lagging behind Russia but that our engineers and scientists have difficulty justifying Space projects more ambitious than the establishment of an Earth satellite. There seems to be general agreement that these satellites will have at least a half dozen practical uses. Yet, when a trip to the Moon or some more ambitious Space project is mentioned, the men who will make that trip operational must struggle for justification of their plan.

For example, in a story from *Newsweek* magazine (Dec. 16, 1957, pp 66-68), the American Rocket Society was reported to have sent President Eisenhower a 20-year project proposal the goal of which is to place American scientists on the Moon. This program was authored by a 15-man group, which included Krafft Ehricke of Convair-Astronautics and Dr. Wernher von Braun, the Army missile expert. Ehricke, architect of the program, said, "I really don't know what good it is to go to the Moon, but the very fact that we don't know is reason enough to scientists for going."

It appears that the brilliant men who will make Space travel possible are too close to their subject to see its most practical side. Perhaps a more reflective view can be provided by some of the older sciences—geology for example.

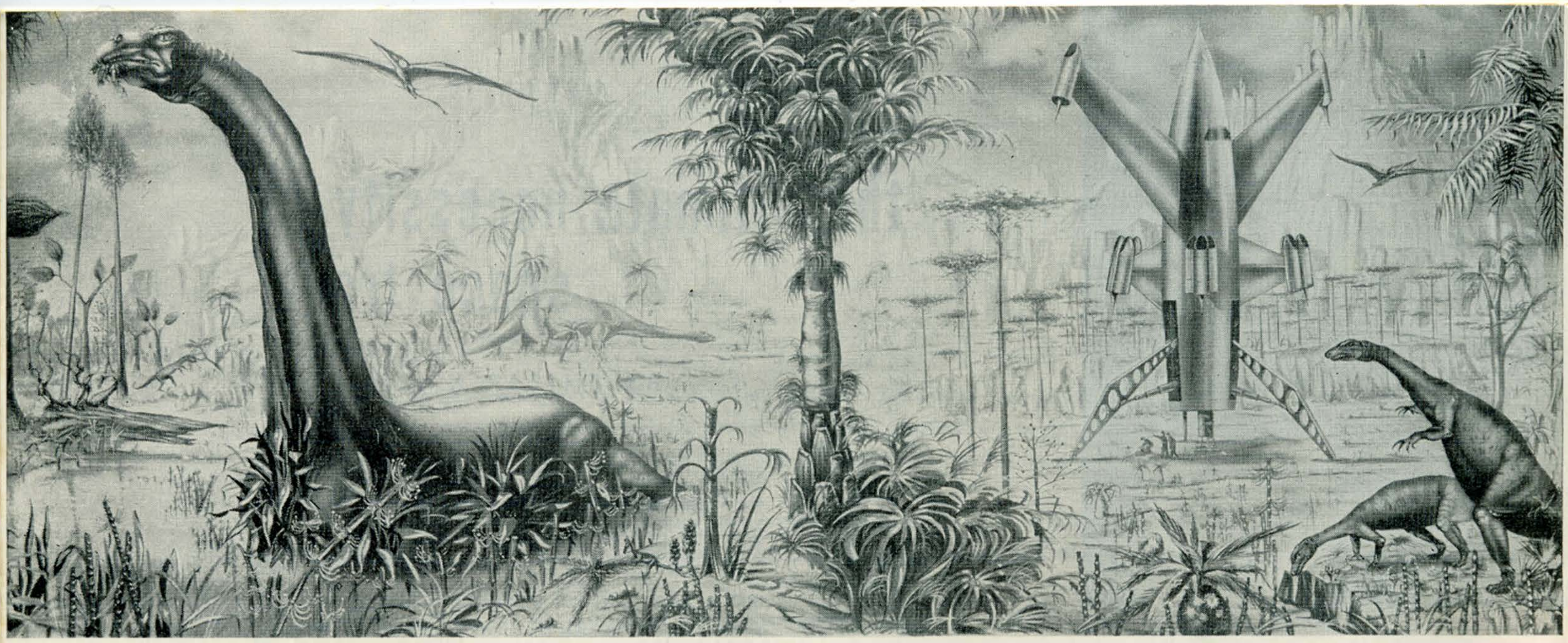
Geology deals with the history of Earth, and because this history covers billions of years, geologists are used to thinking in terms of billions of years. Apparently, most rocket scientists and engineers, like most people, conceive of time in such short duration as to be only an instant, geologically speaking.

In conjunction with the other sciences, geology has made increasingly rapid strides forward since the turn of the present century. All of this new knowledge makes more secure man's climb to outer Space. As will be shown subsequently, specific geologic contributions appear to be: (1) more reliable and detailed interpretation of past Earth environments, (2) more exact dating of past Earth events, and (3) corroboration and augmentation of cosmogonic data. Although far more remains to be learned about Earth than is known, some pertinent conclusions can be drawn from available geologic and allied data.

Earth formed, more or less synchronously, with the other planets of our Solar System some five billion years ago. This figure represents a currently acceptable age to geoscientists.

During the past few billion years, life evolved on Earth from nonplant-nonanimal ancestors of the most primitive marine organisms; to terrestrial plants and animals; and, finally, though not necessarily ultimately, to man. Therefore, it may be said that life on Earth has struggled for billions of years to reach the prevailing state of awareness.

This state of awareness permits limited



LEPIDODENDRON · HORSETAILS   PTERANODON BRONTOSAURUS NEOCALAMITES   WILLIAMSONIA   FAN PALM COMPSOGNATHUS   ARAUCARITES   ASTRA--ALPHA   CYCADELLA   PLATEOSAURUS HORSETAILS

prognostication. Cosmogonists have presumably worked out the evolutionary development of stars like our Sun. By projecting the Sun's development, cosmogonists predict destruction of Earth through gradual "burning out" of the Sun. Reportedly, effects from changes in the Sun will become significant within 50 billion years.[1]

Whether figures and hypotheses cited here are absolutely correct is not important. Cumulative evidence clearly points to the fact that Earth had a beginning some billions of years ago, and it shall certainly have an end some billions of years hence. This conclusion immediately answers the question of why we must venture into Space.

When one considers that our planet is doomed, at least as far as life is concerned, it is impossible to put meaningful value on the titanic forward struggle of life on Earth through billions of years. This struggle, whether conscious or not, appears agonizingly futile if the gigantic mass contribution can not be perpetuated.

Fortunately, this contribution can be perpetuated regardless of its development on doomed Earth. The obvious answer is that all achievement must be transplanted from Earth prior to a significant change in our Sun. If this appears impracticable, it should be recalled that billions of years are available to achieve the proposed goal. In view of the present rate of progress, this would seem to be far more than adequate time. Human frailty may, however, precipitate through war another and successive Dark Ages so that we can never achieve this goal.

Thus, the question is no longer why must we become proficient in Space travel but rather where do we want to go in Space. We must escape beyond our Solar System to environments approximating that of Earth.

In this regard, some cosmogonists, perhaps the majority, think that planet formation is a natural result of star formation. That is, it is possible that many stars, when formed, develop a system of planetary satellites like our own Solar System. Therefore, it is reasonable to believe that there are many billions of planets, because there are many billions of stars in our galaxy alone.

The nearest star to Earth is in Centaurus 4.3 light years away. Available telescopes cannot define planets orbiting about this or any other star. However, the probability of other solar systems is so high that we can safely assume their presence and let actual discovery and the means of reaching them await further technological developments.

By the time escape from Earth is practicable, cosmologists will have chosen a star in our galaxy similar to our Sun and with a satellite planet much like Earth. The important difference will be that the new Sun will not be so far along in evolutionary development as the Sun we now have. Geologists will be able

[1]See "Life on Other Stars," SPACE Journal, spring issue, 1958, p. 16.

to assist in selecting the plant by extrapolating knowledge of the Earth.

It is interesting to speculate on the surface appearance of our proposed new home. If the cosmologists are able to find a planet virtually identical to Earth in so far as gross properties are concerned, adjustment of life there to the overall environment should be simple. Assume, however, that the cosmologists chose a planet only some four billion years old but otherwise identical to Earth. In this event, it is possible that the new planet would have about the appearance of Earth during late Pre-Cambrian time (approximately one billion B.C.). During this period only the simplest forms of marine organisms inhabited Earth; land surfaces were barren of plants and animals; and the atmosphere

probably was deficient in oxygen. On the other hand, if a planet about five billion years old were chosen, it possibly would appear similar to present-day Earth, having, among other forms of life, intelligent beings.

Thus, if the cosmologists can determine accurately the age of the planet to be colonized, it may be possible for geologists to predict approximately, on the basis of historical geology, the environment to be expected by the colonists. For further illustration, assume that in the year 2500 A.D. all is ready for colonization of a carefully selected planet. Assume also that by this time the age of Earth has been determined as 5.5 billion years, plus or minus several million years, and that the age of the Earthlike planet has been determined as 5.4 billion years, plus or minus several million years. Then, other things being similar, the colonists might encounter an environment like that on Earth around 100 million B.C., when reptiles ruled the land. Dinosaurs, flying reptiles, and other terrestrial and marine animals and plants might confront the colonists, who, through geologic deduction, would be prepared for such a spectacle.

In addition to assisting in selection of planets for colonization, geologists will make other important contributions to the conquest of Space. Ores from which Space vehicles will be made and some of the fuels which will propel them will be found and produced by employing geologic principles. Furthermore, firsthand geologic examination of any visited Space target will be most important in establishing suitability of these bodies to human purpose. Consequently, geologists will be among the first scientists landed on Space targets.

This necessary endeavor should have a profound and beneficial effect on the human race. The project is so huge in scope that no single country will be able to carry it through; the physical and mental resources of all the world will be required. This unified effort should produce nonviolent political and religious revolutions terminating in world harmony. These revolutions will be based on education, and they have already begun. It is difficult to see how any of the existing formal religions or political plans, except democracy, will survive scrutiny by a world population applying the scientific method to all phases of life. Maximum freedom of fidelity and self-expression will be demanded by a scientific world population, and democracy is the only form of government that satisfies these requirements. When, through education, superstition and fear are replaced by truth and courage, a new world religion based on fact and closely allied with nature will replace present religions.

In addition to the harmony required to make interplanetary colonization possible, there may be another good reason for its achievement. Whichever major theory of origin of the Universe is accepted, there is no reason to believe that we are the most intelligent life in our galaxy, to say nothing of the Universe. (The existence of extra-Earth intelligence is considered to be about as probable as the existence of other solar systems and only awaiting discovery.) On the one hand, life may have been in existence for an infinity of time, or as long as there has been a Universe. On the other hand, life may be on the order of the age of Earth. Granting the first possibility, some universal intelligence may be unbelievably greater than our own. Granting the second possibility, environmental differences may have promoted far greater development of intellect on some planet other than Earth. Presumably, these advanced intellects plan and may even have carried out interplanetary colonizations for the same reason that we must. As a planet, we will have to be acceptable at least to galactic society; or we may not be permitted to survive.

In conclusion, it appears that we have adequate resources and more than adequate time to make Space travel a certainty. The weakest rung in man's ladder to outer Space is the human element, whereby fanatics may repeatedly obliterate progress by plunging the world into war and physical and intellectual wretchedness. Annihilation of the human race seems possible. Clearly, education is the first duty of all concerned—everyone on Earth. Although education cannot eliminate fanatics, it certainly can prohibit their rise to power in a world of enlightened people.

survival in space

By Siegfried J. Gerathewohl

Siegfried J. Gerathewohl was born in Ebersbach, Saxony, Germany, in 1909. After studying physiology, psychology, and education at the Institute of Technology, in Dresden, and at the University of Batavia, in Munich, he received his doctorate at Dresden in 1936. He also holds a degree as a Diploma Psychologist from the University of Munich.

As a Captain in the German Air Force in 1940, he became chief of the Psychological Testing Center at Homburg. He has also been chief of the Department of Industrial Psychology for the Bavarian Motor Company in Munich. In 1946 he joined the Aero Medical Center in Heidelberg, Germany, and, in the next year, was transferred to the School of Aviation Medicine at Randolph Air Force Base in Texas.

The author of two books and more than 70 articles on military psychology, aviation psychology, and aviation medicine, he is a member of the National Academy of Sciences, the Aeromedical Association, the American Psychological Association, the Scientific Society for Aeronautics, and the German Rocket Society. He is also an associate professor of experimental psychology at the United States Air Force's Air University. In 1958 he received the Arnold D. Tuttle Memorial Award for his research into the problems of weightlessness.

Ever since Lucian, the satirical Greek writer who lived about 1800 years ago, let his Moonmen set out to vanquish the inhabitants of the Sun, the imagination of Earthlings has been inflamed again and again by the dream of interplanetary travel. Space flight has become one of the fascinating subjects under discussion today. It appeals to everyone regardless of age, sex, or profession. It is the thrill of the ice-cream counter in the drugstore as well as of scientific panel discussions at the Massachusetts Institute of Technology. Publications on this topic can be found everywhere from the comics to science fiction, from pulp magazines to learned journals, from novels to research reports in the Pentagon. Although authorities on this subject have written obituaries for one reason or another, Space flight just refused to stay dead. Moreover, it made its way not only into radio broadcasts, TV telecasts, and along Sunset Boulevard, but recently into big business. Since the exploitation of this idea proved fairly profitable, the eyes of all sorts of adventurers were magically drawn toward the stars and the infinity of outer Space.

While the lay public followed this development with enthusiasm, the majority of scientists looked upon it with either awe or contempt. The rocketeers, of course, propagated the idea of Space travel from the start with a sense of mission which—as astronaut Frederick I. Ordway put it—"aroused a vaguely uncomfortable recollection of some of the Biblical prophets." Now, that the technological disciplines have finally recognized their newborn child, astronautics, as being legitimate, the medical, social, and psychological sciences are moving to claim it slowly and somewhat reluctantly.

Never in his history of existence has man been faced with a more fateful decision. The venture into Space is more revolutionary and hazardous than the invasion of land by the aquatic animal in the Paleozoic Era. For these creatures were merely migrating from one terrestrial habitat to another, having 100 million years for adaptation. But the Space invader is leaving Earth altogether; and he seems to be in quite a hurry, too. In preparing himself for this gamble, he must overcome a variety of novel and difficult problems of body and soul engineering. As he usually does in case of serious trouble, he turns to the doctor.

Unfortunately, the human organism has changed but little during its known existence; nor can it be expected to do so in the future. Breeding an entirely new crop of Space travelers seems too lengthy and cumbersome in this time of ours. Hence, we must think of more practical and effective means for fitting Homo sapiens to his expedition. Since he was not constructed to expand into verticality, he must be redesigned for survival.

If man should wander unprepared into the void of Space he would suffocate within seconds because of a lack of oxygen. His blood would boil in the vacuum. Mercilessly exposed to the ultraviolet rays of the Sun and the bombardment of cosmic rays and meteorites, his burned and riddled body would be torn to bits by pressure differentials and would drift weightlessly as "Space debris" into the darkness and silence of infinity.

The question of protecting man in a Space environment, then, is the primary one involved in Space travel. Its solution begins with the selection of the specimen who is to venture out.

Many answers have been given, by more or less qualified men, to the question of what makes a Space pilot really successful; and most of the answers are well-meant, intelligent, and sincere. But some of them just miss the point. Because of the tremendous impact of the comic strips upon American civilization, the thinking of some of the contributors must have been centered subconsciously on such famous personalities as Buck Rogers, Flash Gordon, and the Space Cadets. Granted that picking the right man is one side of the story, then training him to perfection is the other. And this training can be done in many ways.

The moment man leaves the air behind him and cruises out into open Space, the walls of his cabin must contain an approximation of terrestrial atmosphere. Only if his ship is equipped with all the necessities of life and is protected against the hostile environment outside will man be able to survive. The many functions of Earth's atmospheric shield must be reproduced artificially within the Spaceship. Although the human organism is much more sensitive, demanding, and vulnerable than that of many other living beings, his higher intelligence and greater versatility are assets for his survival. He can take his own environment along on his trip. As a matter of fact, rocket power, pressure breathing, oxygen systems, temperature control, sealed cabins, meteor bumpers, power steering, antitumbling devices, ejection capsules, artificial gravitation, astro-navigation charts, telescopes and periscopes, radio, radar and television, electronic computers, univacs, and skywatch men—just to mention a few requisites of futuristic travel—already have been tailored to his demands and will be brought to such a state of automation that he may even be bored to death on his venture into Space.

To be a little more serious, the success of a Space pilot is about 90 percent purely an engineering problem, although natural ability and training skill may well account for the rest.

Let's be more specific about this matter. As was indicated before, we seriously believe that Space travel *per se* is not just a somewhat higher form of conventional flying, but something profoundly different. The pilot of a rocket craft cannot take off or land whenever and wherever he desires. He cannot get out of his ship in an emergency. More than in any other type of piloting will he be told from the ground what to do. He will be fired into the air and guided automatically along a predetermined course. He is neither capable nor will he be allowed to control his vehicle during certain phases of the trip. Control input and feedback are mostly absent or qualitatively different. During conditions of sub-gravity and zero-gravity there is no flying by the seat of the pants. Actually, gliding through Space is not flying at all. It is an anonymous push-button affair and a completely unfamiliar type of locomotion. Only when he plunges back into the disturbing turbulence of Earth's atmosphere will some of his flying skills be required.

We are not even sure whether or not a good jet pilot will be a good Space pilot. Things are too different out there.

Thus, the main requirement for a successful Space flyer is his environment. If the engineers succeed in constructing the hardware—and there is no reason to assume otherwise—the problem of Space travel is near its solution.

Dr. Gerathewohl in the F-94 craft used for experiments on weightlessness.

Although there exist only a few hints about the actual working conditions of Space crews, some rather general conclusions about the job requirements can be drawn. Some preliminary designs suggest that the actual Space craft will be much like the imaginative rocket ship. Admittedly, the quarters will be neither spacious nor luxurious, but working and living facilities are expected to be reasonably habitable and utilitarian. Instruments may be numerous and complex, but every effort will be made to take the load off the pilot. Once launched with a catapult-like acceleration which may increase his weight ninefold, the pilot will have to monitor the ship to a certain degree during the cruise, which will include periods of sub-gravity and complete weightlessness that may exert some strain even on previously conditioned crews. Descent and landing, after an extended glide, will be like that of a large jet aircraft or glider plane.

In none of the many scientific and semi-scientific treatises on Space travel has the task of the crew been specified in SOP (standing operating procedures) terms. This, of course, is a remarkable lapse. Perhaps the designers still do not know what it will be. It may be that they are still working on cybernetics and automation. It is not easy nowadays to make things simple. But only if we can formulate a realistic job description for the Space pilot, can we reason intelligently about the specific difficulties with which the future Space ship skipper will have to cope. And only then can we arrive at a set of physiological and psychological requirements. The selection of rocket pilots and Space crews by means of predictors, the significance of which has never been actually established, is purely academic. And so are the statements about preliminary elimination percentages which say that "of every 1,000 persons who can meet the initial rigid educational, physical and age requirements for space training, only five will ever enter Space—just enough for one rocket-ship crew." How can we know? To publish such data before even knowing what tasks will actually be required of the pilot seems to be putting the Space cart before the horse-power.

Fortunately enough, there are some men who have already flown rocket planes. They are not actually Space flyers, but they have reached the border of Space, at least. They do not claim to be supermen, nor do they believe their problems to be unsurmountable. They have made this point clear in many a conversation, and some of it was brought to light in a panel discussion on "Sky Unlimited" a few years ago. Their main concern is technical. Only if provoked do they touch their body and soul problems. This is what test pilot Scott Crossfield thinks about selection:

> **As far as selecting pilots during the war, for two years I was on carrier-type training in the Navy. I spent that whole two years trying to find men whom I could pick for my students. Everytime I was made out a liar. Who can tell who is going to be a good pilot, or the best pilot?**

And he underlined General Flickinger's statement:

> **The process of selection is a natural one in which those individuals with the requisite flying schools, motivation and technical knowledge gravitate toward the work . . . . That is probably the oldest method of selection we have for test pilots . . . . A good quality to look for in a research pilot is successful tactical experience. A man must know his airplane and be interested in what he is doing.**

And Major Arthur Murray says:

> **. . . as was pointed out, pilots just gravitate into these jobs . . . . We rely on a man's aggressiveness, rather than his inherent ability, physiological age and other factors . . . . We work with pilots such as you see here today.**

Thus it seems we do not have to worry about the selection of Space pilots today because there are enough candidates who are eager to apply whenever the need arises. Even if we wanted to, we cannot do very much about this problem because there are no tests available which would select the successful test pilot or Space cadet. The Air Force tests are of no help either. There is no known example that they ever succeeded in picking the best, or the most capable, or the outstanding man for a particular job. They come out with a usuable average, at best, but Space ships need more than statistical probabilities. On the other hand, there exists quite a reservoir of capable, experienced, and highly motivated combat, test, and research pilots. Take Scott Crossfield, who said recently on TV, that he would give his left arm if he could fly the X-15. Perhaps we start at the wrong end again. It seems more important to pick the right men to direct the program than to pick at our ever-eager pilots.

Being finally afloat in Space, the crew may face grave psychological adjustments. Some doctors think that "by far the greatest problem involves the implications of a seemingly complete break from the Earth and the protective societal matrix in a small, isolated, closely confined container with a few companions. Little is known today about the effect of confinement and social isolation on individual and group behavior, particularly under the hazardous and threatening conditions of flight." In a recent publication on the "Break-off Phenomenon," Clark and Graybiel describe this effect as "a feeling of being isolated, detached, or separated physically from the Earth." (*J. Aviat, Med.*; vol. 28, pages 121-126, 1957.) They let test pilot Bill Bridgman describe his sensations during a flight at the borderline of Space while he experienced the break-off:

> **Fifty-nine thousand, sixty thousand, reeling off sixty-one thousand. I have left the world. There is only the ship to identify myself with. Her vibrations are my own, I feel them as intensely as those of my body. Here is a kind of unreality mixed with reality that I cannot explain to myself. I have an awareness that I have never experienced before, but it does not seem to project beyond this moment . . . .**

This is interesting; but, although this effect was experienced by about 35 percent of the jet pilots interrogated, it was not considered generally to have a significant influence on their ability to operate a plane. Captain Ivan Kincheloe, who held the altitude record, did not think much of it either. And Lt. Col. David Simons, who rode in a small gondola longer than any other person, was scared only when he struck an electrical storm. Nobody will deny that the experience of being high up in a small capsule may produce uncomfortable feelings, but it does not make much

Major H. D. Stallings, Dr. H. Strughold, and Dr. Gerathewohl discussing experiments in front of the Air Force T-33 used for early experiments on weightlessness.

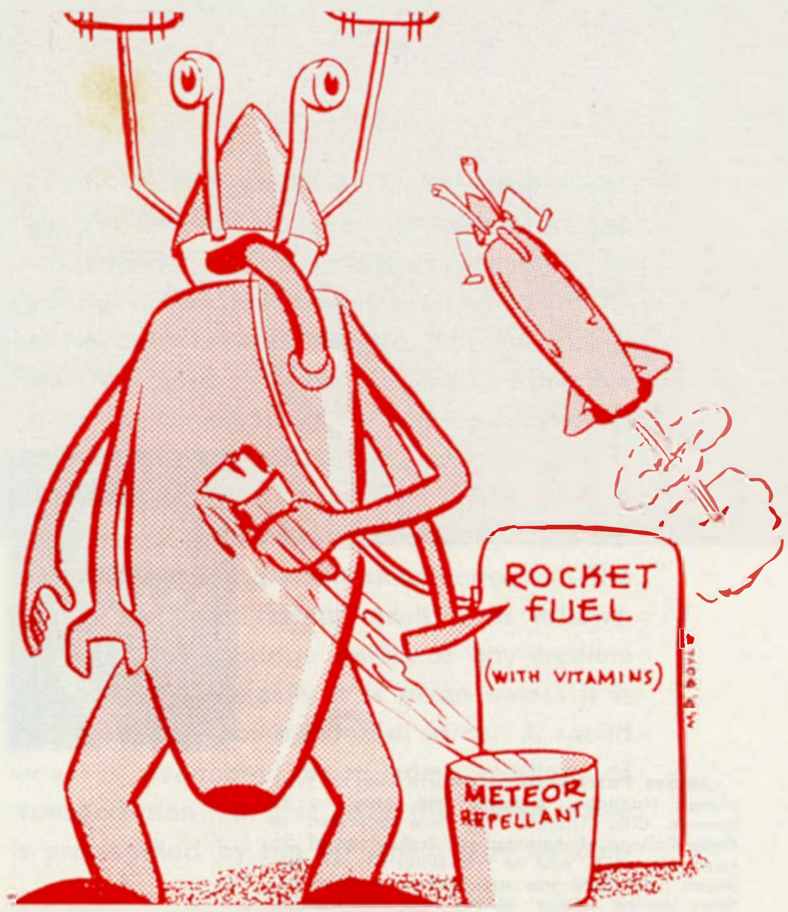
difference whether one is 100,000 feet or miles from the ground, if the chance of survival is about the same. The Space flyers will be in continuous contact with Earth. They can listen to the radio, call whenever they feel like it, have radar pictures and eventually television for their orientation and entertainment. Hundreds of small boats, submarines, light houses, observatories, and outposts are manned and maintained under extreme conditions of isolation and danger; but their unselected inhabitants do not crack. It seems that Columbus was more detached and desperate in his trip across the ocean than the Moon traveler will be five hundred years later.

Moreover, the point is not that people get scared, but that they snap out of it. Most men can adjust to a certain degree of danger, and only a few crack up; but again we are facing a dilemma because there is no test that would predict them with certainty. Says Scott Crossfield:

> **If a test pilot has real pyschological problems he would never be in this business. I have never been able to get anyone to tell me what they are. You're darned scared. Unfortunately, perhaps, it seems to be the characteristic of most aggressive pilots that they more or less sustain this apprehension. To my knowledge, in the past, none of the flight test pilots has had a physical checkup prior to a mission, unless there had been some reported difficulty. All pilots are required by military regulations to obtain physical examinations.**

And Crossfield is completely normal. So are the others who have seen blood, sweat, flak, and disaster. However it seems that the people on the ground are more inclined to worry than the men in the air. How did Lindbergh feel when he made his way over the northern seas? Of course, we can spend a million dollars on soul searching, but there seems to be some other worthwhile projects to sink the money in. The soul is not the weakest link in Space flight.

What is most impressive of all these preliminaries is neither the human factor nor interplanetary Space, but the powerplant that will make the ship akin to a celestial body. Seeing a rocket on the test stand is a unique experience; it is terrific and horrifying. To imagine that a man will ultimately walk over to such a three-stage, man-made volcano, board it through an elevator, calmly check his instruments a hundred feet atop the deadly furnace, and launch it with a roar, has still something of the science fiction about it. This



Dr. Gerathewohl's ideal space man, having four arms and hands (two hands developed into tools) to do the many things necessary for survival in Space, would include antennae instead of ears, telescopic eyes, direct oxygen supply from built-in tank, rocket fuel intake, and legs which act as fins during flight.

task, however, may be modern man's real crossroads of decision. It seems unlikely that we will have any real test other than letting him try it. It is a test of courage, not of skills. This thought is like that of Tony LeVier who said about the requirements of flying the F-104:

> **This bird is easy to handle and can be flown by a child. But you must be conditioned to it. I have looked at the faces of a bunch of test pilots when they saw the bird for the first time. Some just liked it. Some looked pleased. But some looked terrified. They were frightened. I could have picked the ones who can fly it just by looking at their expression.**
> **To condition these men seems to me the most important thing of all . . .**

No better comment can be made than this: We have the men and they are eager to go. They will be thoroughly conditioned through their experiences of test and research flight. They are ahead of the engineers and the fiction writers. They do not take these stories seriously about the "psychotic Russian Space girls," who are said already to have an edge on them; and they are not alarmed about manning the Space craft "with male and female pairs of unmarried psychotic midgets." (*Time*, September 16, 1957.) They know that they are the crop to choose from, and that one day they will take off. But this will not take place before they have at least a 99 percent chance of returning safely to Earth.

reality, relativity and common sense

BY JAMES P. GARDNER

James Patrick Gardner was born in Winnipeg, Manitoba, Canada, and grew up in Granite City, Illinois. He was educated at Parks College of Aeronautical Technology of St. Louis University and at the University of Alabama. His field was aeronautical engineering. Since leaving college, he has been employed by the Missile Design Section, Future Projects Design Branch of the Structures and Mechanics Laboratory at the Army Ballistic Missile Agency.

Common sense is that layer of prejudices laid down in the mind prior to the age of eighteen.
—Albert Einstein

No individual was more aware of the inherent difficulties associated with the acceptance of a new idea than was the creator of the theory of relativity. The more basic the idea, the greater the difficulty. Probably the foremost cause of this difficulty is the tendency to confuse reality with human experience. In early childhood we begin to form positive ideas in relation to space, time and motion. Anything that challenges these fixed notions is considered a violation of common sense and therefore unreal.

Fortunately there is a way out of the dilemma if one is willing to take the necessary steps. The first step is the recognition of man's place in the world as a casual observer with rather limited equipment. The second step is the acceptance of the fact that man does not have the capacity to conceive reality in the ultimate sense. With these things in mind we are ready to re-examine our ideas of space, time and motion.

We think of everything that moves as having some sort of conveyor. A train moves along a track with some velocity relative to the track. A ship moves through the water with some velocity relative to the water. Sound waves travel through the air with some velocity relative to the air. When we say something has a velocity, we usually mean relative velocity. The importance of the relative velocity concept may be illustrated by the following example.

Suppose we have two rifles, each of which fires a bullet with a muzzle velocity of 1,000 feet per second. To simplify the experiment we will assume that sound waves travel at exactly 1,000 feet per second. The two rifles are mounted on a stationary bench and are equipped with a mechanism which will allow us to fire them simultaneously, and a metal drum is placed 4,000 feet down range to serve as a target. When the guns are fired the bullets will travel down range, strike the drum, and the impact sound will travel back to the starting point. In this case we will hear both impacts at exactly the same time, or eight seconds after we fire, since the time required for the bullets to travel to the target will be exactly equal to the time required for the sound to travel back to the starting point.

Now let us repeat the experiment in a slightly different manner. We will mount one rifle exactly as before, but we will mount the other on an automobile which is moving toward the target with a velocity of 115 feet per second. Both rifles are fired the instant the car passes the stationary bench and again we wait for the impact sound waves to return. This time the sound waves will return approximately ½ second apart. Although both bullets left the rifles with the same muzzle velocity, they each had a different velocity relative to the ground. The bullet fired from the moving rifle had a higher relative velocity (muzzle velocity + car velocity) therefore it must arrive at the target first.

Now let us try another similar experiment. This time we will replace the rifle on the car with a horn. We will let the car travel in the same direction and with the same speed as before, and we will assume that the sound from the horn will bounce back from the target like an echo. As before, the instant the car passes the stationary bench the horn is sounded and the bullet is fired. In contrast to the previous experiment both sounds will return to the starting point simultaneously. The reason for the different result is as follows: A bullet moves independently of any medium with whatever velocity it is given unless it is acted upon by some external force. A sound wave is dependent upon some medium of transportation. In this case the sound wave is propagated by the air which may be con-

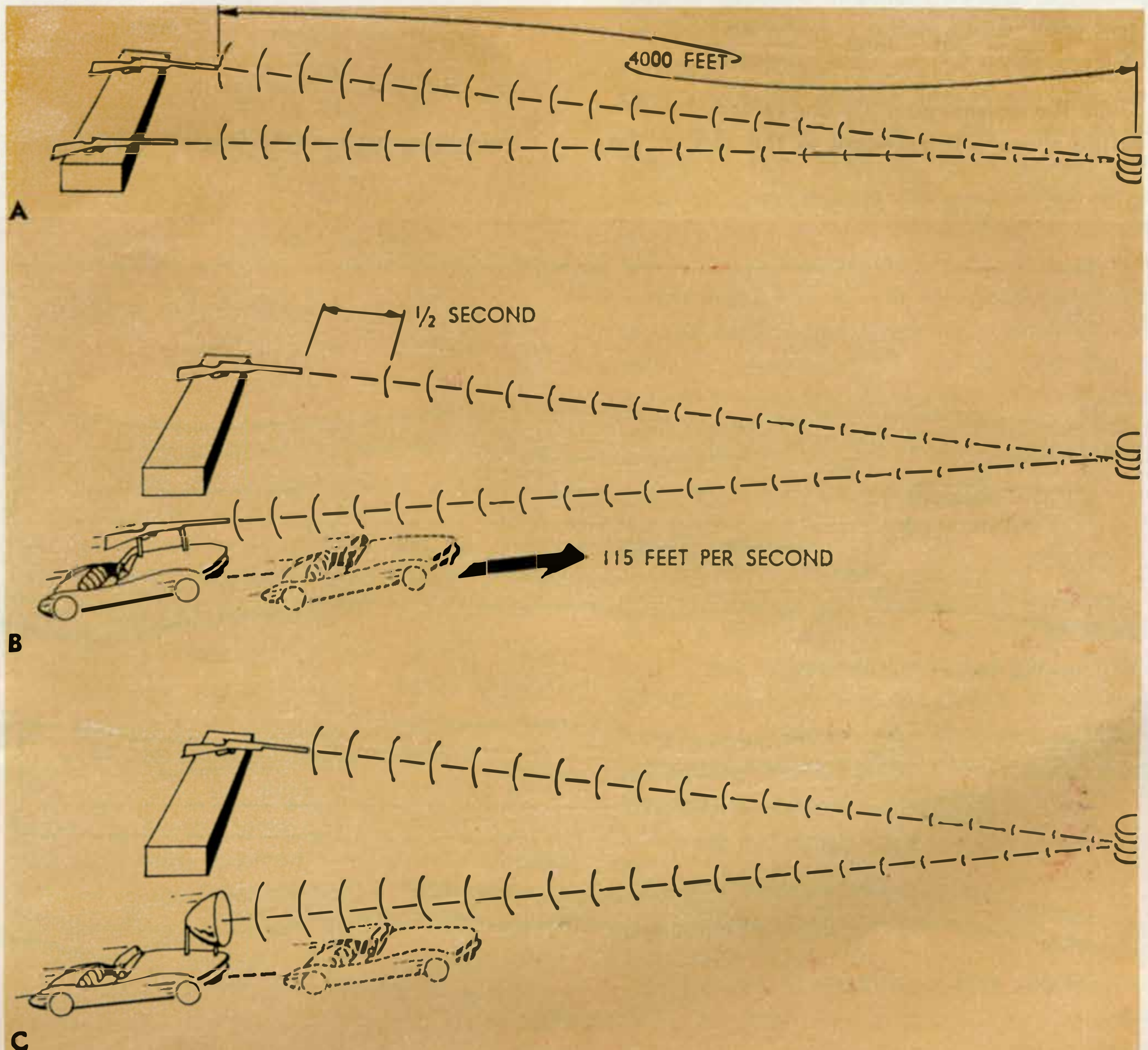


FIGURE 1

sidered at rest relative to the earth. So we find that the sound wave moves with a constant velocity relative to the air and is independent of the velocity of the source. This is an important point which will be referred to later.

We are now ready to perform an hypothetical experiment which will be helpful in explaining the Michelson experiment which opened the door to the theory of relativity.

The experiment is shown in Fig. 1, and proceeds as follows. Points A and B are located on a river 100 miles apart. We will assume that the river is flowing from A to B with a velocity of 10 miles per hour. We wish to travel by boat from A to B and back to A, and would like to calculate the time required for the trip. Our boat has a speed in still water of 20 miles per hour.

The basic equation of motion is:

$$t = \frac{d}{v} \quad \text{or} \quad \text{time} = \frac{\text{distance}}{\text{velocity}}$$

On the downstream trip our velocity relative to the shore will be equal to the sum of the velocity of the boat in still water and the velocity of the current.

$$v_{(\text{downstream})} = 20 + 10 = 30 \text{ mph}$$

$$\text{therefore:} \quad t_{(\text{A to B})} = \frac{100}{30} = 3.33 \text{ hr}$$

On the upstream trip our velocity relative to the shore will be equal to the difference between the velocity of the boat in still water and the velocity of the current.

$$v_{(\text{upstream})} = 20 - 10 = 10 \text{ mph}$$

$$\text{Therefore:} \quad t_{(\text{B to A})} = 100 = 10 \text{ hrs.}$$

$$t_{(\text{B to A})} = \frac{100}{10} = 10 \text{ hrs.}$$

The total time for the trip is:

$$10 + 3.33 = 13.33 \text{ hrs.}$$

Now let us stop the current and repeat the experiment.

$$v_{(\text{downstream or upstream})} = 20 \text{ mph}$$

$$\text{Total time} = \frac{200}{20} = 10 \text{ hrs.}$$

We have a time difference of 3.33 hrs.

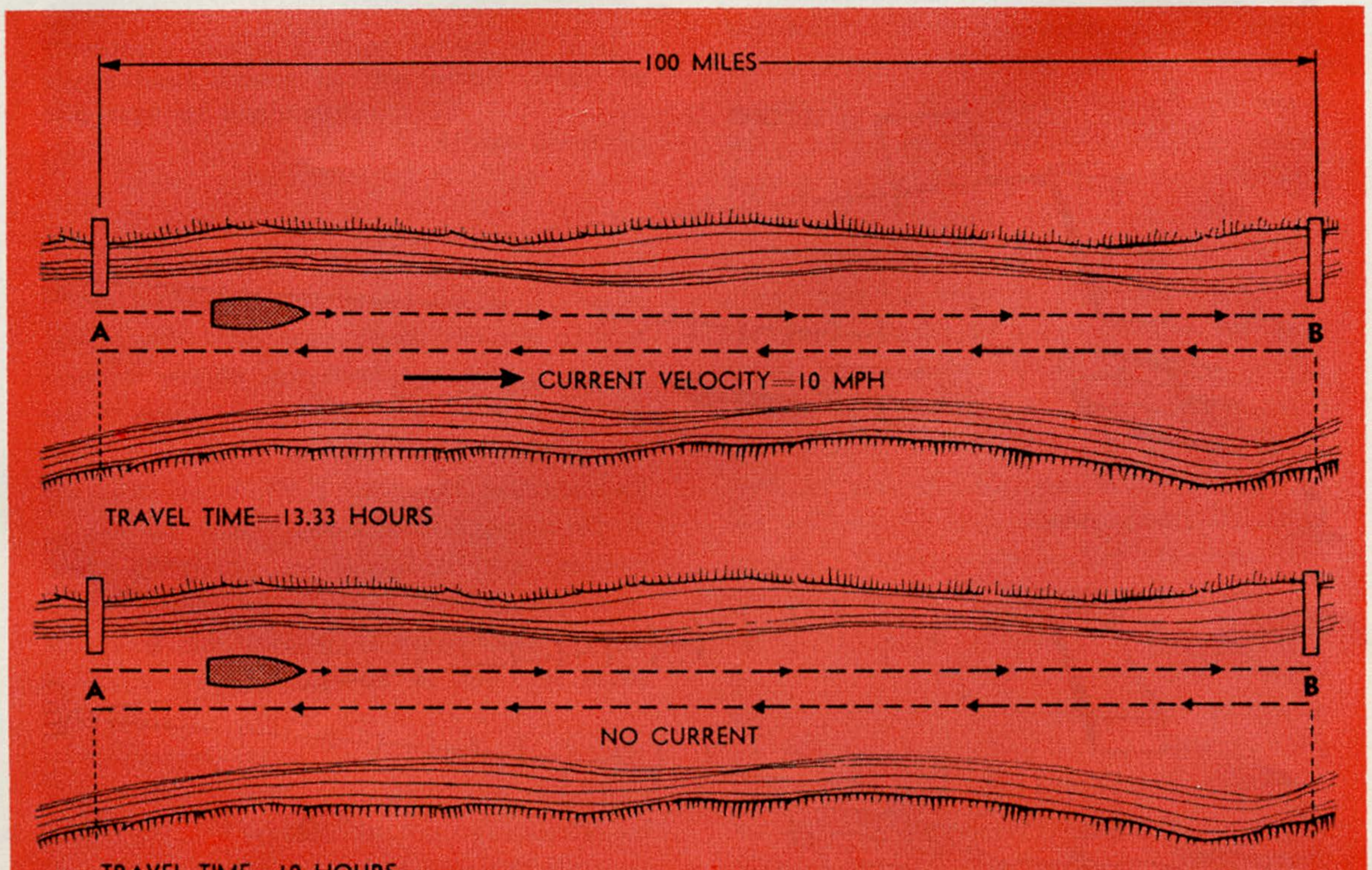


FIGURE 2

This time difference will vary proportionally to a factor involving the ratio of the current and boat velocities. By the use of some simple algebra we can derive the equation for the time shift and time shift factor.

t_1 = time downstream
t_2 = time upstream
d = distance A to B
v = boat speed in still water
c = current speed
t_t = total time for trip

$$t_1 = \frac{d}{v+c} \; ; \quad t_2 = \frac{d}{v-c}$$

$$t_t = \frac{d}{v+c} + \frac{d}{v-c}$$

$$= \frac{d(v-c) + d(v+c)}{v^2 - c^2}$$

$$= \frac{dv - dc + dv + dc}{v^2 - c^2}$$

$$t_t = \frac{2dv}{v^2 - c^2} \text{ (with current)} \; ;$$

$$t_t = \frac{2d}{v} \text{ (without current)}$$

$$\text{time shift factor} = \frac{1}{1 - \left(\frac{c^2}{v^2}\right)}$$

It is clearly seen that a time shift is introduced when an experiment is performed which involves motion in opposite directions through a medium which is in motion. With this in mind we are ready to review the famous Michelson experiment.

In the last half of the 19th Century there was much speculation in regard to the method of propagation of electro-magnetic waves, or more specifically light waves. As was mentioned before, we think of everything that moves as having some sort of conveyor and it is reasonably assumed that light was no exception to the rule. It can be easily proved by experiment that light does not use air as a conveying medium. If air is not the conveyor, what is? This is essentially the problem which confronted the 19th Century physicists. They found it difficult to imagine light waves propagating through empty space, so they decided that space must be filled with some mysterious substance. The mysterious substance was called ether and was endowed with some unique characteristics. It could propagate a wave, but it could offer no resistance to motion.

The next step in the ether hypothesis was obvious. If space is filled with this ether which propagates lightwaves, and it is at rest, then it should be a simple matter to find our (the Earth's) velocity through this medium. This is what Michelson set out to do.

Since light must move through the ether much as sound moves through the air, we know from our experiment with the rifle and the horn that the wave velocity is independent of the velocity of the source. We also know from the boat experiment that velocities measured in opposite directions through a moving medium will result in a time shift. With these assumptions Michelson set out to measure the Earth's velocity through the ether. His apparatus is shown in Fig. 2, and operates as follows. Two arms of equal length are mounted perpendicular to each other on a table which may be rotated about a vertical axis. A light source is placed at S, a half mirror at the axis A, and an optical instrument is mounted at the observation point O. A mirror is placed at the end of each arm at B and C. The optical instrument at O is called an interferometer which is an instrument which can be used to measure the slightest shift in the fringe pattern resulting from two interfering light beams. For instance, if a light beam is split into two beams, allowed to travel a given distance, and then re-united, an interference pattern will be observed. If the velocity and therefore the travel time of one of the beams is slightly altered, a different interference pattern will be observed. This change is referred to as a shift in the interference fringes.

In the Michelson experiment, if we consider the Earth at rest and the ether flowing by, we have a situation similar to that in the boat experiment. We are substituting a light beam for the boat and a flowing ether for the river. The light beam starts at S and proceeds to A where it is split into two beams, one of

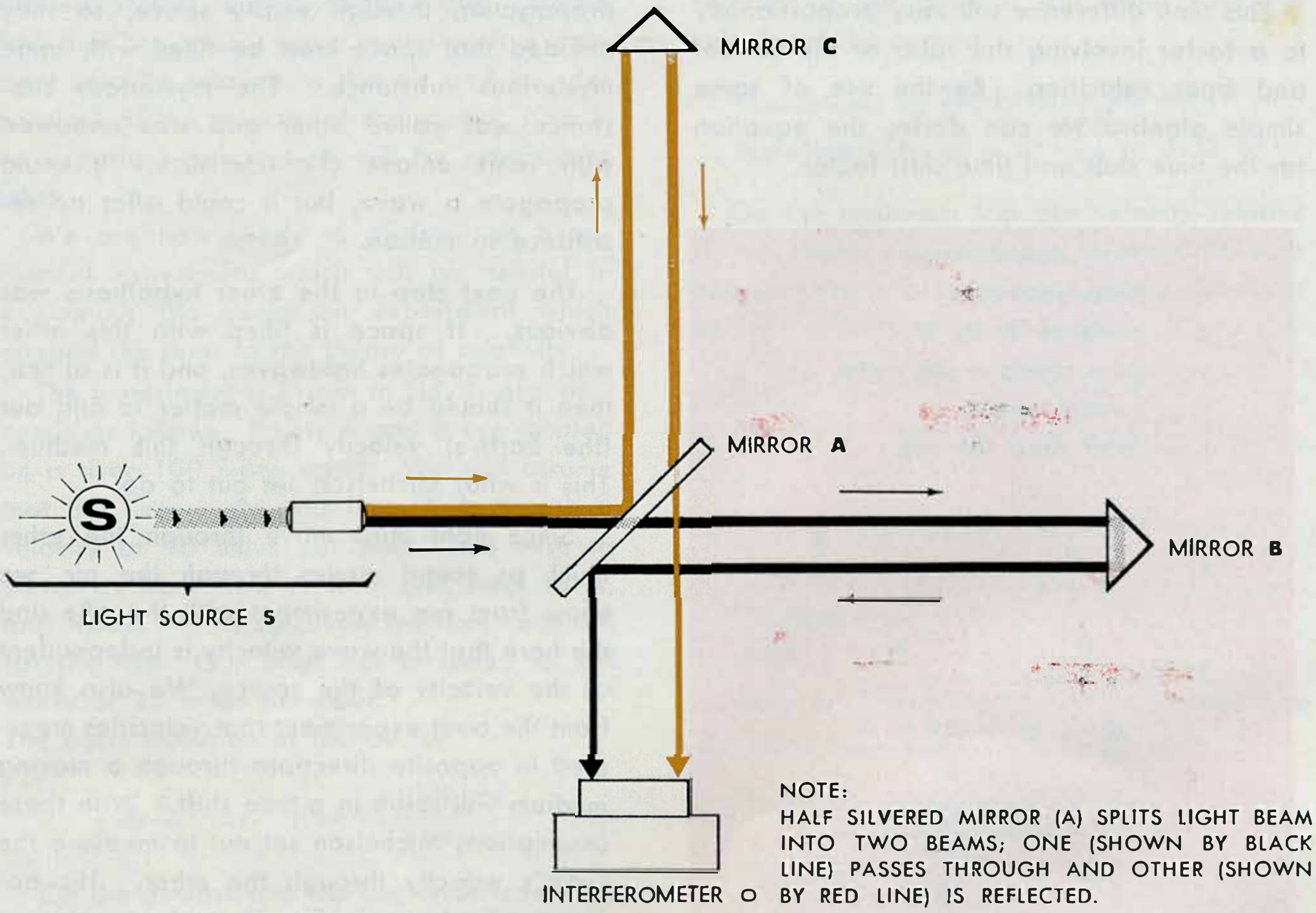


FIGURE 3

which passes through A and proceeds to B, and the other is deflected 90 degrees and proceeds to C. The two beams are reflected at B and C, re-united at A, and proceed to O where they enter the interferometer. If the entire apparatus is rotated 90 degrees so that the light beam from A to B is first moving parallel to the motion of the ether and then perpendicular to the motion of the ether, we would expect to find a time shift as we found in the boat experiment. In this case motion perpendicular to the ether stream is comparable to motion with no current in the boat experiment.

Michelson performed his experiment with extreme accuracy, and several variations were introduced to eliminate the possibility of error due to external influence. To his amazement, in each case no appreciable shift in the interference fringes was observed, and no time shift could be recorded.

The results of this experiment had a greater effect on physical science than perhaps any in history, for they cast a shadow of doubt upon existing fundamental concepts which were the very foundation of modern physics. Many leading physicists of that day took up the challenge and attempted to explain the results of the experiment by slightly modifying or extending present views, but this path usually led to further complications and contradictions. Of these attempts probably the most brilliant was made by H. A. Lorentz in the field of electro-magnetics. He showed that the negative result of the interference experiment could be explained by applying a theory previously advanced by Fitzgerald which stated that the physical dimensions of a body are altered if the body is in motion. This change in dimension is known as Fitzgerald contraction, and is described in the following manner. If a body is in motion its length measured along the line of motion will be decreased by an amount proportional to the ratio of the velocity of the body and the velocity of light. As the velocity of the body approaches the velocity of light it will gradually become shorter until at the velocity of light its length will become zero. If this theory is applied to the Michelson experiment, we see that the arm of the apparatus which is parallel to the Earth's motion will be shorter. When the apparatus is rotated 90 degrees, the other arm will be shorter. The equations of Lorentz show that this change of length due to velocity is the right amount to cancel out the effect of the time shift and cause the observed negative result. Lorentz believed this shrinking to be a physical reality resulting from magnetic field interactions within the atomic structure of the material. He compared this effect to that which can be observed in certain electrical phenomena involving charged bodies moving in electric fields.

The electro-magnetic theory necessitated the introduction of new hypothesis and heavy restrictions, and therefore could not be fully accepted as an explanation of the experimental results.

One other possible explanation was brought out. This was the theory that the ether moved with the Earth thereby eliminating the ether stream. This possibility was disproved by experiment.

As one attempt after another failed, the scientific world wondered what to do with these experimental results which seemed to violate every rule of science and common sense ever laid down by man.

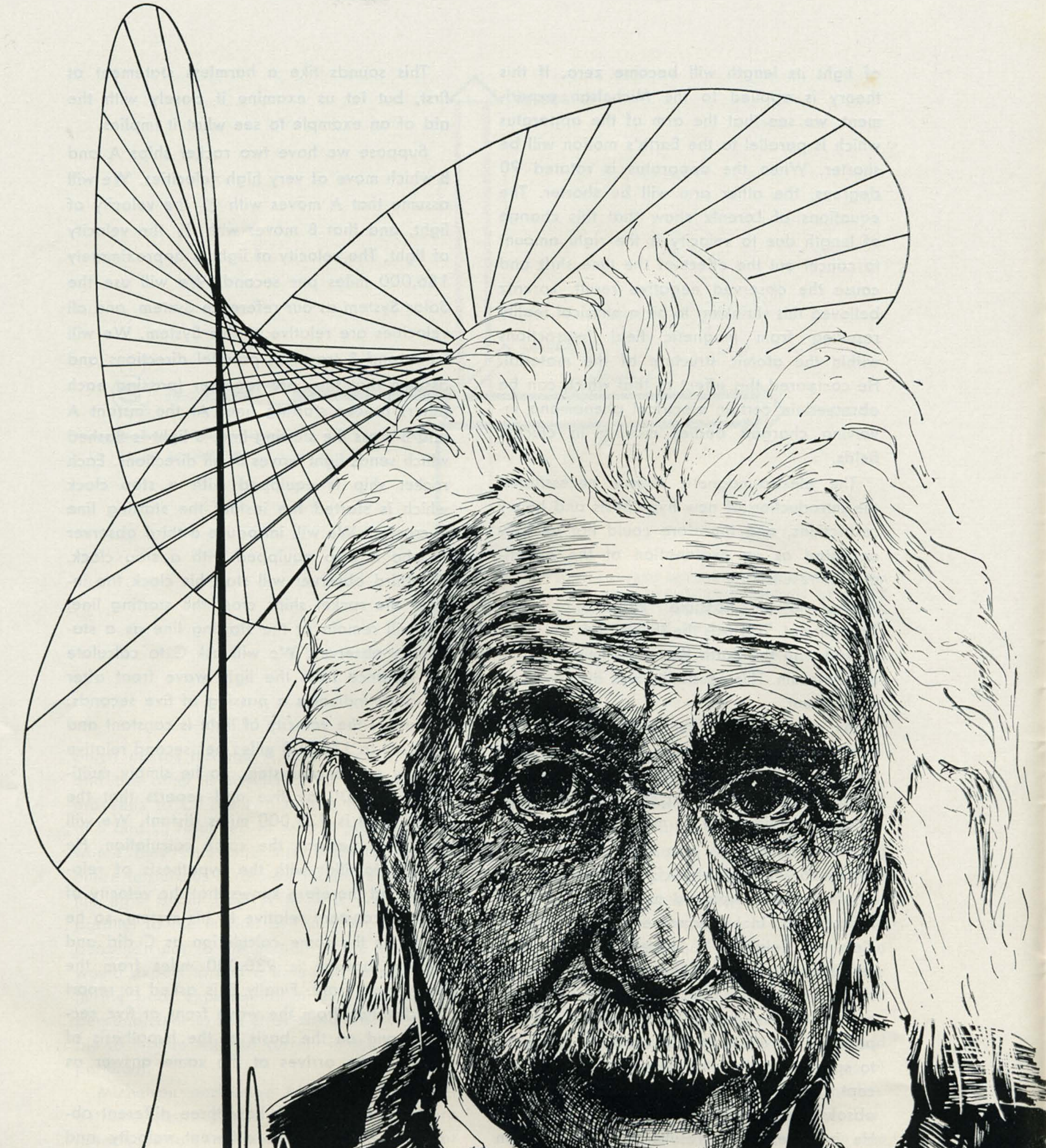
The answer came in a short paper written by a 26-year-old physicist, Albert Einstein, who was then employed as a patent clerk in Switzerland. In his paper entitled "The Principle of Relativity", Einstein introduced a whole new concept of the physical world. He showed that the difficulties encountered in explaining the results of the Michelson experiment were due to false concepts in regard to space and time. He showed that the concept of space and time as individual and absolute entities was completely meaningless. He interpreted the results of the Michelson experiment as indisputable proof of the following statement which is the basis of the theory of relativity.

"The velocity of light in vacuo is the same in all reference systems moving uniformly, relative to each other."

This sounds like a harmless statement at first, but let us examine it closely with the aid of an example to see what it implies.

Suppose we have two rocket ships A and B which move at very high velocities. We will assume that A moves with ¼ the velocity of light, and that B moves with ½ the velocity of light. The velocity of light is approximately 186,000 miles per second. We will use the Solar System as our reference System, and all velocities are relative to this System. We will let A and B travel in parallel directions and assume that they are together (passing each other) at our starting line. At the instant A and B cross the starting line, a light is flashed which sends light waves in all directions. Each rocket ship is equipped with a stop clock which is started the instant the starting line is crossed. We will introduce a third observer C who is also equipped with a stop clock. The third observer will start his clock the instant the rocket ships cross the starting line, but will remain at the starting line as a stationary observer. We will ask C to calculate his distance from the light wave front after his clock indicates a passing of five seconds. He knows the velocity of light is constant and is equal to 186,000 miles per second relative to any reference system, so he simply multiplies 186,000 by five and reports that the wave front is 930,000 miles distant. We will ask A to perform the same calculation. He is also familiar with the hypothesis of relativity and therefore knows that the velocity of light is constant relative to his system, so he performs the same calculation as C did and reports that he is 930,000 miles from the light wave front. Finally B is asked to report his distance from the wave front at five seconds and on the basis of the hypothesis of relativity he arrives at the same answer as did C and A.

Now we must ask how three different observers each with a different velocity and each starting from the same point at the same time can be the same distance from a point (the light wave front) the same number of seconds later? Apparently the wave front is in three different places at the same time. This certainly is a violation of common sense!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In search of an explanation, we are confronted with a choice. We either must accept this result and look deeper for the cause, or we can forget the hypothesis of relativity and go back to the old method of adding and subtracting velocities. The Michelson experiment has shown the disastrous results of the old method, so we will take the first choice.

We must accept the fact that the wave front is where the observers say it is since their calculations are based on the hypothesis of relativity, but we cannot accept the possibility of the wave front occupying three different positions at the same time. The answer to the puzzle lies in our concept of time which we have considered absolute, or the same, for all observers regardless of their state of motion. We are actually forced to give up the concept of absolute time and accept the fact that it is impossible to compare time measurements directly between systems which are moving relative to each other. In our rocket ship experiment we can consider the time measured by the stationary observer C as our basic time for comparison. I do not wish to give the impression that there is anything special or absolute about the time measured by C. We only use this time as a basis for comparison because we considered C to be at rest in our reference system.

Since A is moving with some velocity relative to C, we must assume that his clock runs somewhat slower than the clock at C. Since B is moving at a higher velocity than A relative to C, his clock must run slower than A's clock. So we have three observers performing an experiment based on time, and each observer has a clock which is running at a different rate. No wonder our results were ridiculous!

Actually the wave front was much closer to A and B than it was to C when C's clock showed a passage of five seconds since they were traveling at high velocities in the direction of the light wave. The clocks carried by A and B were running slower, so when they finally recorded a passage of 5 seconds the wave front was the same distance from them as it had been from C.

In the theory of relativity, time by itself has no meaning, and space by itself has no meaning. It is only the combination of the two, or the defined point at the defined time which can really describe an event. Because of this interlocking of space and time, comparisons of length, distance, and velocity cannot be made between systems which are moving relative to each other unless the laws of transformation, which were first derived by Lorentz, are applied. These laws enable us to calculate the length of a body which is in motion relative to a given reference system. These laws are in the form of equations, and are stated as follows:

$$L' = L_0 \sqrt{1 - \frac{v^2}{c^2}} \quad ; \quad t' = t_0 \sqrt{1 - \frac{v^2}{c^2}}$$

Where:

L_0 = Length of a body at rest relative to a system.

L' = Length of a body in motion relative to a system.

t' = Time lapse of a clock in motion relative to a system.

t_0 = Time lapse of a clock at rest relative to a system.

v = Velocity of a body or clock relative to a system.

c = Velocity of light in any system.

These laws which are based on the constant velocity of light as given in the hypothesis of relativity completely explain the results of the Michelson experiment. If these same equations are applied in the boat experiment, we see that the change of length and time will exactly compensate the effect of the moving current. As stated before, in this case the boat represents the light beam, and the current represents the relative velocity. If the contraction and time change equations are properly combined they result in the time shift factor which was derived in the boat experiment.

At first the theory of relativity strikes most of us as, at best, an interesting philosophical diversion, but if we seriously ponder the subject we become aware of the significance of it's implications. In certain areas these implications seem to border on the supernatural. A good example of this is the slowing down of time. Time, which is usually taken quite for granted, is actually somewhat of an abstraction in itself. When we think of time we usually think of a clock which is a periodic mechanical device which is calibrated to the rotation of our planet. If the rotational speed of our planet should suddenly increase or decrease, we would be forced to throw away all of our clocks.

So we see from the preceding discussion that time is meaningless unless it is associated or interlocked with physical events. The theory of relativity shows that the velocity of light is the upper limit or maximum velocity with which any physical body can move since to exceed this velocity we would find ourselves dealing with negative time or clocks running backwards.

An interesting result of this time dilatation is illustrated by the classic example of the Space traveler who leaves the Earth, flies about in Space for a few weeks with a velocity near that of light, and then returns to Earth to discover that several hundred years have elapsed. During his voyage his clock was almost stopped due to his high velocity relative to the Earth. He was of course completely unaware of this slowing down of time since all of his physical and mental processes were slowed down in the same manner.

Examination of the transformation equations shows clearly that relativistic effects do not come into play unless velocities near that of light are attained. We do not experience such velocities in everyday life, but as man moved into Space such velocities must be obtained if we wish to travel to another solar system within an individual's life span.

"Doggone it! Are they THAT hard up for Space Cadets?"

EDITOR'S NOTE: Recent investigations in astronautics have resulted in a new concept which may help relate the macrocosm to the microcosm, with the tie between them being *time*.

Briefly the idea is this: in basic physics we learn that the total energy of a mass is equal to the sum of its potential energy and its kinetic energy; or, in formula $\Sigma E = E_p + E_k$. But this is true only in a state of equilibrium; for example, a satellite in orbit around Earth or one of its sister planets, the swinging pendulum of a clock, etc. But if we consider the total energy required to bring a mass into a new state of equilibrium, then this formula no longer holds true—according to the new concept of "displacement energy" or ΔE.

To illustrate, let us analyze the football quarterback who makes a "jump" pass. Before he leaps into the air, his body possesses potential energy. As he springs into the air, two things happen: time elapses and his potential energy is converted to kinetic energy. However, during the time he is moving upward, energy must also be expended to lift his energy needed to throw the ball. This, then, is the "displacement energy," and it must be accounted for in any computation of the *total* energy needed for such a pass. Thus the formula must now become: $\Sigma E = E_p + E_k + \Delta E$. The same holds true for launching a satellite into orbit around Earth, lunar probes, and interplanetary Space flights.

Within the microcosm the concept of ΔE may also have far reaching consequences. It may even impinge upon a unified concept of universal occurrences. In this respect, ΔE seems comparable to Maxwell's "displacement current," which explains, among other things, the action of a capacitor (condenser) in an electric circuit. Indeed, there is a striking similarity between the two concepts in that both involve the consideration of *time* as the essential determinant.

The discovery and formulation of this important concept was made by Helmut Hoeppner, formerly of the Army Ballistic Missile Agency and now Senior Scientist for Astronautics at the Chrysler Corporation, and his co-worker at ABMA B. Spencer Isbell, also editor of SPACE Journal. Both Hoeppner and Isbell credit Professor Hermann Oberth with assistance and encouragement during their work on ΔE.

—Mitchell R. Sharpe

design criteria for buildings on the moon

By John S. Rinehart

John S. Rinehart, a physicist, received his Bachelor of Science degree from Northeast Missouri State Teachers College in 1934, his Master of Science degree from California Institute of Technology in 1937, and his doctorate from the State University of Iowa in 1940. He has taught at Kansas State College, Wayne University, and Harvard University. A former associate director of the Smithsonian Astrophysics Observatory, he has also worked for the Naval Ordnance Test Station and the former New Mexico Experimental Range. He is presently a professor of mining engineering at the Colorado School of Mines and director of the Mining Research Laboratory. A member of Sigma Xi, the American Physical Society, and the American Association for the Advancement of Science, he is the author of *War Weapons for Air Warfare* and *The Behavior of Metals Under Impulsive Loads*. For his services during World War II, he was awarded a Presidential Certificate of Merit.

Man will, within the foreseeable future, construct permanent buildings on the Moon to serve as living quarters for Moon explorers, laboratories for astrophysical and astrochemical research, maintenance shops for the vehicles of the Space traveler, stations for communication networks, and numerous other structures. How are these buildings to be built? What are the basic design criteria? How do they differ from those applicable to Earth-situated buildings? What special facilities must be provided that are not needed on Earth? What are the environmental differences and hazards? What determines the material we use? What problems must the architect and the construction engineer face? How are the materials to be transported?

The Moon is a large, essentially spherical body which moves in a slightly elliptical orbit around Earth in accordance with well-established physical and astronomical laws: Newton's laws of motion; Newton's universal gravitation law; and Kepler's laws. Its mean distance from Earth is 238,857 miles, and it takes 27.3 days to revolve once about Earth. During this revolution it turns exactly once on its own axis so that it always presents the same side to Earth (but the Sun illuminates all points on the Moon at some time during this revolution.) The Moon wobbles a bit so that actually we see about 59 percent of its surface.

Its diameter is 2160 miles, approximately ¼ that of Earth, but its mass is only 1/81 that of Earth; thus its density (pounds per cubic feet) is only 0.61 times that of Earth or about 280 pounds per cubic foot. From this we derive, from Newton's universal law of gravitation, a most significant and important result, namely, that the gravitational attraction at the Moon's surface is only 0.165 (approximately 1/6) that on the surface of Earth. Thus on the surface of the Moon every object will weigh only 1/6 as much as on the surface of Earth. The mass of each object is, however, independent of its location. *In design one must continually keep the distinction between mass and weight clearly in mind.*

The environment of a building on the Moon differs markedly from its environment on Earth. The Moon has no observable atmosphere. There is no haze, no clouds, no winds, no rain or snowstorms. The building is either bathed in intense sunshine or looks upon stark, black, cold Space. It will be continuously plagued by a great gnat-like rain of interplanetary dust.

The Moon has lost its atmosphere, if it ever had any, because of its small size and, hence, low gravitational pull. The velocity of escape from the Moon is quite low, 1.5 miles per second, as contrasted with 6.9 miles per second for that of Earth. The gravitational attraction of Earth is strong enough to grip and hold to it the nitrogen and oxygen molecules that form our atmosphere. This is not the case on the Moon. The thermal velocities of the gas molecules are sufficiently high that if gas molecules were ever present, they would long since have wandered off into Space. A few molecules of heavy gases such as carbon dioxide, krypton, and xenon may have remained behind or may be seeping out from the Moon's interior but these are not significant. *Thus the atmospheric pressure is zero, and any building constructed there must be internally pressurized with an atmosphere in which human beings can survive.*

The Moon's surface, unshielded by an absorbing atmosphere, can feel the full force of the Sun's rays and become extremely hot on one side while the other side will quickly have radiated its heat into Space and become exceedingly cold. Day and night on the Moon are each about two weeks long.

The temperatures on the surface of the Moon have been carefully measured, using a telescope equipped with a vacuum thermocouple. On one occasion this was done during an eclipse and it was found that the surface of the Moon cools very quickly, reaching a low temperature in 20 or 30 minutes after the Sun stops shining. The temperature at lunar midday is 214° F; at sunset—32° F; and at midnight —243° F. It is possible to guess the sort of temperature environment, maximum and minimum temperatures and rates of changes in temperature, any structure placed on the Moon will be subjected to. *Any structure placed there must be able to withstand these extreme temperatures and especially the tremendous temperature gradients.*

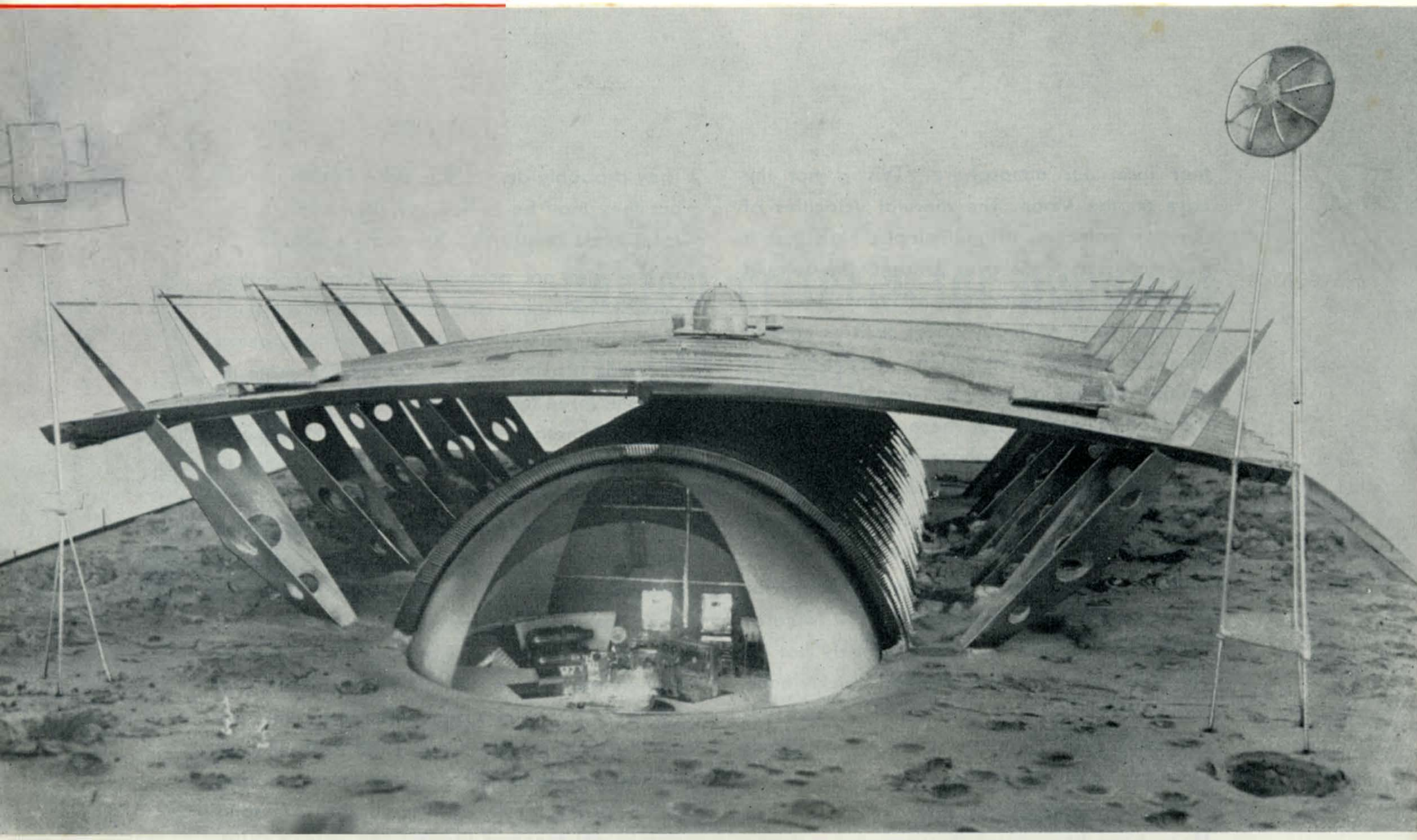
The ultraviolet radiation, normally absorbed by Earth's atmosphere, will be sufficiently intense to render panes of glass or plastic useless as windows. Thus, shutters for such windows must be provided.

The Moon is continually bombarded by particulate matter: cosmic rays, charged particles, and meteoric particles. Not much is known about the rate of influx of cosmic rays although recent records from Explorer III indicate that they are considerably more abundant in space than we have thought. They probably do not present a health hazard but they may be sufficiently abundant to discolor glass or plastic after long exposure.

It is also not possible to define accurately enough the nature and distribution of meteoric matter to estimate it as a potential hazard to lunar structures. Extraterrestrial material exists in three forms: the most abundant by far is interplanetary dust, the dust which forms the zodiacal light, a faint band of light seen extending from the Sun at the end of twilight; the next is debris from comets, which, when they streak through our atmosphere produce intensely luminous trails, called meteors, and, lastly, the meteorites, probably great masses of stone and iron and fragments of planets which once resided between Mars and Jupiter in our solar system. The interplanetary dust ranges in size from 1 to 300 microns in diameter; meteors are fragile, porous bodies of low-gross density; and meteorites are solid chunks of iron and stone. The velocity with which any of these might strike the Moon ranges from 1.5 miles per second to about 44 miles per second. There will be no atmosphere to check its velocity as is the case with Earth, where the interplanetary dust and the meteors are rendered impotent.

The fall of a meteorite is a relatively rare event: about five per day reach Earth. Interplanetary dust is by far more abundant in Space with the abundance of this dust in the vicinity of the Moon being about 5×10^{-21} grams per cubic centimeter. The Moon sweeps up this material at the rate of 110 tons in a 24-hour period.

Thus the chance of a large building being struck by a meteorite or a meteor is negligible, one hit in perhaps several thousand years. Interplanentary dust is the real hazard, and we do not know how great it is. The particles are small; and even though of great velocity, they could be easily warded off with an umbrella-like shield. The best estimate is that about three or four particles, with diameters ranging from 0.0002 to 0.0004 inches, would strike each square yard of exposed surface per day. *A meteoric shield must be a part of any structure* built on the Moon.



Scale model of a Moon building designed and built by the Wonder Building Corporation of America, as a permanent structure for our Moon explorers. The plastic bubble-type observatory in the foreground is protected from ultraviolet radiation by sliding metal doors. The overhead structure is a meteorite shield to protect the building proper. The dome in the center of the barrier is a traffic control tower. The proposed building would be 340 feet long, 160 feet wide, and 65 feet high.

From a practical viewpoint, the exact nature of the surface of the Moon is our greatest unknown. On a grand scale we know that the Moon's surface is covered with large and deep craters, huge mountain ranges, and vast flat areas. But we can not look at the Moon in the intimate detail needed to provide us with realistic design data for construction. Resolution with our best telescopes is about one mile.

Opinion is now divided as to the nature of the Moon's landscape. At an Air Force symposium on this subject in April 1958, three eminent astronomers summarized their variant ideas:

1. The maria (large dark flat areas) are almost certainly covered with lava and will make firm landing spots for Earth's spaceships.

2. The rock has turned slowly to dust by bombardment of rays and particles from the Sun and Space. The dust, kept stirred up by the same agents that formed it, has flowed like a slow liquid into the Moon's low places so the maria are not filled with lava, but with dust perhaps several miles deep. Dust near the surface may be as fluffy as baby powder. Unwary ships might disappear in dry quicksand.

3. Although the Moon may have plenty of dust, its surface has been solidified. There may be a thin layer like dust on a grand piano, but the underlying material, cemented together (not stirred up) by bombardment from Space, is probably "crunchy" and strong enough to support air alighting spaceships.

With this lack of knowledge and great divergence of opinion, we can only design for the worst condition: a sea of dust upon which we must float our structures.

Without defining the specific function of the building we know that it must provide for the following:

1. Living quarters, including rooms for sleeping, cooking, eating and recreation.
2. Physics, chemistry, and biological laboratories.

3. A control tower for communication, meteorological studies, earth observations, astronomical observations, traffic control, etc.

4. Air conditioning, heating, power and refrigeration plants, oxygen production units, extreme-temperature regulating devices, water supply and sewage disposal plants.

5. A machine shop and equipment maintenance area. Further, we know that the structure must be built as an integral floatable unit.

We assume the following: (1) that the location of the building on the Moon will be fixed; (2) that the building will be constructed from materials brought from Earth; (3) that the building will provide the functions listed above; and (4) that it will be a permanent-type building in the sense that it will be occupied on a continuing basis for several years.

A Moon building presents its own peculiar problems, and first is the matter of gravity. The force of gravity on the Moon is approximately 1/6 that of Earth. This means that the deflection of a cantilever beam or any other load-supporting beam or column will be only 1/6 as great as it would be on Earth. Changes in gravity will not affect the strength properties of the materials. For design purposes we can, in static situations only, replace the gravity of 32 feet per second which repeatedly appears in our strength of materials formulas by 1/6 its value, say five feet per second. A whole new field of design is opened up. It is as if we had an exceedingly high-strength, lightweight construction material.

We must, however, be wary of any dyamic situation. We do not change the mass of our material by transporting it to the Moon. It would be just as difficult to accelerate a car on the Moon as it is on Earth. Thus, designs involving vibratory or rotary motion must conform to the normal Earth pattern. An electric generator designed for Moon use would not appear substantially different from an earthly one.

Reduction in gravity will influence the convective flow of air and the rate of flow of liquids downhill. These changes are likely to become important in design of the heating, power, water, sewage, and ventilating system.

Ramps and stairs can be much steeper because man will be able to lift himself with 1/6 the effort required on Earth. A crane designed for a one ton load on Earth can be lift at least six tons on the Moon. We must, on the other hand, be careful with our elevators for here we are *accelerating* and *decelarating* masses.

No consideration need be given wind or snow loads since they will not exist. Our major stresses now come from the artificial atmosphere contained within the hermetically sealed building. Normal atmospheric pressure, 14.7 pounds per square inch, is a realistic figure to use for design purposes; 10 pounds per square inch would be sufficient. The problem is not unlike that encountered by the designers of high-flying aircraft except perhaps in one respect which could be significant. On the Moon we can play the gravitational forces against the air pressure forces, achieving some kind of equilibrium which may gain us an advantage. This is a matter that needs looking into. Broad expanses of curved structures can be used, but we must tie the whole together with rods or similar means so that it does not explode.

Rapid, intense heating and sudden, severe cooling present difficult but certainly solvable design problems. The parts of the structure becoming shaded will immediately become very cold, while those in the Sun will remain heated to a high temperature. During the lunar day, when the Sun is upon the structure, devices must be provided to regulate the influx and efflux of heat. These should be tied together to the heating and ventilating systems. But we must also be prepared to be without our principal energy source, the Sun, for two weeks at a time. This means providing energy storage facilities of no mean proportion.

The potential hazard from cosmic rays, while still one of the big unknowns, is probably not great enough to warrant modifying building practices. Eventually the living quarters may be lined with thin sheets of lead.

The bombardment by meteoric matter is serious but can be dealt with. The best approach is to use the scheme long in use by tent dwellers to protect themselves from the fury of rainstorms; a canvas canopy covering, placed above and separated some distance from the roof of the tent, which dulls the force of the impact of the raindrops and diverts the material away from the roof of the tent. On the Moon, the canopy must be of a metal, with a thickness sufficient to stop meteoritic dust. A 1/32-inch thick aluminum shield should be sufficient. We cannot hope to protect against chance encounters with large meteoric bodies anymore than a canvas shield protects aginst large hailstones. Provision should be made for replacing sections of the shield as they become damaged.

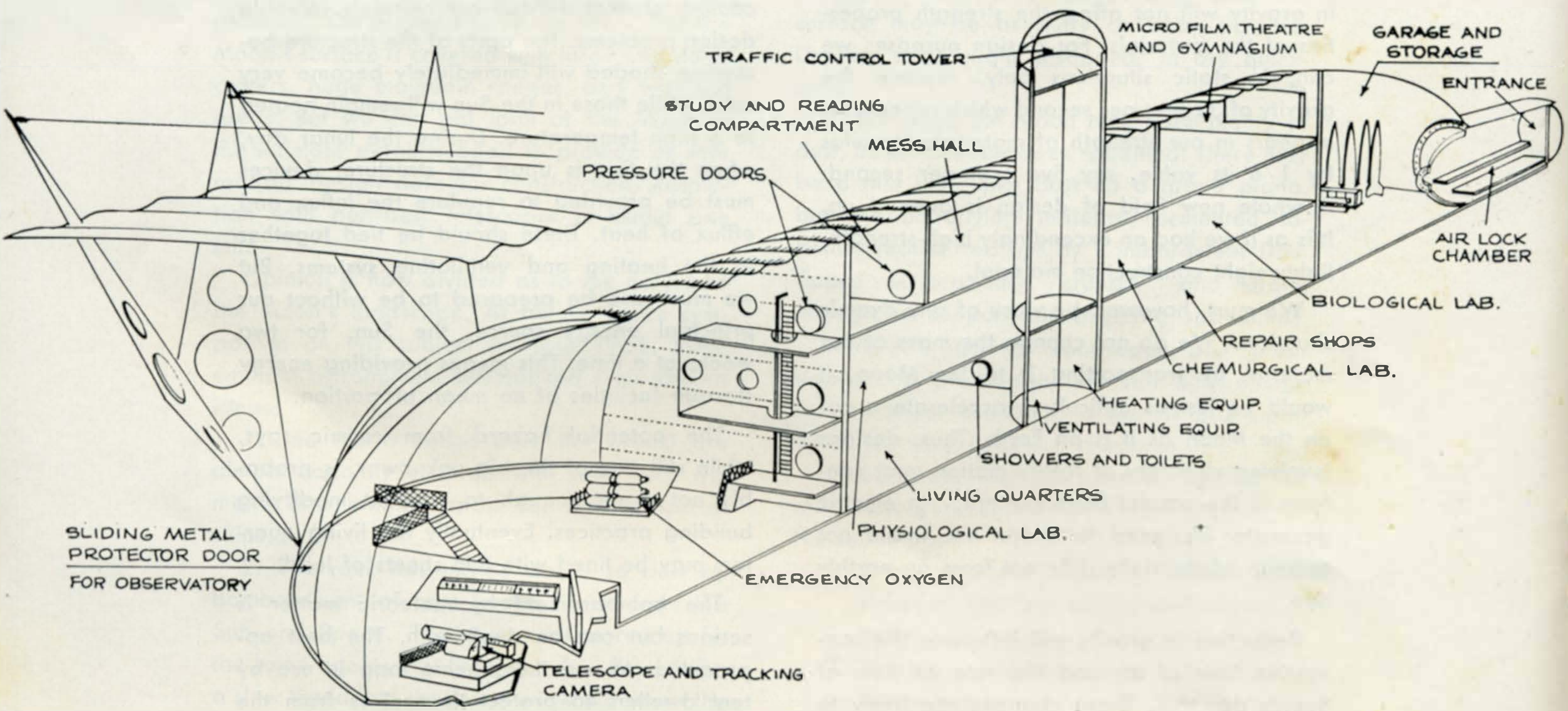
Finally, we are concerned with foundations for the building and here is the greatest difficulty. There seems to be but little else to do but to design the building as a structure which floats in a stationary ocean of dust, anchored in place by large, heavy blocks suspended by long cables from the body of the structure. In many ways its construction will resemble that of a ship at anchor, a freely-floating, self-contained unit. The building need not be streamlined. Fortunately, also, it need not be built to withstand the tumultuous forces exerted by a watery ocean. The dust on the Moon is as calm as a mild pond.

According to Archimedes' principle a body immersed in a fluid is water buoyed up by a force equal to the weight of the fluid it displaces. A 10,000-ton ship, for example, has 320,000 cubic feet immersed when it is floating. Now, how will the dust ocean act in this respect? We are safe in concluding that it will act as a fluid of low density: for design purposes, about 0.5 times the density of water or 30 pound per cubic foot. Thus the lower part of our building will be covered with dust, the volume, V, so covered being given by

$$V\ (ft^3) = \frac{\text{Total weight of building (pounds)}}{30}$$

The dust will tend to support the lower floor or hull. At a 6.6-foot depth, the pressure acting on the floor will be just equal to atmospheric pressure. If the hull is embedded to depths greater than this it must be designed so as not to be crushed by the weight of the dust.

Cutaway view of the interior of the Moon building shows compartments for research, living quarters, observatories, etc. The entrance is at the right end of the building where there is an air lock. Pressure doors separate the main areas from each other and prevent loss of internal air pressure in case of a puncture of the overhead shield and building by meteors.



Since the building is floating, weight must be fairly uniformly distributed if it is not to topple over or settle unevenly.

If the Moon's surface proves to be sufficiently solid, it will provide normal support for the building and may be used as foundation blocks.

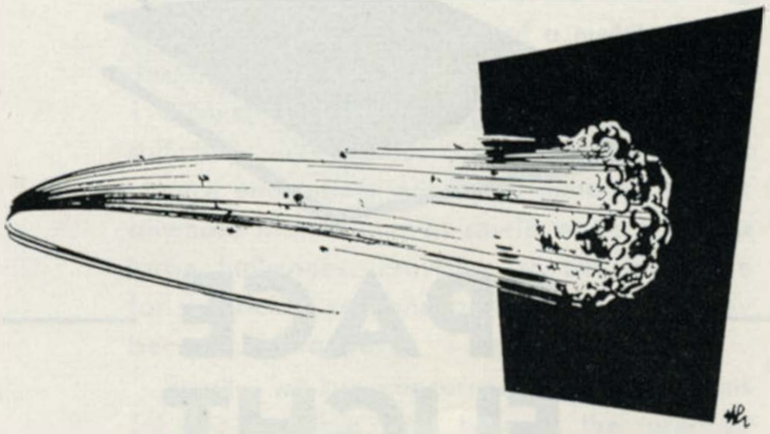
There is no one building uniquely qualified for placement on the Moon. Design requirements allow as well as demand a diversity of structural types, proportions, materials and forms. The Buck Rogers portable and inflatable plastic balloon house is a perfectly practical type of temporary housing.

Permanent housing must be fabricated from more durable materials. Aluminum suggests itself immediately because of its high strength, low weight, and ease of fabrication. Aluminum also provides a good reflecting surface which aids in cooling problems.

The basic elements of the Wonder Building Corporation of America's "Truss-Skin" roof system are well suited for construction of Moon buildings because of its great flexibility and versatility. Some details have necessarily been modified, including the development of means for hermetically sealing the structures.

The basic scientific information needed to complete first designs of functional and attractive buildings for use on the Moon are at hand. Our task has been the very specific one of taking these scientific guide lines and producing a practical model.

—METEORITES



GLOBAL REPORTING

Russia

★ Soviet cosmic ray studies are being pursued at a new Pamira Mountains scientific center in Central Asia. The center is equipped with a 70-ton electromagnet, a cloud chamber, an ionization hodoscope, and automatic control equipment. When the apparatus is assembled, Soviet scientists will be able to detect the flux of cosmic particles over a wide area. Studies of nuclear interactions at energies of 50-billion electron volts are going on, too.

★ A Soviet satellite for relaying TV broadcasts appears to be in the planning stages, with scientists anxious to carry out preliminary tests of both the rocket vehicle and the broadcast relay apparatus. The decision to push ahead with such a plan was made last January by the TV section of the USSR Scientific and Technical Society of Radio Technology and Electrical Communications. It is claimed that a steady reception would be assured throughout the Eastern Hemisphere. Thus, the TV satellite would give the Russians an "electronic foot" in the door of countries inhabited by some 2.2 billion persons.

★ The Moscow City Council is sponsoring a contest among Soviet sculptors for the design of a monument in commemoration of the launching of Sputnik I. Many models and designs have been submitted and are currently on view in Moscow for public reaction. Visitors to the exhibition are asked to write their comments on various designs as an aid to the panel of judges that will make the final selection.

Great Britain

★ A Space medicine symposium, organized by the British Interplanetary Society and the Royal Air Force, Institute of Aviation Medicine, was held on 16 October 1958. The subjects discussed included the effects of conditions likely to be encountered in Space (excessive acceleration, weightlessness, radiation, temperature extremes, etc.) and means for their mitigation, food supplies, psychology, current research programs, etc.

★ The new British rocket testing center "Spadeadam" is now under construction near Carlisle, Cumberland. The project, which includes a complete settlement with restaurants, recreation halls, stores, hospital, fire house, is being erected with government funds. After completion it will be made available to the rocket and missile divisions of Rolls Royce and de Havilland.

FRANCE

★ The French atomic scientist C.-N. Martin has come to the conclusion that the Russian Sputniks were not launched from the Caspian Sea area but from the Ukraine. He reports his reasons in *Les Satellites Artificiels.*

United States

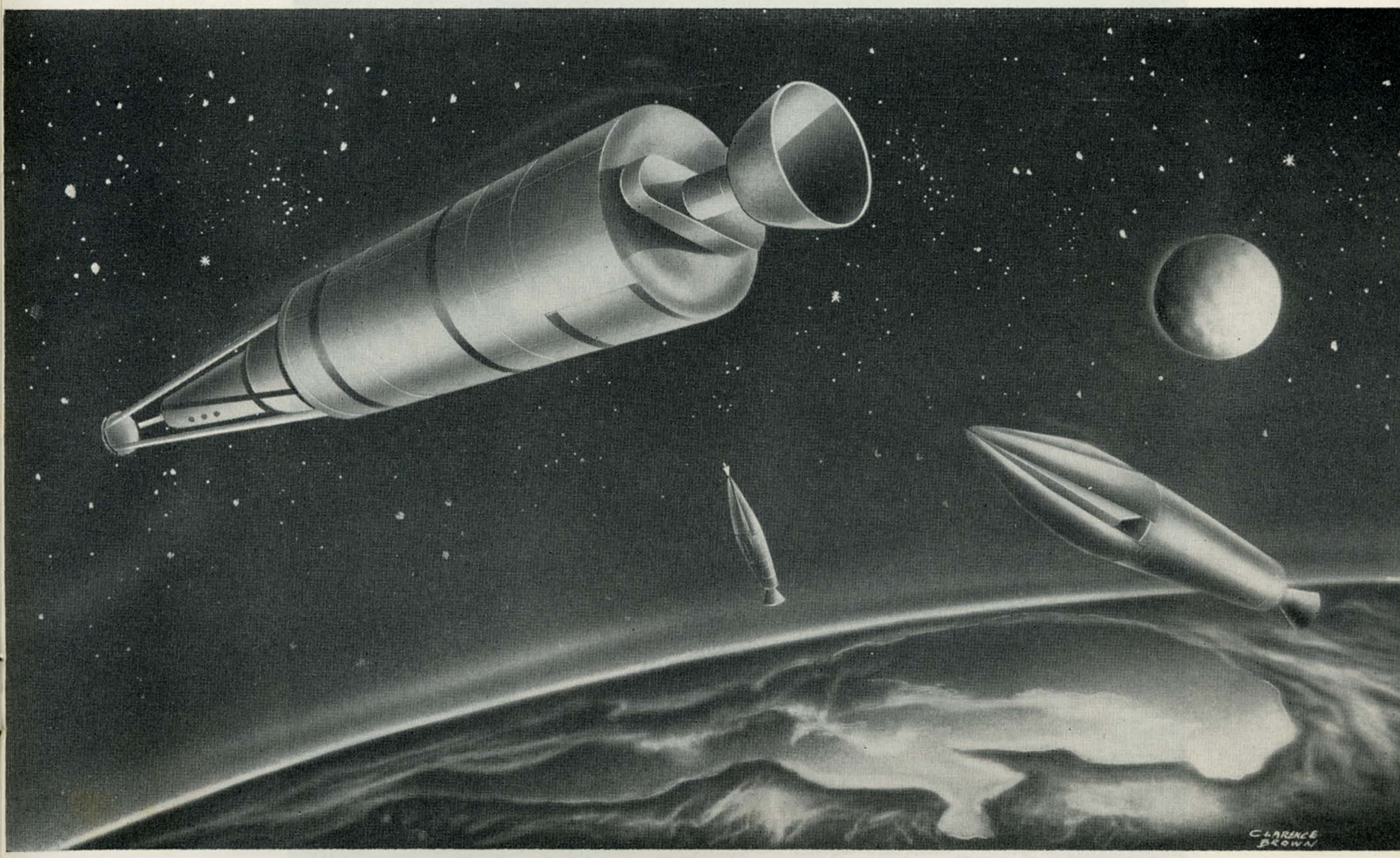
★ The United States Air Force recently disclosed that it has been recovering recorded scientific information from outer space with some of its Thor and Atlas missile flights that carry operational nose cones.

The nose cone, developed by General Electric, is equipped with a "messenger" that records data during flight. Before the nose cone returns to Earth, the "messenger" is ejected from it by a small jato unit. The "messenger" itself is a small plastic sphere 18 inches in diameter. It contains a tape recorder, a junction box, a battery pack, dye markers, and a sofar sounding bomb. The plastic is strong enough to protect the instruments yet light enough to allow the "messenger" to float in water.

★ A four-man experimental Space station, launched by an Atlas missile and orbiting 400 miles above Earth, has been proposed by the Convair Division of General Dynamics Corporation. According to the proposal which the firm says could be a reality within five years from the starting date, an Atlas without nose cone or associated weapons gear would be fired into orbit. The shell would be equipped as a Space station. Escape gliders are fastened to the back for return to Earth.

United Nations

★ The abolition of national claims to the Moon and the planets of the Solar System is expected to be a major issue on the provisional agenda of the United Nations Assembly. Secretary General Dag Hammarshkjold voicing the proposals of the United States and Russia has called for international agreement which would rule that outer Space should be a community affair with individual power claims to celestial bodies illegal.



INTO SPACE

The Moon has beckoned for ten thousand years
To tribes and generations of mankind;
And now this world is ringing loud with cheers
As men set out, another world to find.
The Greeks before us watched the stars, and dreamed
Of travellers beyond this earthly sphere;
They gazed enraptured at the Moon, which seemed
To beckon—and which filled their souls with fear.
The Middle Ages came and passed, devoid
Of any hope, beyond the realm of dreams
That men could ever travel in the void
Through which the Moon sends down its golden beams.
For space flight once was just a prayer, but now
We stand upon the verge of knowing how.

by Wade Wellman

"Through science we seek to owoken man to his philosophical significance in the setting of the Universe. This activity of science hos never been more dominant than it is today. For, whereas the men of yesterday were interested in extending their frontiers merely over the face of the Earth, we ore today extending our frontiers into Outer Space, thinking not of one world but of many."
ANDREW C. IVY

"I believe that the time hos orrived for medical investigation of the problems of manned Rocket flight, for it will not be the engineering problems but rather the limits of the human frame that will make the final decision as to whether manned Space flight will eventually become a Reality."
WERNHER von BRAUN

dynamics of life in the universe

By John Hulley

John Hulley was born in Florida and educated in Europe and the United States, graduating *magna cum laude* from Harvard in 1944. A veteran of World War II, he has worked for the Office of Strategic Services as a historian and was chief of the European Regional Staff in the Washington headquarters of the Marshall Plan. At present he lives in Washington, D. C. where he is doing original research into Space philosophy from the ecological approach.

The preceding article (*Space Journal*, Summer, 1958) described human activity from an ecological aspect: seeking expansion and survival, humans may carry life from planet to planet. Illustrations were taken from nature as we observe it on Earth's surface. The next step is to examine the hypothesis from the point of view of nature as we observe it in the Universe around us. At this level, the interacting forces are simpler and more fundamental.

During most of recorded history, men have gazed upon the heavens with a mixture of wonder and foreboding. In the heavens they personified forces which could give, alter or remove life. These personifications represented a view of reality which approximated the truth. One important error, however, was the shortness of time-concepts; the end of the world has been anticipated on specific dates which turned out to be incorrect.

In recent centuries, the pendulum has swung the other way. The extreme view was adopted that the present order of things is eternal. The first telescopes revealed only stable revolutions in our planetary system. Discarding historical beliefs, early scientists substituted a relaxing view of invariable and perpetual motions in a calm Universe.

Today we have bigger telescopes, as well as spectroscopes and radiotelescopes, supplemented by increasing microscopic observations and a growing knowledge of Earth's history. The application of physical sciences takes us out of static analysis and introduces us to the dynamics of the Universe. In the words of C. Payne-Gaposchkin,

> Ten years ago in our hypotheses of cosmic evolution we were thinking in terms of gravitation and light pressure. . . . Tomorrow we may contemplate a galaxy that is essentially a gravitating, turbulent electromagnet.
> (*Scientific American,* September, 1953)

Modern astronomy is approaching a middle position between the extreme views of earlier times. We live in a cosmos, the forces of which can indeed create, change or remove life.

All bodies in the Universe—stars, comets, planets, asteroids, meteors, cosmic clouds and dust—are composed of the same atoms; all are radiant, but in different degrees. Stars represent the highest degree of atomic activity. Nuclear fusion occurs at temperatures ranging from thousands to millions of degrees. This process transforms an original supply of hydrogen into other types of atoms. In their formative stages, stars may cast off the aggregations of matter which form the lesser bodies of the Universe. While the degree of stellar radiation varies, it is always intense.

On smaller bodies, atomic activity is substantially below the level of nuclear fusion. On their surfaces, the relative coolness permits the stability of atomic structure. Under certain limited conditions, a planetary surface may support processes which cannot occur in the nuclear furnace of a star. With the right combination of atoms, with sufficient gravity to retain atmosphere, and under the stimulus of stellar radiation, complex transformations and activities may develop on the planetary surface.

Chemists have long since shown how the more complex inorganic compounds arise from simpler ones. In recent years, American scientists have also shown how molecules essential to organic life may develop. They have attempted to simulate the conditions and stimuli occurring on our planet several hundred million years ago.

At that time, the surface probably consisted of oceans of the simpler atoms. Without plants, there could be no oxygen or ozone shield. Consequently stellar rays would beat directly upon the oceans. The resulting reactions have been partly reproduced in the laboratory, with various groups of atoms and electrical stimuli. The product was amino acids. These are key acids necessary to the build-up of proteins, which in turn are essential to organic life.

What has particularly interested scientists is the fact that varying combinations of atoms under varying stimuli produced amino acids. The tendency to evolve molecules essential for the life process occurs in varying conditions.

Together with other finds, these experiments narrow the gap between chemistry and biology. The bridge between the two has not yet been found, but the continuing progress sustains scientific opinion that it exists: life naturally evolves in appropriate situations.

So far as we can observe, the evolutionary process may be taking place on at least one other of the planets in our solar system. Observing the uniformity of the Universe and the commonness of our Sun, leading astronomers today infer that similar processes are occurring on a proportionate number of the billions of planets estimated to be in our galaxy.

On the basis of our present understanding of Earthly evolution, it appears that plant life must come first, because it depends directly on Solar radiation. Once it appears, it discharges oxygen. The resulting build-up of atmosphere absorbs or scatters back about 30 percent of the Solar energy, including particularly the ultraviolet. This protection both preserves life and slows down the rate of transformation at the planetary surface.

The evolution of species occurs through genetic mutations. These may be stimulated by residual radioactivity at the surface; by such radiation as pierces the atmosphere; by thermal, chemical and unknown forces, internal or external. Experiments have shown that mutations are induced by such stimuli.

Radiation from stars like our Sun changes susbtantially. In the long run it rises steadily. Medium-term fluctuations raise or lower its intensity. These changes in stellar radiation not only determine whether life will evolve, but also the rate of duration of its evolution.

The long-run trend determines how long a planetary surface will be favorable to organic life. According to E. J. Oepik (*Scientific American,* June, 1958), Solar radiation became sufficiently intense for continuous life on Earth about 750 million years ago. Prior to that date, medium-term fluctuations may have stimulated the origin of life several separate times before continuous life became possible. About one billion years in the future, similar discontinuities may result from fluctuations around the long-term trend toward excessive radiation.

Fifty million miles further from our Sun, Mars now receives much less radiation. Observations indicate that only primitive forms of life, such as algae, lichens and fungi, have developed on its surface thus far. Provided the water shortage is not prohibitive, it should become more favorable as increasing radiation makes Earth less so.

Conceivably the ice-laden surfaces of Jupiter and the further planets may in turn become more hospitable to such life as can adapt to their gravity. At some point, however, the long-run curve of solar radiation will begin to rise sharply. Our Sun's expansion will reach explosive proportions, and life will no longer be possible in this planetary system.

During the hundreds of millions of years that the long-term trend favors life on a partic-

ular planet, the medium-term cycle markedly affects it. Oepik attributes Earth's 250-million year recurrence of Ice Ages to periodic declines in Solar radiation. During the six million years of an Ice Age, the ice cap may advance and recede. Such glaciations as well as other crustal disturbances select those species which can adapt to them.

The evolution of new forms may also be affected by fluctuations in radiation. Paleontology divides the history of life on Earth into a series of ages. Ages are characterized by the prolonged stability of their various species; the rate of evolution is slight. Shorter intervening periods separate the ages; during these, the extinction of old species and mutation of new ones apparently occur at a massive rate. Changes of temperature and radiation may account for these simultaneous extinctions and mutations.

Elemental sensitivity to radiation is thus a continuing process. The origin, rate, direction and possible conclusion of evolution are forms of interaction between variable stellar radiation and planetary enviroment.

The tendency of evolution is to absorb an increasing amount of Solar energy through the activity of increasingly complex forms of life. Simple forms, like algae, utilize Solar energy directly. A fuller use is achieved by interdependent organisms. Plants, insects, birds and other animals are able to absorb more energy by specialization and exchange.

Through mutation, these complex interdependent forms evolve. In the words of H. J. Muller,

> Living matter, unlike non-living, is by reason of its doubling and redoubling always tending to expand, not like a gas that becomes more dilute and feebler in the process, but with increase of its mass and no relenting of its pressure outward and into diverse corners and crevices. In fact, the pressure of the living matter tends to increase with its expansion, since at the same time, by means of its mutations, it is trying out all sorts of new versions of itself and perpetuating and sending furthest forward those that can expand the fastest and that can enter regions and situations that had acted as barriers to its earlier versions. (*Scientific Monthly,* May, 1957)

Mobility is essential to this process. The environment varies with seasons, latitudes and daily weather. As new species evolve, capable of utilizing environmental forms of energy more effectively than others, they expand through migration. Plants are as migrant as animals in the long run; the seeds of most botanical species are adapted to transport by wind or water, on the fur or feathers of animals and birds as well as in their intestines.

Over periods of time, continuing interchange of species permits those best adapted for any locality to displace those less adapted. The result is the development of interdependent ecological communities which take maximum advantage of the solar and other energy available in any particular climatic region.

Occasional natural calamities may denude whole areas. Migration permits species to survive such events and subsequently to revitalize those areas. Land which has been laid bare by fire, flood or other local catastrophe receives solar energy only to dissipate it into Space. Gradually the seeds of crude plant forms, borne by wind, birds or other carriers, take root. Certain types of insect life migrate into the area, attracted by the plants. When they have adequately developed the top-soil, more advanced plants move in, displacing the previous inhabitants and making possible the arrival of higher types of animal life. Thus, over a century or two, the area progresses to what ecologists call a "climax" community—a close-knit and delicately balanced system of plants, insects and animals.

Oceans bar migration of most land species other than man. Until modern times, the separate continents supported communities varying in their degree of adaption and energy-utilization. As a general rule, larger areas developed more advanced forms of life because they afforded greater opportunity for variation and selection. In the Americas and in Australia, species were fewer and often more primitive than those of the Afro-Eurasian land mass. They were still sparser on islands.

About a million years ago our highly-specialized form of life evolved on the large continent. Physically weak and dependent on other species for the conversion of Solar energy, man has an intelligence which permits the use of tools. During 99 percent of the period from then till now, our ancestors experimented with stones, sharpening them for use in catching and processing other animals; their societies receded and advanced in the face of the cyclical glaciations of the present Ice Age. Then about 10,000 years ago, they developed carpentry. They began to exploit the environment, and gradually became the most mobile of species.

During the last five centuries, men have overcome the ocean barrier. As they crossed the seas with increasing frequency, our forefathers carried other forms of life. In part this process was intentional: they took their favorite trees, flowers and pets, as well as the plants and animals they wanted to consume. Probably to a greater extent, it was unintentional: seeds, insects and sometimes even larger forms of life chanced to accompany the voyagers. Darwin, among others, noted the beneficent effects of human mobility in advancing the levels of organic life on areas previously cut off from one another.

Transoceanic mobility was a big step when it occurred. But it has become evident that human powers far exceed this accomplishment. Men explore the highest mountains, descend to the oceans' depths, balloon into the atmosphere. The development of aerial flight and the first probings of outer Space have led to preliminary experiments in the direction of interplanetary exploration. There seems to be no limit to our mobility so long as environments at both ends of the trip are hospitable.

To expand our efficiency we have exploited other organic life and reduced the net absorption of Solar energy. But the cost is small compared to the possible gains. The achievement of interplanetary mobility would make it possible to expand wherever the temporary conditions in a variable Universe permit.

Here on Earth, we are familiar with minor variations and disturbances. Atmospheric changes give us cloudy or clear skies, wind, rain, snow, hail, lightning and the like. We adapt to these. The tilt of our planet's axis gives us seasons, and we adapt to these. Occasional disturbances include local hurricanes, tornadoes, floods and earthquakes.

Photograph by Dr. V. Ben Meen

CHUBB CRATER FROM THE AIR—The crater, perfectly round and more than two miles across at the rim, is an unmistakable landmark from the air. It was explored and proved to be of meteoritic origin by a National Geographic Society-Royal Ontario Museum expedition during July and August, 1951.

Our mobility permits us to minimize losses and afterwards to restore life to demand areas.

On a larger scale the cosmos offers many hazards, as well as stimuli, to planetary life. These occur at a leisurely pace, spanning millions of years. But they are correspondingly much greater, and sometimes destructive to celestial bodies. Long as are the time-periods, they are only fractions of that needed for the evolution of advanced life. Consequently an effective organic response must include sufficient specialization and mobility to adapt to them.

In addition to the cycles of Solar radiation, other events occur. As yet we know too little to predict them all; but the time spans between major events appear to be much longer than between minor ones.

Some of the hazards of the Universe are relatively small—useful as reminders that they do exist. Perhaps a few thousand meteors strike our atmosphere each day. Occasionally one is large enough to come down to the surface and even more infrequent ones are

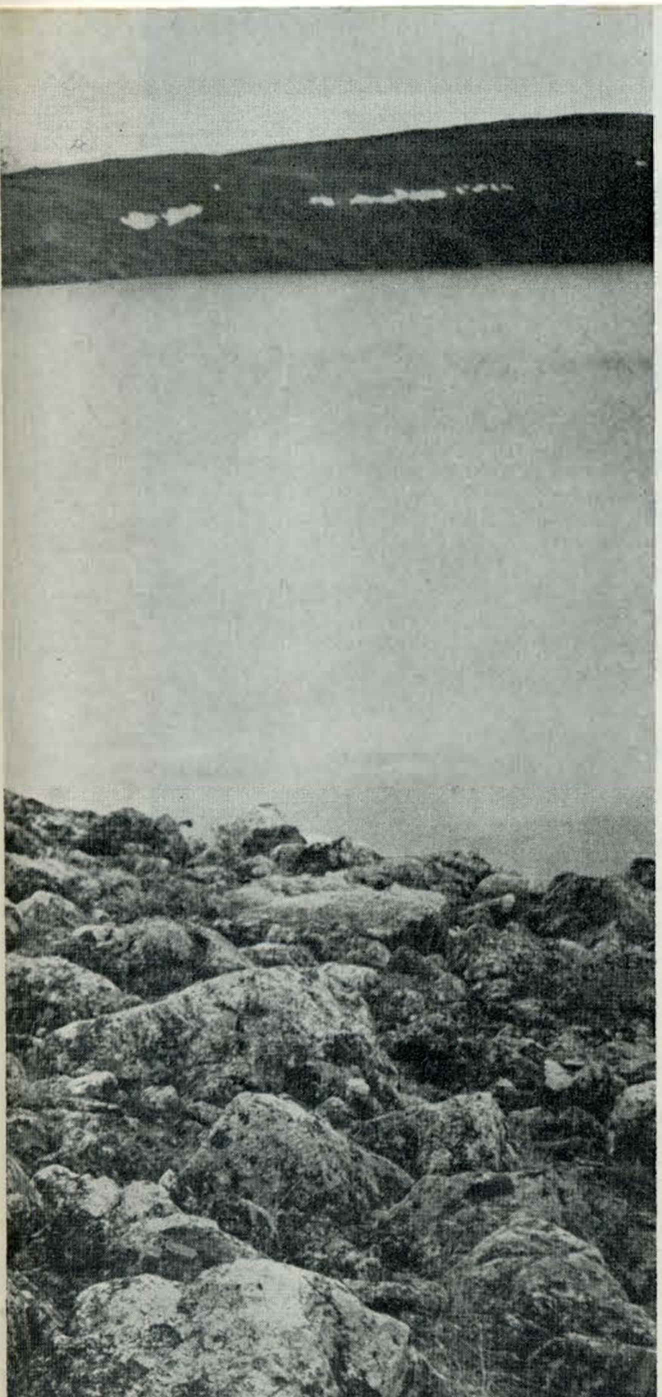
A National Geographic Society-Royal Ontario Museum Expedition under the direction of Dr. Victor Ben Meen, Museum geologist, in 1951 probed the mysterious crater daily for four weeks and concluded that it was formed by the crash of a meteor some 30 to 150 centuries ago. Frederick Chubb (above, left), prospector and explorer who first spotted the crater, and Dr. Meen (right) describe their field procedure to a visiting scientist, Dr. I. W. Jones, chief of the Geological Surveys Branch of the Quebec Department of Mines.

large enough to mark the surface. Canyon Diablo in Arizona is ¾-ths of a mile across and 600 feet deep. Chubb Crater in Canada is bigger. Other craters may have been formed and subsequently erased by wind, rain and organic life. The 30,000 craters on the earthward side of the Moon may illustrate what our planet would look like without these erosive forces.

Asteroids are much fewer and less likely to collide with our planet. On the other hand, their size—up to 400 miles in diameter—would end life over a substantial area. Comets range from 4 to 20 times Earth's diameter; but they are so thin that collision would ordinarily have little effect.

Collisions between planets or other large objects may occur. The asteroid belt, the meteors and the bodies reflecting zodiacal light are all thought to be remnants of a planet which used to circle at one remove from us, between Mars and Jupiter. We do not yet know the cause of its break-up; it has tentatively been attributed to collision.

Another possible type of planetary disturbance is a shift of axis while remaining in orbit. Magnetic analysis of ancient rocks indicates that Earth's polarization has been at various times opposite and perpendicular to its present direction. The location of ice-cap remnants below, and on, the present equator may be interpreted in support of what Gold and Hoyle call "polar toppling." However, there is no agreement yet on the evidence or on the internal or external forces which might cause such shifts.



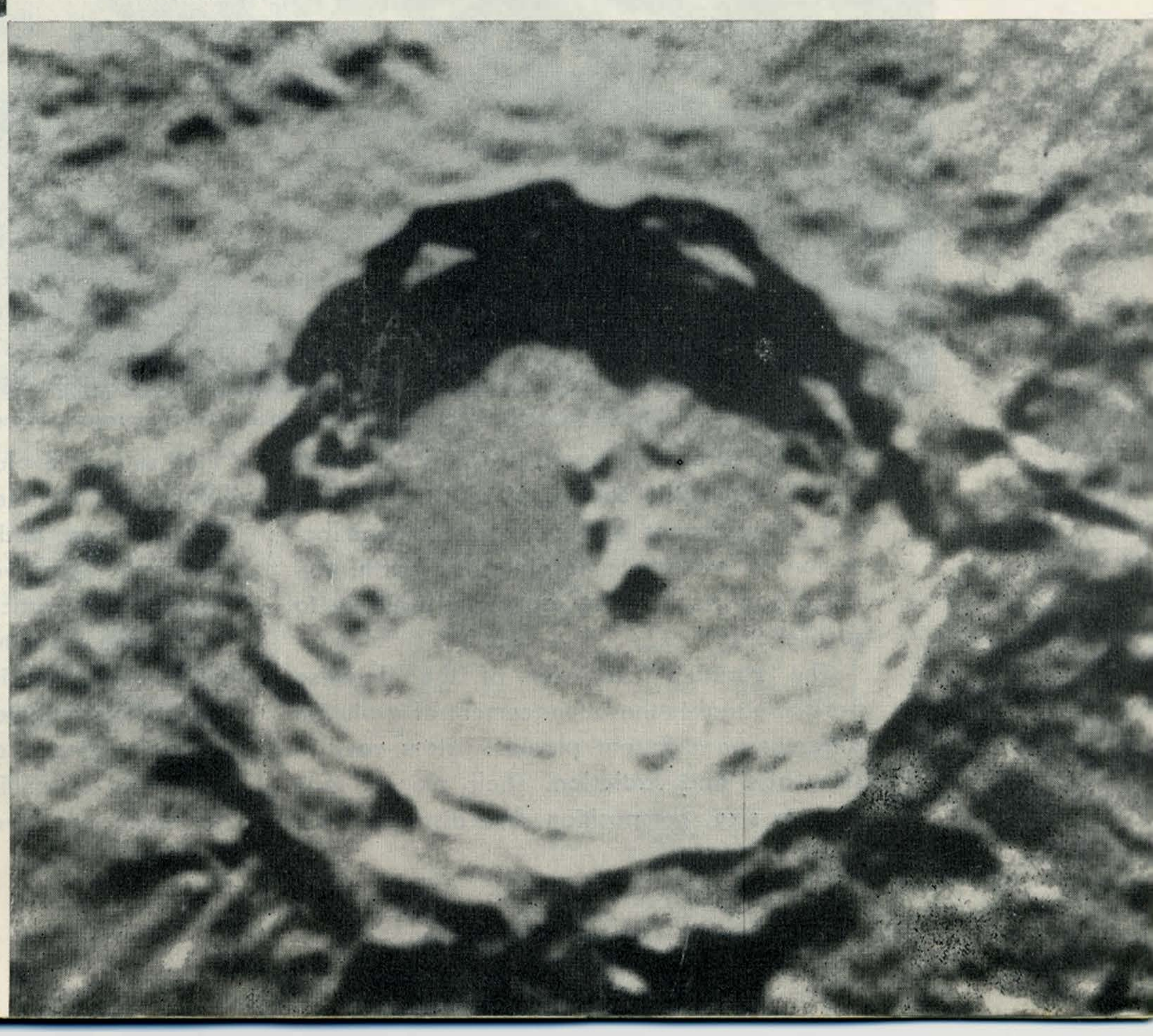
On a water-dominated planet like ours, polar toppling would induce continental floods. A Great Flood, the story of which is told in most ancient sacred/epic works, perhaps really happened. As those oral traditions indicate, however, partial survival of animal life is likely, especially if preparatory measures have been taken.

The chance of collision between stars of different galaxies seems to be greater than it is between stars of the same galaxy. Galaxies are quadrillions of miles across, and move at thousands of miles per second. In consequence, their paths occasionally intersect. Members of the Coma metagalaxy, for instance, are sufficiently close together that intersection of two or more of its galaxies must occur every 150 million years on the average.

Several galactic intersections are currently under observation (a most striking one at NGC 5128). But they are too far away for us to ascertain much about them, except that they are the loudest transmitters of radio noise in the Universe. Stars are so widely spaced that galaxies probably pass through one another with only a few actual collisions. Near misses might affect stars and their planets in various ways. Such effects could stimulate life on some, retard or destroy it on others.

These are the types of turbulence which

Comparison of the enlarged view of the Moon's crater Copernicus indicates striking similarities to craters on Earth.



Lacking the Earth's dense atmospheric protection, the Moon has been scarred by a perpetual deluge of meteorites.

scientists are investigating today. Natural events disrupt the courses of celestial bodies, just as hurricanes and other phenomena occasionally overwhelm localities on Earth. Living organisms must be especially sensitive to such events.

The variable character of the Universe probably makes the advancement of evolution different on different planets. Stars vary in size, age and radiation. Their planets may vary in size, composition and distance from their suns. If evolution proceeds on billions of planets simultaneously, conditions, stimuli, disturbances and intervening time periods will vary. Some variations will encourage the growth of advanced forms of life. Others will not. Some areas may be relatively rich, others relatively barren in the evolution of plant and animal communities.

The evidence of this planet suggests that hundreds of millions of years are required to reach our level. Over so long a period environmental changes may exceed favorable limits. Radiation is a principal determinant. A planet now well-suited for life may, in a preceding age, have undergone an excessive drop or increase in radiation. Fire or ice may have left only primeval organisms to take advantage of the intervening favorable period. Other hazards may have had similar effects.

More often than not, the evolution of life on a planet may be interrupted before it reaches advanced stages. This conclusion parallels biological observations here. Nature's lavish method is to initiate far more life than need ever reach maturity.

On the other hand, some planets may support a more luxuriant variety of life than has evolved on Earth. These would offer species which could advantageously be transferred to less developed planets. Somewhere, too, beings may have evolved at least as complex and as mobile as ourselves. Possible relationships between such beings from different planets stretch our imagination (and may stretch theirs also).

Among planets, differences would probably be much greater than those which our ancestors discovered between the continents and islands of Earth. The natural remedy is the same. Mobility allows life to recede, advance and adapt to changing conditions. Through mobility, it can strive for optimum development in every area where conditions are currently favorable.

Migrant life can revitalize areas denuded by turbulence. It can seek opportunities on planets just entering favorable periods. It can explore the attendant bodies around new stars. In the earlier stages of evolution, galactic intersection makes the future of an individual planet uncertain; but to an advanced and agile community, it offers a rare opportunity for intergalactic migration.

If time, wisdom and circumstances are adequate, we on Earth may become mobile in Space. Seeking expansion, our species is fully involved in the organic response to the challenges of the environment. We are part of the Universe. We share the natural instinct to enlarge the domain of present as well as of future generations. Like those who went before us, we probe new frontiers. We are explorers, pioneers.

radiation in space travel

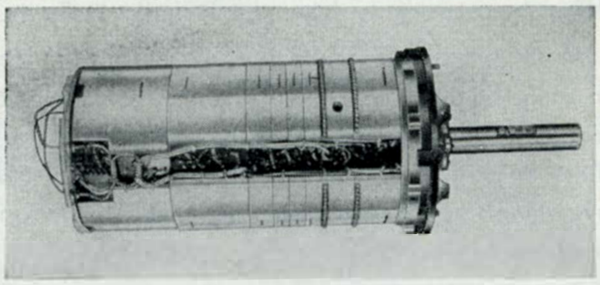
BY JAN S. PAUL

Jan S. Paul was born in Iowa and lives in California. She specialized in nuclear engineering when much of the Free World had never heard of the field. She acquired her Ph.D. from Phoenix University in Italy. She served with the British and later the U.S. forces during World War II, and with the Air Force Public Information Office in Korea. Dr. Paul is now specializing in radiation pathology and is engaged in teaching and research.

With the confirmation of the presence of bands of dangerous radiation in Space, the concern over the effects of such radiation on man and materials ceased to be the sole concern of nuclear scientists, and became a part of the Space and rocket engineer's thinking as well.

What is the significance of all this? First of all it should not be assumed that such findings will prevent, or even appreciably slow down the research now going on; we may still travel to the Moon and beyond in due time. The basic problem of keeping radiation inside a reactor is much the same as that of keeping it out of a Space ship. Therefore, with many of these basic problems already solved, the direction from here will be primarily in adaption and modification.

What, then, are the actual limitations and effects of this radiation? As with the beginning stages of many undertakings, certain assumptions are sometimes necessary. Here we must



A Geiger Counter used in connection with radiation experiments conducted by the Explorer earth satellites.

assume that this radiation is the same basic type with which we are familiar on Earth and that the same basic irradiation principles are true. The National Committee on Radiation Exposure has set the permissible radiation dose at 15 roentgens per year, or 0.3 rotentgens per week, based on the curie system of measurement in which radioactivity undergoes 3.700×10^{10} disintegrations per second.

In such case, 15 roentgens is the maximum safety factor for which Space engineers must plan, design, and build. But just what happens to the human organism beyond that limit? Experiments, conducted for the most part on animals, have brought to light the following facts:

An excess overall total dose of 1000 roetgen will produce a shortening of average life expectancy by five years.

An excess dose of 100 to 1000 roentgens causes a marked decrease in the weight of the spleen and thymus.

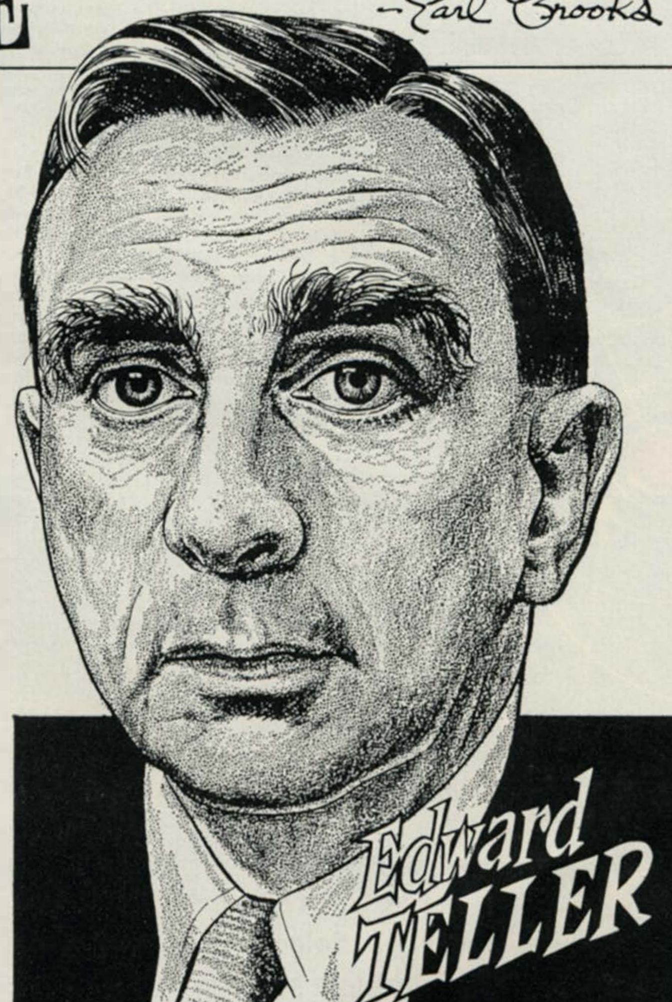
The kidneys are affected by excess doses of 100 to 500 roetgens; and an excess dose of 50 to 300 roentgens was found to affect the sex organs.

However, only one organ, the eye, need ever cause immediate concern. It was found that a dose of 12.5 roentgens—less than one year's total exposure if directed only at the eyes—could cause tendencies toward cataracts. But let us note carefully two words—*could* and *tendencies*. What this means is that for certain persons 12.5 roentgens of radiation on the eyes could be dangerously harmful, just as for some, the sting of a bee or the bite of a spider may prove deadly, while for others the effect would be simply uncomfortable.

The obvious conclusion appears to be that Space engineers will work out protective ratios to take care of the overall exposure and to keep the dosage below the 15 roentgen level. Perhaps leaded glass goggles will be the vogue for all Space travelers. Regardless of the technicalities, one fact remains: man will travel through Space safely. These bands of radiation may call for changes in ideas and designs in Space gear; but they will neither halt, nor slow down to any appreciable extent, man's conquest of Space.

MEN of SCIENCE

—Earl Brooks



FORMER A.E.C. CHAIRMAN LEWIS STRAUSS ONCE STATED, "THERE ARE THREE KINDS OF PHYSICISTS; THEORETICAL, APPLIED, AND POLITICAL." THE NAME OF EDWARD TELLER STANDS OUT IN ALL CATAGORIES. AS AN EXAMPLE – HIS PURE RESEARCH IN STELLAR FUSION WAS LATER APPLIED IN DEVELOPING THE HYDROGEN BOMB. TELLER THEN HAD TO DEFEND THE DECISION TO MAKE THE BOMB AGAINST MANY OF HIS SCIENTIFIC COLLEAGUES LED BY ROBERT OPPENHEIMER AND A LARGE SEGMENT OF THE PUBLIC. TELLER, OF COURSE, DID NONE OF THIS SINGLE HANDED, BUT HIS LEADERSHIP WON HIM THE UNOFFICIAL TITLE "FATHER OF THE H-BOMB". EVEN BEFORE THAT, HE WAS INFLUENTIAL IN PERSUADING EINSTEIN TO WRITE HIS NOW-FAMOUS LETTER TO F.D.R. THAT INITIATED "MANHATTAN PROJECT" AND THE ATOMIC AGE.

BORN 50 YEARS AGO IN HUNGARY, TELLER FLED STRIFE TORN AND ANTI-SEMITIC EUROPE WHEN THE NAZI THREAT LOOMED. HIS STRONG DEVOTION TO HIS ADOPTED COUNTRY IS EVIDENCED BY HIS HIGHLY VOCAL CONCERN OVER RUSSIAN PROGRESS IN SCIENCE. HE HAS BEEN TIRELESS IN HIS EFFORT TO AWAKEN THE U.S.

TELLER WORKED EXTENSIVELY WITH THE LATE ENRICO FERMI AT CHICAGO'S INSTITUTE FOR NUCLEAR STUDIES. AT PRESENT HE IS CARRYING ON RESEARCH AT CAL-TECH.

★ ★ ★

project star

By Helmut Hoeppner and
B. Spencer Isbell

Helmut Hoeppner (left) was born in Ueskueb, Turkey, in 1911 and attended the Technical Academy, Chemnitz, Germany, and the Technical University, Dresden. After graduation, he worked for the Klemm Aircraft Company in Stuttgart, Germany. He served a short tour in the German Luftwaffe and then became an associate of Dr. Wernher von Braun at Peenemunde, where he worked on the development of the V-2 and other rockets. He became an engineer for the Messerschmitt Aircraft Company, Augsburg, and helped to develop the ME-163 and ME-262 jet aircraft. From 1951 to 1954, he was employed by the International Business Machine Corporation in Stuttgart. In 1954, at the suggestion of Dr. Walter Dornberger, he came to America as an aeronautical engineer for the Bell Aircraft Corporation, Buffalo, New York. In 1956, he joined his former co-workers at Peenemunde at Redstone Arsenal in Huntsville, Alabama. He is presently a Senior Scientist for Astronautics with the Chrysler Corporation in Detroit, Michigan. A member of the German Rocket Society, the British Interplanetary Society, and the American Rocket Society, he has published many articles and reports in the field of astronautics. **B. Spencer Isbell** (right) is a native of Birmingham, Alabama, and attended the University of Alabama, where he majored in both mechanical and aeronautical engineering. Since 1951 he has been employed as an Aeronautical Engineer at Redstone Arsenal, Huntsville, Alabama. He presently serves on the technical staff Office of Director, Development Operations Division, Army Ballistic Missile Agency. He is a member of the American Rocket Society, the British Interplanetary Society, the American Association for the Advancement of Science, and the American Astronautical Society. He is on the editorial staff of *Astronautical Sciences Review* and is editor of SPACE Journal.

Editor's Note: This is an introduction to a series of articles on interstellar Space travel which will appear periodically in SPACE Journal. The authors confined this presentation to a discussion of the project's concept, assumptions, and design approach. A more detailed explanation of the system, design, and performance will be given in future installments of the series.

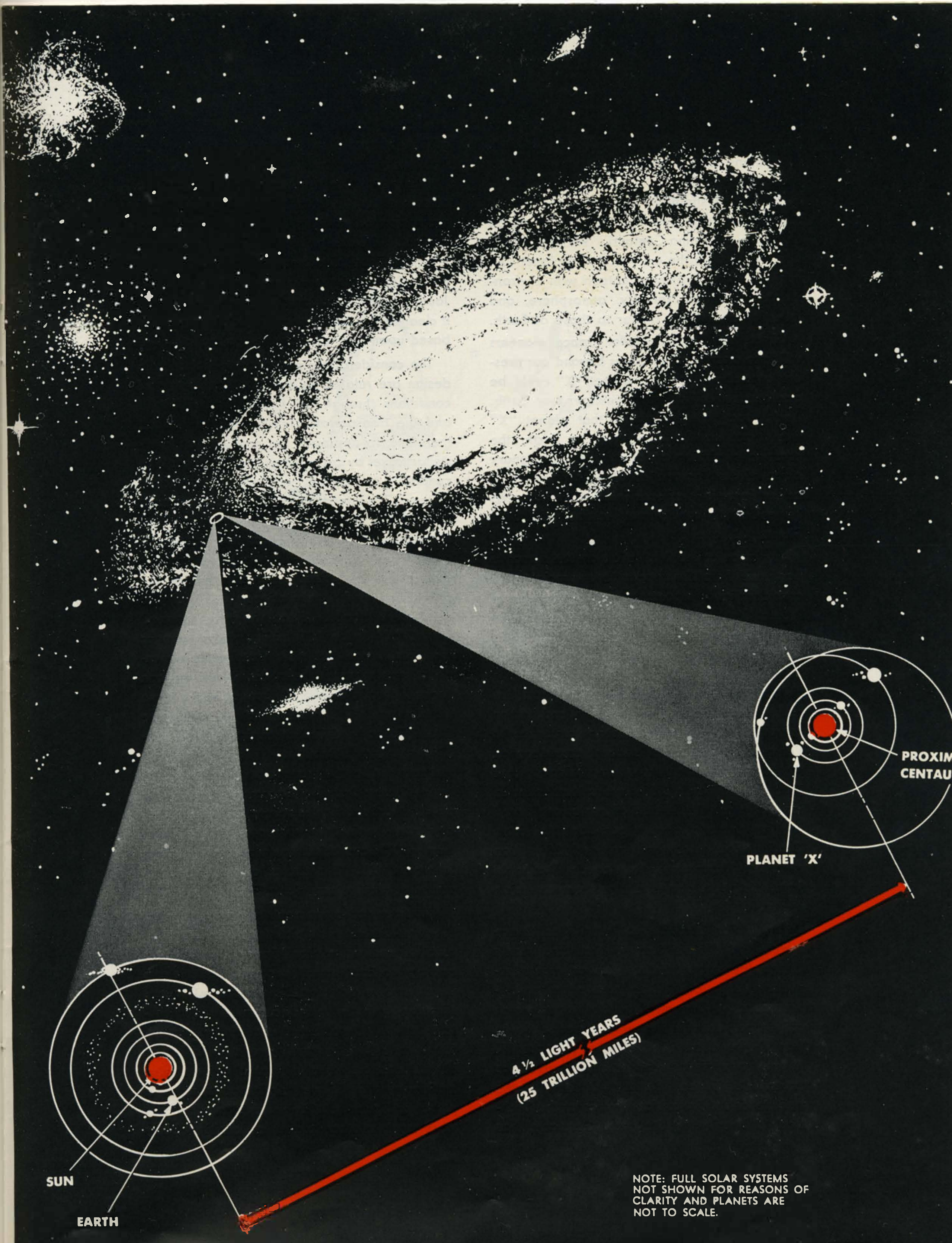
First Interstellar Voyage by Earthmen

Interstellar Space travel will be feasible as soon as man has mastered travel between the planets of our own Solar System. Contrary to the present contention by many astronauts that man's technology will require hundreds, and even thousands, of years to carry him beyond our planets, he can extend his explorations to the stars within a few years after he reaches Mars. If man's past history on Earth is any indication of future events, there is little doubt that he will find the justification and soar past Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto to one of the Sun's nearest neighbors within the family of stars we know as our galaxy.

Today, it is anyone's guess what motivation will provoke Earthmen to venture beyond the vastness of their own Solar System. Perhaps John Hulley[1] has found the key to the answer in his ecological approach to a definition of the role of humanity. Hulley postulates that the primary purpose of the Homosapiens is to carry life from planet to planet. Dr. Philip N. Shockey suggests other possible motives in this issue of SPACE Journal. The reason may evolve as a by-product of interplanetary travel. Exploration of our own Solar System is certain to solve many of today's mysteries. The newfound knowledge could reveal previously unknown dangers to life in this Solar System—triggering one of man's oldest prime movers, self-preservation.

As strange as it may seem, astronomers know more in some respects about distant stars than they do about the planets in our own Solar System. The planets are visible only in the reflected light of the Sun. Stars, on the other hand, shine in their own light, permitting astronomers to learn much about them through spectroscopes and other equipment. An example of this advanced knowledge of the stars is that, by comparison, our Sun is a third magnitude star. There are

[1]The Purpose Of Man In The Universe", SPACE Journal, summer issue, 1958.


PROXIMA CENTAURI
PLANET 'X'
4 ½ LIGHT YEARS
(25 TRILLION MILES)
SUN
EARTH
NOTE: FULL SOLAR SYSTEMS NOT SHOWN FOR REASONS OF CLARITY AND PLANETS ARE NOT TO SCALE.

billions of stars in the Universe radiating more energy than our Sun. And, too, other stars have many more planets orbiting around them than does our Sun.

As the destination solar system for this study, we have selected our Sun's closest neighbor—Proxima Centauri. With this selection, we assume the existence of a planet "X" orbiting about Proxima Centauri with environmental conditions (gravity, atmosphere, and celestial mechanics) similar to those of Earth.

Since the first interstellar Space pioneers will face many circumstances beyond our present capacity to foresee, planet "X" could be one hundred million years younger than Earth. Aside from the probability that planet "X" would not be the same age as Earth, the prospect of visiting a planet in an evolutionary stage of development so different from Earth as we know it is of such interest that it could be added to any primary objective Project Star might have.

A glance at the illustration on the opposite page will help the reader to appreciate two considerations important to the concept of Project Star. It is apparent that the distance covered by our projected journey is small in relation to distances involved in our Solar System and the Universe as a whole. But, the distance of Proxima Centauri from our Sun and planet seems enormous, indeed, when compared to the interplanetary distances to Venus or Mars. This second consideration should bring to mind the often-published times (146 days to Venus, 260 days to Mars) needed for such trips. These time estimates are based on the planet's closest approach to Earth (34.5 million miles for Mars and 25 million miles for Venus) and the speeds attainable from existing or proven designs for propulsion power.

The major obstacle to interstellar Space travel, and Project Star, is *time* and man's limited life span. Before this or any interstellar voyage can be undertaken, a power-plant must be designed and developed which will propel Space ships at a speed close to that of light (about 186,300 miles per second). At least one distinguished missile and Space expert, Dr. Eugen Sanger, director of the Institute of Jet Propulsion Physics at the Technical University of Stuttgart, Germany, has predicted that man may be traveling at 670 million miles an hour (almost the speed of light) within the next 50 years.

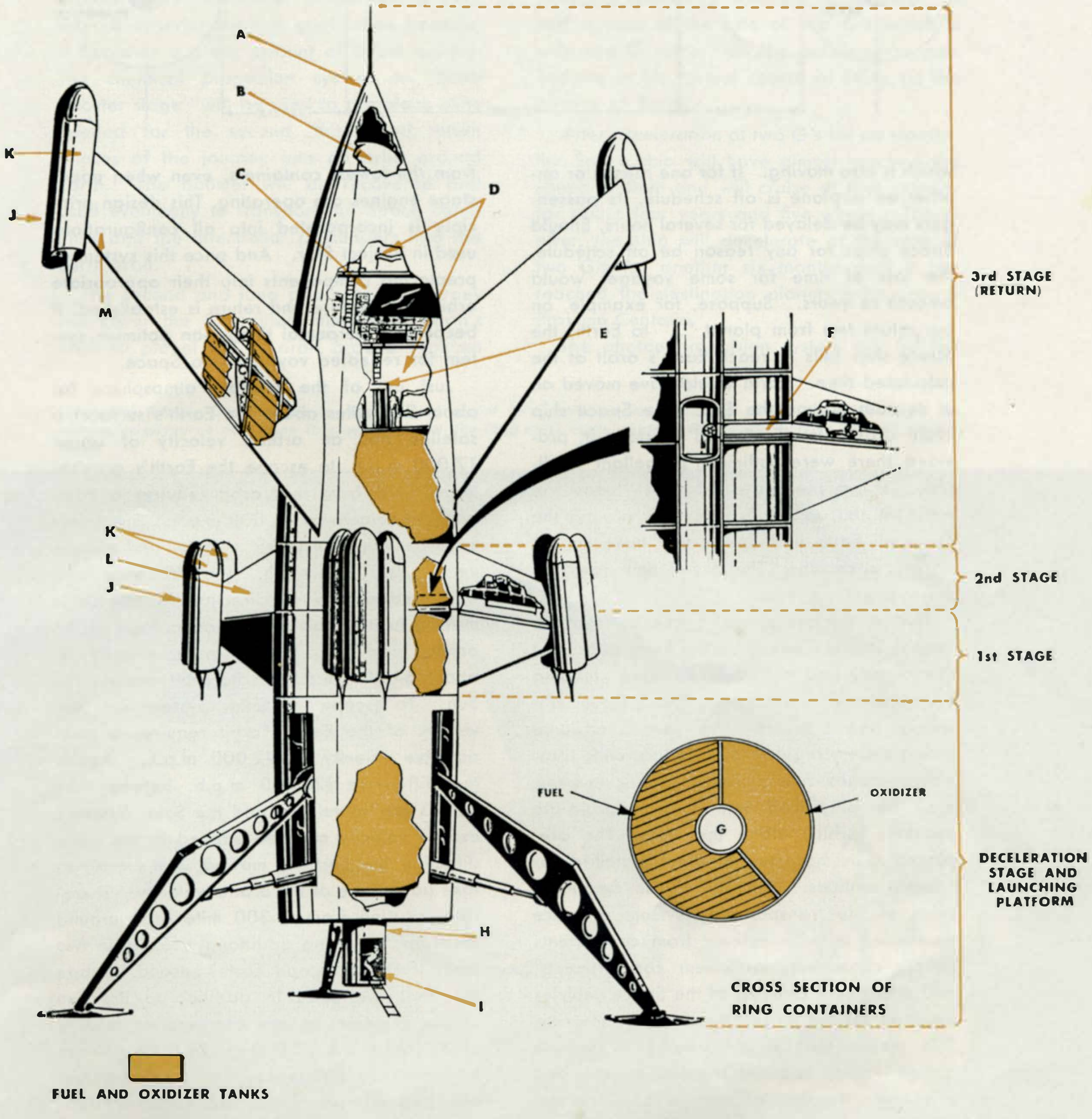
It is not within the scope of this article to discuss either the feasibility of photon (light) propulsion or traveling at or near the speed of light. The design feasibility and relativistic effects will be discussed in future articles of this series and by other contributors to SPACE Journal. The important thing here is to make it clear to the reader that Project Star must be based upon such an extreme assumption.

The considerations necessary to Space ship design are relative to both the environmental conditions through which the ship will move and the transportation system. It is logical, therefore, to approach the problems of interstellar travel by considering simultaneously the conditions encountered and the concept of the system. The interstellar Space ship must travel through the Earth's atmosphere and gravitational field, the near vacuum and practically gravity-free conditions beyond the sensible atmosphere, and, finally, descend through the atmosphere and gravitational field of the destination planet. Since we have assumed planet "X" to be 100 million years younger than Earth, and we know that Earth's atmosphere was more dense at that time, we can assume that planet "X" has a very dense atmosphere. This means that we will have three distinctly different environmental conditions to move through. With this in mind, we can divide the transportaton system into three phases: first, the placement of units into an orbit around Earth; second, the long journey from the Earth's orbit to an orbit around planet "X"; and third, the placement of units to planet "X". The phases are of course reversed for the return trip to Earth.

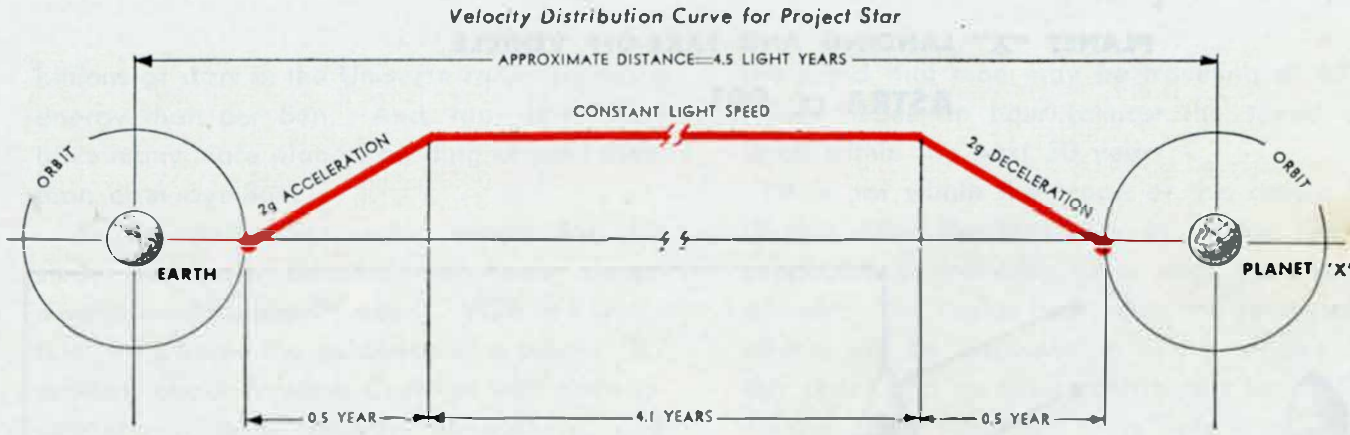
Consider for a moment the complexity of the four-dimensional planning necessary for efficient and economical Space travel by an analogy to Earthbound transportation systems which involve only two-dimensional planning. Airplane arrivals and departures are important to the operation of our airlines today. But whereas the airplane leaves one *stationary* airfield and arrives at a second airfield, also *stationary;* the Space ship departs from a planet or Space satellite which is *moving* and must meet another planet or orbiting body

PLANET "X" LANDING AND TAKE-OFF VEHICLE

ASTRA-α-001



A—DETACHABLE NOSE CONE
B—RE-ENTRY NOSE CONE
C—CONTROL ROOM
D—CREW QUARTERS
E—ELEVATOR ENTRANCE
F—ENGINE ACCESS TUNNEL
G—ELEVATOR SHAFT
H—TELESCOPING ELEVATOR SECTION
I—ELEVATOR EXIT
J—CONVENTIONAL ROCKET ENGINES
K—COMBINATION TURBO-RAM JET ENGINES
L—FINS/OUTRIGGERS
M—WINGS/OUTRIGGERS



which is also *moving.* If for one reason or another an airplane is off schedule, its passengers may be delayed for several hours. Should Space ships for any reason be off schedule, the loss of time for some voyages would amount to years. Suppose, for example, on our return trip from planet "X" to Earth, the Space ship fails to reach Earth's orbit at the calculated time. Earth would have moved on in its path around the Sun. The Space ship could chase after Earth and overtake it, provided there were sufficient propellant available. If not, the Space ship must "coast" in an orbit near to the Earth's orbit around the Sun until Earth and Space ship have caught up with each other. The loss of time could be more than one year.

The vehicle design and system concept for Project Star are based on the three phases of the journey and a four-dimensional planning system already mentioned. For optimum efficiency and economy, the four-dimensional timing system requires that certain units (propulsion stages, fuel containers, servicing units, etc.) be preplaced into their appropriate positions (orbits) along the way. The preplaced units become, in effect, satellites or "Space stations." They are also functional parts of the transportation system and are assembled in orbit entirely from components (empty containers, instrument compartments, and attachment devices) of the Space vehicles required for the three phases of the journey. This means that a compromise in vehicle design is made to permit the dual purpose and economy. But the compromise in vehicle design is held to a minimum by optimizing design features, for example, the outrigged engines and staging principle, where the *engine propellants are always burned first from the lowest containers,* even when upper stage engines are operating. This design principle is incorporated into all configurations used in Project Star. And once this system of preplacing components into their appropriate orbit of departure and return is established, it becomes a perpetual thing—an optimum system for repeated voyages into Space.

Just out of the sensible atmosphere (at about 300 miles above the Earth's surface) a satellite has an orbital velocity of about 17,000 m.p.h. to escape the Earth's gravitational field from that orbit requires a comparative velocity of 24,000 m.p.h. The difference between the obital velocity and escape velocity is 7,000 m.p.h. The difference must be added in the same direction the satellite is moving in it's orbit to take advantage of it's orbital velocity. Earth has a velocity of about 64,000 m.p.h. in its orbit around the Sun. To escape the Solar System from the vicinity of the Earth's orbit requires a comparative velocity of 92,000 m.p.h. Again, the difference (28,000 m.p.h. between the Earth's orbital velocity and the Solar System's escape velocity must be applied in the same direction the Earth is moving in it's orbit to take advantage of the orbital velocity. Therefore, starting from a 300 mile orbit around Earth and applying additional velocity in two steps (first, to escape Earth; second, escape the Sun), we need in addition to the two orbital velocities a total comparative velocity of 35,000 m.p.h. (7,000 + 28,000). When both velocity differences are combined into one step instead of the two separate steps described above, only one energy displacement is involved and the additional comparative velocity necessary is 29,000 m.p.h.

Solar system escape velocity should be

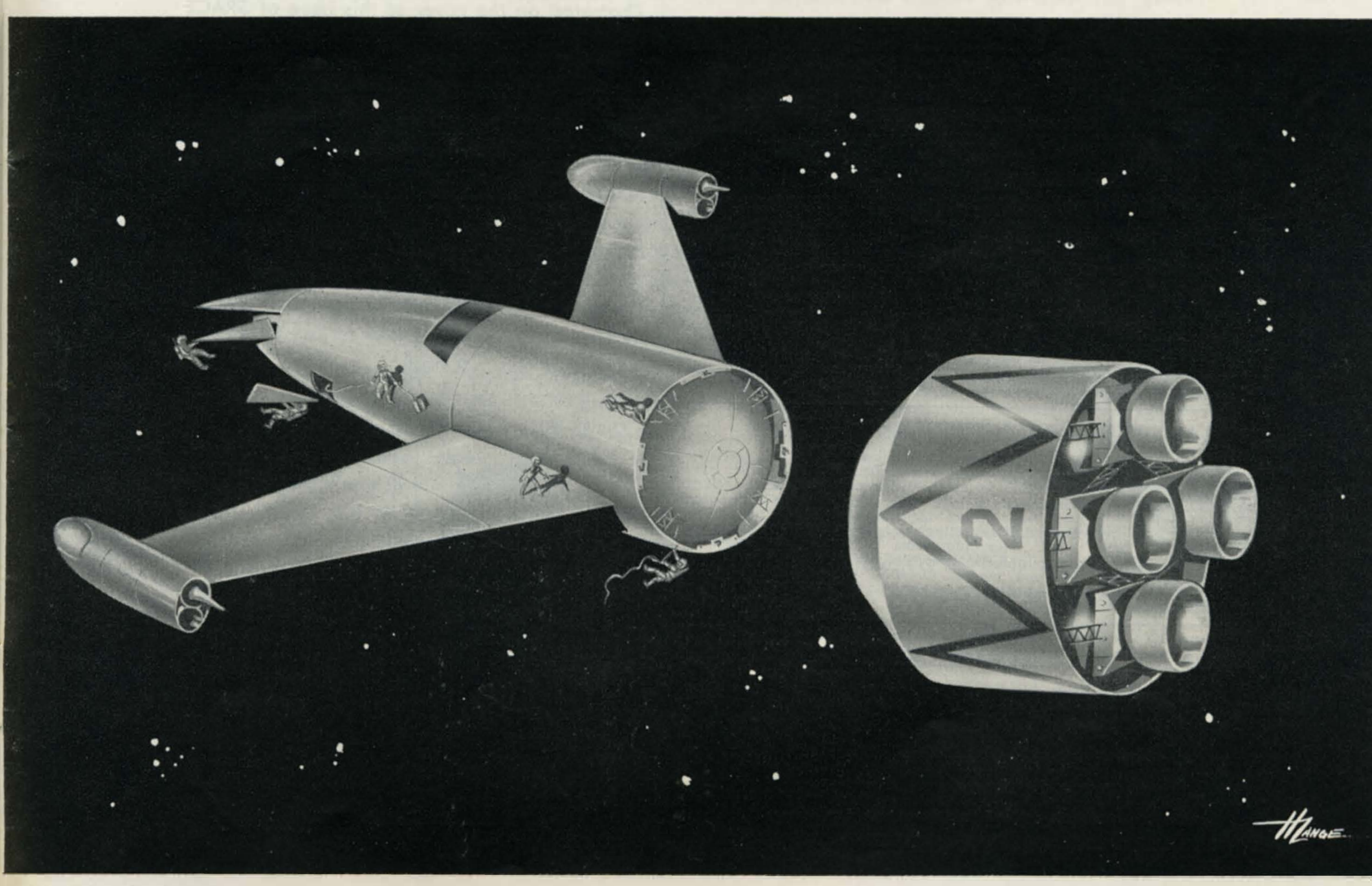
attainable within a decade by conventional chemically propelled powerplants. In fact, we have selected the chemical rocket engine as the power source for the first phase of Project Star. Chemical propulsion is considered superior for this application because it furnishes a great amount of thrust quickly. The chemical propulsion system or "Earth booster stage" will be used to pre-place units needed for the second, third, and return phases of the journey into an orbit around Earth. The booster will be recovered and used eventually to transport the Space cabin units and the interstellar passengers into the Earth orbit.

The second and long phase of the journey will cover the 25 trillion miles from Earth's orbit to planet "X" 's orbit around Proxima Centauri. A photon propulsion system will be assembled in the orbit around Earth and will propel the outer Space ship to and at a velocity approaching the speed of light. The photon-propelled phase will accelerate for half a year at the rate of two G's which is only one G more than the acceleration man endures in his normal course of living on the surface of Earth.

After acceleration at two G's for six months, the Space ship will have almost reached the speed of light and will cruise at that velocity for about four years and five weeks. Thereafter, the ship will decelerate at the rate of two G's for another six months until it has reached the destination planets orbit around Proxima Centauri.

The photon propulsion system will be left

Interstellar Return Configuration in orbit around planet "X". Earthmen are attaching photon thrust unit and removing aerodynamic nose cone in preparation for the long outer Space phase of the journey back to an orbit around Earth.



in an orbit around planet "X" to be picked up again on the return trip through the long phase of outer Space. After the disconnection of the photon unit and other preparations for atmospheric re-entry, the third and last phase of the journey to planet "X" is undertaken. Since the atmosphere of planet "X" is denser than that of Earth, the choice of a third and different type of propulsion power is necessary. The dense atmosphere would enhance the operational efficiency of an air-breathing type of propulsion. A turbo-ramjet powerplant in combination with conventional chemical rockets seems to be ideal for this third phase of our journey. The rockets would be used for the initial part of the descent, until the ship reached the sensible atmosphere of the planet. Whereupon the turbo-ramjet engines would take over. Unlike the ballistic-type trajectory or path of ascent that characterized the first phase of our journey from Earth to the orbit around Earth, the approach to a landing on planet "X" must be a path of gentle spirals. The spiral approach is necessary to avoid disaster as a result of aerodynamic heating.

By controlling the thrust of the six outrigged turbo-ramjets and with the aid of retro rockets, a final vertical landing can be made after the long, spiralling descent has sufficiently slowed down the landing craft.

The one-way trip to planet "X" will take a little over five years—barring any unforeseen circumstances and provided the scheduled timing for each phase is successfully accomplished. With certain alterations in the system, the three phases of the journey will be reversed for the return trip to Earth. Therefore, traveling even near the speed of light, the first interstellar Space trip will require at least ten years.

In the event that planet "X" is in a stage of evolution younger than Earth, then the scene illustrated on the cover of this issue of SPACE Journal may well be what the interstellar Space pioneers will first see when they arrive on planet "X". Future installments of this series will further discuss how Project Star may become a reality.

YOU GAVE ME QUITE A START, I THOUGHT FOR A MOMENT IT WAS A BILL COLLECTOR!

SPACE BOOKS

RECENT & FORTHCOMING

Reviewed by
David L. Christensen
Ralph E. Jennings
M. Raymond
Conrad Swanson

Peace Or Atomic War? By Albert Schweitzer. 47 pages. New York: Henry Holt and Company. $1.50.

Few men in contemporary civilization are as universally admired as Albert Schweitzer. This little addition to his published works can do nothing but enhance his reputation. What is needed now, Dr. Schweitzer feels, is action on the part of all peoples, the United Nations, and most important, negotiations at the highest level—the Summit. To quote President Eisenhower, Dr. Schweitzer calls for "a gigantic leap into peace" and a new spirit of good sense and morality. This book cannot be ignored. It is a testament of conscience and of faith for today and tomorrow. In this hour of destiny, Albert Schweitzer, the most notable world citizen of our age, has sounded an urgent call to end the nuclear-arms race.

". . . At this stage," he says, "we have the choice of two risks: the one lies in continuing the mad atomic arms-race, with its danger of an unavoidable atomic war in the near future; the other in the renunciation of nuclear weapons, and in the hope that the United States and the Soviet Union, and the peoples associated with them, will manage to live in peace. The first holds no hope of a prosperous future; the second does. We must risk the second."

It will be significant to the reader to learn that this book is based upon three appeals broadcast from Oslo, Norway, on April 28, 29, and 30, 1958. Except for a few brief visits to Europe to raise money for his hospital in Lambarene in French Equatorial Africa and a trip to the Goethe Festival in Colorado in 1949, Dr. Schweitzer has remained with his patients, books, and Bach. This most recent excursion reflects his profound nobility of spirit and "reverence for life."

—Ralph E. Jennings

Once Around the Sun. By Ronald Fraser. 160 pages. New York: Macmillan. $3.95.

Dr. Fraser's book succeeds admirably in its purpose: to explain just what the International Geophysical Year is. This book ties together all of the many facets of IGY activities and shows the interrelationships between them. The author organizes his material in a neat way: he presents the known boundaries of geophyics and then explains how various IGY activities will either expand, refute, or prove them.

While the average, interested layman thinks of the IGY in terms of Earth satellites, Dr. Fraser—and rightly so—devotes only 12 pages of his book to the rocket and satellite phase of the program. In this way he illustrates that the most glamourous feature of the entire program is merely one link in the chain and that it is neither more nor less important than any other.

The book does not go into all of the details of each phase of the IGY. Reasonably, it could not. The book is broad in scope, and within the confines of 160 pages it manages to present in a clear and readable manner the greatest scientific investigation man has ever undertaken. The fact that the book is so readable is due in no small part to the facility which the English scientists in general have with their own language.

—M. Raymond

Satellites, Rockets and Outer Space. By Willy Ley. 128 pages. New York: Signet Key Books, The New American Library. $.35.

It is hard to say whether this little paperback is a synopsis or an introduction to Willy Ley's *Rockets, Missiles, and Space Travel*. It appears to be both at once. Like the longer work, the book is written in clear and simple language, and yet it covers a lot of material. The title almost sums up the contents. In general the book brings some parts of the earlier *Rockets, Missiles, and Space Travel* up to date. In addition it contains some excellent advice for youngsters who are planning a career in astronautics—and even defines the word astronautics. Perhaps its best feature is the author's neat summing up of flying saucer research and his convincing dismissal of the saucers as being from Space. The two short chapters on Russian missiles and American missiles are interesting, but technical flaws in describing American missiles tend to make the reader doubt the validity of his data on Russian missiles.

Another excellent feature of the book is the section "Beyond the Satellites." It is particularly appropriate now since it is concerned primarily with shooting a rocket to the Moon, the problems involved, and what we may expect to gain from such a shot. All in all the book is well worth its price; all the more so since it contains four excellent, full-color pictures of the Jupiter-C launching the first Explorer satellite, the 500,000-pound static test stand at the Army's White Sands Guided Missile Range, the Jupiter missile in flight, and the Redstone missile being fueled.

—M. Raymond

A Key to the Stars. By R. van der Riet Woolley. 144 pages. New York: Philosophical Library. $4.75.

For a small book (5" X 7½" X ½") this volume contains a surprising amount of information. Dr. Woolley, Astronomer Royal of England, writes as an authority, but in a smooth, flowing and readable manner of presentation. The occasional use of the first person gives conversational flavor to the discussion of subject matter sometimes difficult to put across to new students of astronomy. "I hope that (this book) will be of use to readers who are willing to take a little trouble to think about the subject," declares the author, "but who have no great acquaintance with the background and physics which would be necessary for a more elaborate examination of our knowledge of things outside the Earth."

Although little has been changed from the first edition, written as it was more than twenty years ago, the reader will find that the basic principles discussed by Dr. Woolley are just as important today as they were then. Chapter headings are: 1, Time and Longitude; II, The Solar System; III, Stellar Distances and Magnitudes; IV, The Temperature of the Stars; V, The Composition of the Stars; VI, The Galaxy; VII, The World's Observatories. The last chapter, by the way, is not a tabulation of a great number of observatories, but centers attention on a few of those of historical interest plus a short discussion of the Greenwich Observatory, and brief mention of Mt. Wilson, Palomar, and Lick.

—C. D. Swanson

Sputnik Into Space. By M. Vassiliev. 147 pages. London: Souvenir Press Ltd. 1958.

First published in Moscow in 1955, this book has been revised to include limited data concerning the first Russian satellites. The English version is translated from an Italian translation of the original, which may account for some of the numerous technical errors.

Although the Russian author prepared the text under the supervision of a Professor at the Soviet Academy of Science (V. V. Dobronravov), there is very little information presented that is not already well known or readily available to Space enthusiasts. The book does reveal, however, the deep-rooted Soviet devotion to rocketry, and its many Space travel aspects. The fact that the original book and similar documentation was available for some time prior to the first Sputnik launching causes one to wonder why the event was not anticipated by the Free World to a greater degree.

—D. L. Christenson

REACTION

VOX POPULI

In order to prevent delays, all reaction mail and manuscripts submitted to SPACE Journal must be addressed to SPACE Journal, P.O. Box 82, Huntsville, Alabama. Similarly all subscriptions or inquiries concerning subscriptions must be addressed to SPACE Journal, P.O. Box 94, Nashvlle, Tenn.

Dear Editor,

Upon reading the fall, 1958, issue of SPACE Journal, I noted that there was no part III to Dr. Stuhlinger's "Life on Other Stars." Is the series complete in two parts or are there more parts forthcoming in future issues?

Takoma Park, Md. Ronald Chiabotta

There is a third and concluding part to Dr. Stuhlinger's series. We hope to have it ready for the spring, 1959, issue. Needless to say, Dr. Stuhlinger has been very busy lately; but he has promised us the remainder of his series very soon. Editor.

Dear Editor,

Mr. Kumagai has incorporated something new in his village on the Moon, slanting floors in several buildings 18 degrees (comparable to a 3 degree slope on Earth.) It's quite conceivable that the Moon's 1/6 gravity will not give a man much of a feeling of "up" and "down"—to the extent that he might have trouble standing up straight, actually catching himself toppling over before he realized that he was off-balance. Of course, he would topple slowly with plenty of time to react; but that slow motion would be as much harder to sense, perhaps not until he was leaning over to quite a sharp angle. In handling equipment, placing tools where they wouldn't roll off, even in such common tasks as eating, it could be rather irritating.

Certainly, a sloping floor will enhance anyone's sense of "up" and "down", and any actor who has performed on Europe's sloping stages (where "upstage" and "downstage" originated as terms with definite physical meaning) will confirm that. . . .

In fact, I don't believe it is the best way—and that Mr. Kumagai has overlooked at least two conditions of lunar village life in his proposed plan. His designs show utilization of horizontal floorspace exactly as any architect would consider it on Earth; but you'd virtually have no upstairs or downstairs on the Moon. Stepping up on a chair two feet high on Earth is equivalent to stepping up to the next floor, 12 feet overhead, on the Moon. Thus it would be as easy, or easier, to enter a room upstairs as to walk into an adjoining room on the same floor. You can "stack" any department vertically as well as spread it horizontally on one floor. With that you'd probably have ramps extending upward in every room; they're as sensible as having a door to every room!

Secondly, there will be a pressure of one atmosphere (or even half an atmosphere) inside the village dome—with only the Moon's 1/6 gravity. Air resistance to the human body becomes a definitely noticable factor when one wants to drop down three or four floors to visit someone else's office.

When these factors are considered, it seems that the villagers will have considerable opportunity to enhance their sense of "up" and "down" without slanted floors; also, they will be constantly practicing and developing their sense of balance to a degree known on Earth only to tight-wire performers. . . .

Berkeley, Calif. Joe Gibson

Reader Gibson has some interesting and relevant points. Added to those which Dr. Rinehart puts forth in his article in the current issue, our readers should get some idea of the complexity of the problem of building a structure of the Moon which will offer its occupants both comfort and some degree of orientation

akin to that which they knew on Earth. With Dr. Rinehart's basic design criteria and the Wonder Building Corporation's scale model, we have taken a positive step in solving the problem. Perhaps other readers, particularly architects, would like to add to our growing knowledge of what must be done to place a village on the Moon. Editor.

Dear Editor,

. . . These photos show some in-school attempts by early-grade students to model their impressions of Moon features. I hope you find them of interest. . .

The models were done in clay or salt-flour-alum medium. They represent one project for the children in expressing their ideas about the Moon in order the better to understand it.

Cockeysville, Md. Ruth K. Stroh

Considering the fact that the models are made by third graders, we are surprised at their realism; and we wholeheartedly endorse the project. Imaginative projects such as this one used in conjunction with well-disciplined courses in the three R's can do much to reclaim American primary education from the Dark Ages into which it has fallen during the past 30 years. Such projects, too, must certainly serve as a stimulus to youngsters with a latent interest or inclination for the sciences. Editor.

Dear Editor,

Let me thank you for the opportunity of reading your magazine. It is a great pleasure to share the views and thoughts of our Space scientists about the physical and philosophical aspects of coming Space travel. . . .

I am one of those unfortunate individuals who is able to criticize the objectivity of an article like Dr. von Braun's ["The Acid Test", summer, 1958]—since I have recently come from Soviet Hungary. Between 1941 and today I had the opportunity to make comparisons between the German and Russian dictatorship and Western democracy. I might add perhaps some more explanation to Dr. von Braun's, because in our case none of the tyrannies were even our own, though we enjoyed a flowering—if not free—scientific life.

I have to say frankly that after a certain time, under those circumstances, there is hardly any individual resistance. The will to survive, the old instinct for self-preservation takes over—up to a point. There was a saying in Hungary, at the beginning of the war, "Somebody is going to eat us. The German at least washes his teeth; the Russian does not." This attitude and the totalitarian state's This attitude and the totalitarian state's first-preference policy toward science are the explanation.

Naturally there is a breaking point, depending upon a nation's pride, patience, and temperament, where something snaps and the nation just simply must kick out some of those teeth regardless of the consequences. That happened in Hungary but because of the lack of any help the only highly negative result was the new caution with which Russia readjusted its grip individually to each satellites' tolerance level.

That is why I agree with every word of "The Acid Test". I do hope that the Western world will make full use of the experience of people like us.

Toronto, Canada Steven L. Simon

INFORMATION FREE

BY ARNOLD E. HAGEN

The following sources of free and inexpensive materials are made available to the readers of SPACE Journal as a convenient service in obtaining worthwhile information concerning the astro-sciences and other related topics. Students, teachers and parents will find many of the listed items of extreme interest and value. We hope that this information will be both helpful and informative. Send requests to the addresses listed below. Each company or institution represented in the column reserves the right to withdraw its offer whenever it sees fit.

Civic organizations, government agencies and industrial firms are encouraged to submit material for consideration for use in this column. Send material to Arnold E. Hagen, "INFORMATION FREE," P. O. Box 703, Compton, California.

SONIC BOOM—SOUND OF PROGRESS—This interesting booklet that is concerned with supersonic fighter aircraft that can fly faster than the speed of sound in level flight should be a must for all scientifically minded people. Includes many excellent drawings showing shock waves created by airplanes flying at speeds faster than sound.

North American Aviation, Inc., Dept. IF, International Airport, Los Angeles 45, California.

THE EARTH AND STAR—Included in this 16-page booklet are the answers to such questions as: How much does the Earth weigh? How fast does it spin? How fast does it move through Space? These answers and a wealth of additional fascinating information are included in this timely booklet. Many photographs and illustrations in color.

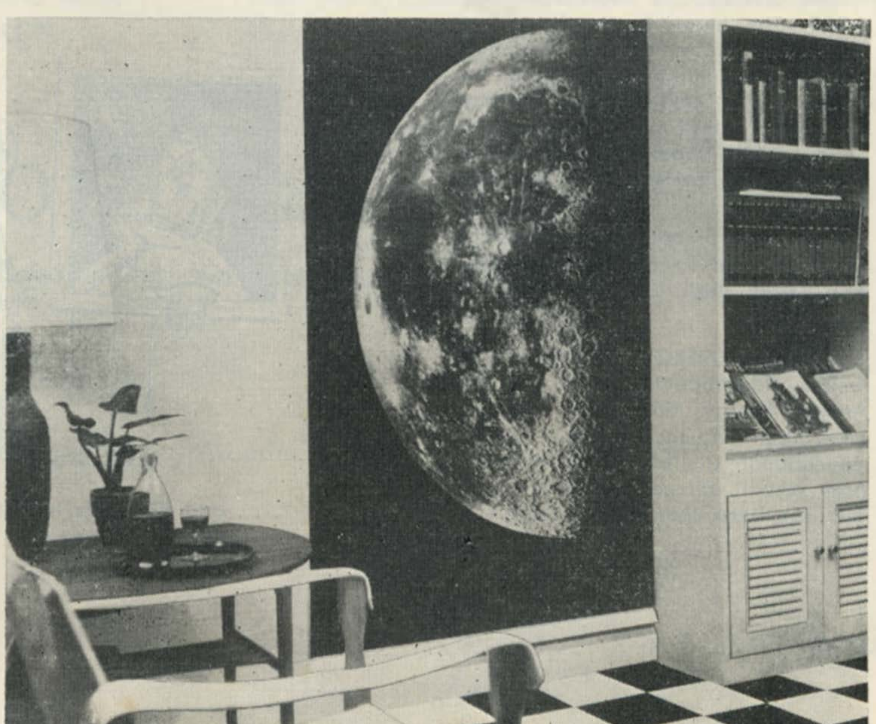
SPACE TRAVEL & GUIDED MISSILES—Man has envisioned travel through space for hundreds of years. Today it is rapidly approaching reality. This 14-page booklet explains clearly and factually how Space flight engineers base their research on scientific discoveries and precise mathematics. It also tells an exciting story of how scientists developed the guided missile, the world's most amazing weapon.

Field Enterprises Educational Corp., Public Relations, Dept. IF, Merchandise Mart Plaza, Chicago 54, Illinois.

ASTRO MURALS—Send for this interesting catalog that tells you how you can bring the exciting wonders of outer Space right into your own home. These are the first exploitation of famous celestial phenomena for use as decorative wall covering in homes, schools, and institutions. For a sense of space and sheer natural beauty with a classic timeless quality, these spectacular black and white murals are unsurpassed. Astro Murals is the only company in the entire world selling celestial enlargements exclusively. These "resistane" treated murals are exciting for use in dens, living and bedrooms.

Astro Murals Inc., Dept IF, 231 W. 58 St., New York, N. Y.

THE INVENTOR'S GUIDE—Information on how to sell your unpatented ideas, useful gadgets—devices for cash or royalty. This interesting



booklet is loaded with useful information concerning unpatented inventions.

Inventor's Creative Service, Dept IF, 354 South Spring Street, Los Angeles 13, California.

CLOUD CLUES TO HELP MAKE WEATHER WORK FOR YOU—Just about everyone wants to be something of a weather forecaster, but you'll probably need all the help you can get in order to become your own reliable weather man. By leafing through this 15-page booklet, you'll see the cloud sequences and learn the different kinds of clouds that follow each other in a kind of weather pattern. Excellent photographs and illustrations in this fact-filled educational booklet.

New Holand Machine Company, Dept IF, New Holland, Pennsylvania.

SHOULD YOU BE AN ATOMIC SCIENTIST?—This article, originally addressed to parents, first appeared as an advertisement in the *Saturday Evening Post, Ladies' Home Journal* and *Collier's*. Written by Dr. Lawrence R. Hafstad, vice president in charge of the research staff of General Motors. Excellent material for educators, guidance workers and parents.

New York Life Insurance Company, Dept IF, 51 Madison Avenue, New York 10, N. Y.

SOME FACTS ABOUT THE LIBRARY OF CONGRESS—Send for a copy of this informative publication which gives detailed information about the world's largest library. It was created by and for Congress in 1800. Its usefulness today is extended not only to Congress but also, through many services, to other government agencies, to other libraries throughout the country and the world, and to the general public.

Office of the Secretary, Dept IF, Library of Congress, Washington 25, D.C.

THE GYROSCOPE THROUGH THE AGES—The gyroscope is the oldest mechanism in the universe. It existed before any living thing could be found on the Earth's surface because the world itself is a gyroscope. Learn more about this interesting subject by reading this 28-page booklet.

Sperry Gyroscope Company, Dept IF, Division of Sperry Rand Corporation, Great Neck, L. I. New York.

ATOMIC ENERGY INFORMATION—The Educational Branch of the Atomic Energy Commission distributes, upon request, in single copies, educational kits at the elementary, high school, college and teacher levels. The items that go into these kits vary from time to time as copies of some of the publications become exhausted and new ones are added. For this reason individual booklets are not listed in this notice. Excellent material for educational and reference use.

United States Atomic Energy Commission, Dept IF, Educational Services Branch, Washington 25, D.C.

CAREERS IN SCIENCE—Information about careers in science at the National Bureau of Standards. The National Bureau of Standards is a major laboratory of the Federal government. It is devoted to research and development in the physical sciences and provides the basic standards of physical measurements for government, science and industry.

U.S. Department of Commerce, National Bureau of Standards, Dept IF, Washington 25, D.C.

THE EYE OF THE INTERCEPTOR—Since World War II, all-weather interceptors have become the backbone of our air defense. Their evolution has been impressive. Read about the interceptor, its control system, and its armament. Also important facts about the job of the airborne armament-control system.

GUIDED MISSILES FROM ENGINEERING THROUGH PRODUCTION—Interesting scientific booklet that tells about a new concept for an age-old weapon. Excellent material for Social Studies and Science classes.

KEY MAN IN ELECTRONICS MANUFACTURING, THE ENGINEER—The engineer at Hughes Electronics Manufacturing Activity in El Segundo, Calif., is a special kind of man . . . with special abilities and special interests. Read this interesting booklet and learn about the actual service that these important men provide for the Nation's defense.

THIS IS HUGHES AIRCRAFT COMPANY . . . ELECTRONIC RESEARCH . . . DEVELOPMENT . . . MANUFACTURING—This 28 page booklet is an over-all panorama of Hughes—of the organization, people and activities which have built the company. Today, engaged exclusively in electronics research, development and manufacturer, it is an acknowledged leader in airborne weapon systems and guided missiles for the Military . . . ground systems for aircraft surveillance and control . . . and components, instruments and systems for commercial and industrial electronics.

Hughes Aircraft Company, Public Relations Department, Culver City, California.

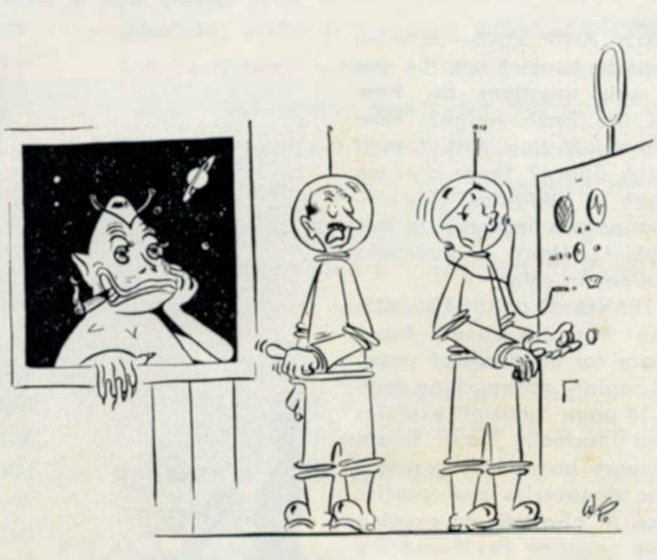
FREE MAILING SERVICE—to teachers who request teaching aids, NAEC sends (to elementary teachers) a free copy of Aviation Education Bibliography (Elementary School), pictures, and other teaching aids. Suitable teaching materials are sent also to secondary teachers. In addition Skylights, the NAEC monthly fact sheet, is sent throughout the school year without charge to all teachers requesting it.

To boys and girls who request pictures and facts, NAEC sends free photographs, booklets, and Skylights.

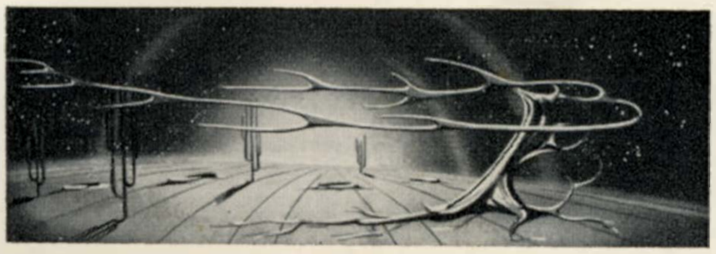
National Aviation Education Council, 1025 Connecticut Ave. N W. Washington 6, D.C.

THE COPYRIGHT OFFICE OF THE U.S.A.—This 30-page booklet includes brief answers to some common questions about copyright, a listing of important dates, a chart showing registration trends, as well as lists of copyright office publications and application forms.

Copyright Office, Dept IF, The Library of Congress. Washington 25, D.C.



". . . and *HE* wants to know how the Braves came out?"



OBJECTIVE: *Survival*

Cape Canaveral makes news—many failures and a few successes. To the man in the street, the Space Age is a competition of sputniks, a sports event with the solemn overtones of science.

The military are engaged in a race for effective intercontinental ballistics, with subsequent unclear corollaries.

The ultimate objective of the Space Age is survival — not merely from supersonic bombs and satellites but from the limitations of the earth planet.

The spiraling population forecasts a ghetto civilization with insufficient food and depleted energy sources. Our future mine fields may lie in asteroids, our central stations operate on cosmic rays, our food supply and suburban developments depend on colonies on other planets.

Missiles are already a big business, costing over $3.5 billion, with a possible eventual $20 billion program. Today 22 industries, 3000 suppliers and 80,000 people are involved.

The need for information extends not only to industry but to all the armed forces, the entire educational system, and the taxpayer who must foot the bill. Herein lies the field of SPACE Journal, conveying the knowledge of the experts interpreted for the layman.

The immediate and eager acceptance of SPACE Journal is indicative of its ultimately enormous audience — and the enormous potential of its market. A breakdown of SPACE Journal's paid subscriptions is as follows: Business and industry, 43.5%; college and military, 12.2%; other students, 18%; libraries, 4.5%; teachers, 3.3%; non scientific professions, 4.3%, information and media, advertising writers, 3.6%; general, 10%.

As an advertising medium, SPACE Journal's impact and readership cannot be gauged by its still unknown net paid circulation.

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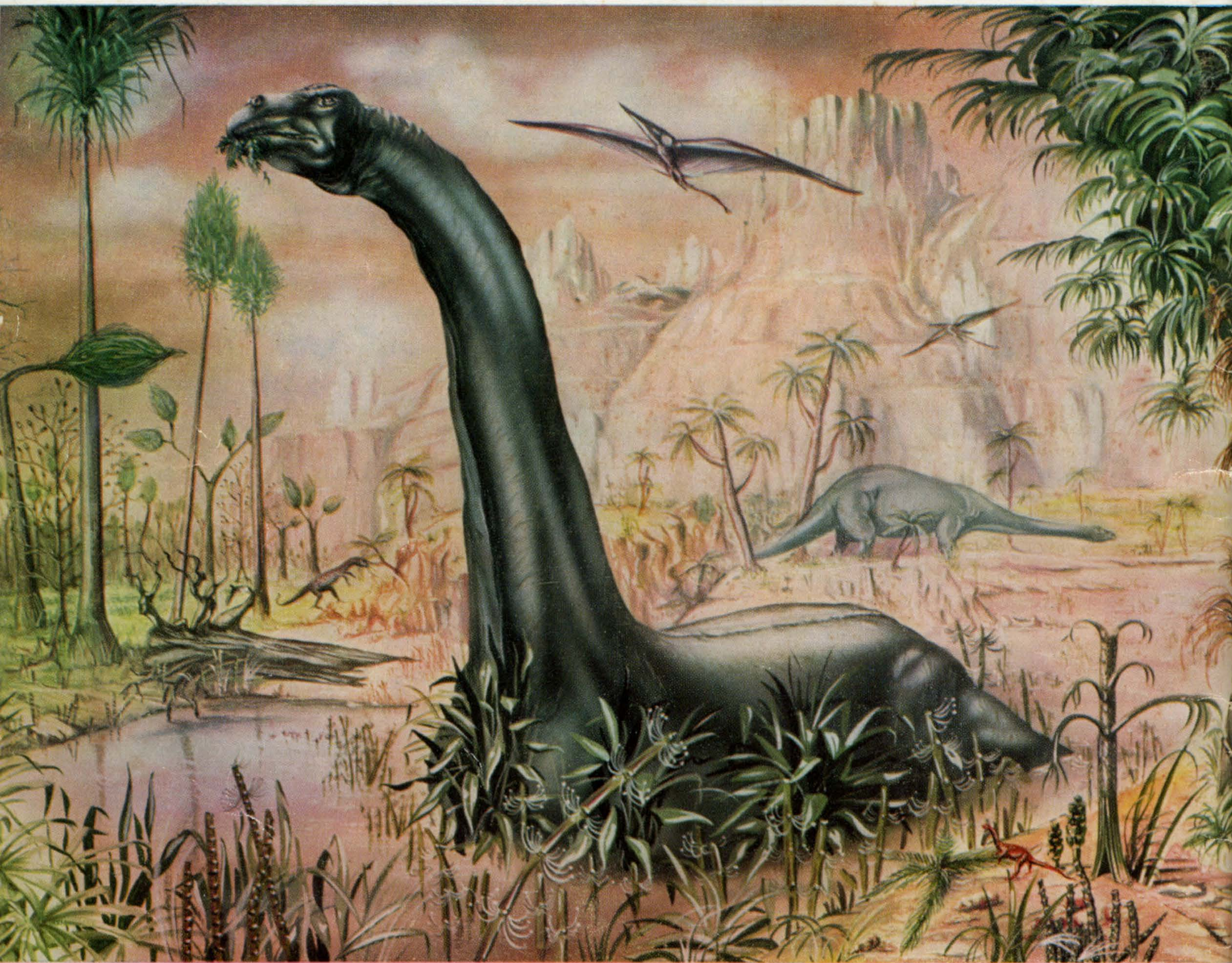

SPACE JOURNAL PROUDLY PRESENTS ARTIST HARRY LANGE'S PANORAMA OF EARTH'S FIRST INTERSTELLAR SPACE SHIP (DESIGNED BY ASTRONAUTICAL ENGINEERS HELMUT HOEPPNER AND B. SPENCER ISBELL) LANDING IN ANOTHER SOLAR SYSTEM. WITH A DEFT HAND AND PAINSTAKING CARE FOR AUTHENTIC DETAIL, LANGE HAS CAPTURED THE FASCINATING SCENE ENVISIONED BY DR. PHILIP SHOCKEY IN "THE NECESSITY OF SPACE TRAVEL" APPEARING IN THIS EDITION. DR. SHOCKEY SUGGESTS THE PROBABILITY THAT SHOULD EARTHMANS' FIRST INTERSTELLAR SPACE TRAVELERS FIND A PLANET WITH NEAR-EARTH ENVIRONMENTAL CONDITIONS, THE PLANET WOULD NOT BE IN THE SAME EVOLUTIONARY STAGE AS EARTH. THIS RENDERING SHOWS THE DESTINATION PLANET IN ITS CRETACEOUS PERIOD OF DEVELOPMENT. THE MONSTERS CREATED BY NATURE AND MAN STAND IN STARK CONTRAST.